# Proceedings of the 2001 KLAMATH BASIN Fish & Water Management Symposium

Klamath River Inter-Tribal Fish & Water Commission and
Humboldt State University Colleges of
Natural Resources & Science and Arts, Humanities & Social Sciences

February 2002

# Proceedings of the 2001 KLAMATH BASIN Fish & Water Management Symposium

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**Klamath River Inter-Tribal Fish and Water Commission and**
**Humboldt State University Colleges of**
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**Co-Convenors**
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Humboldt State University College of Natural Resources & Sciences
Humboldt State University College of Arts, Humanities, & Social Sciences

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## PREFACE

### Purpose of the Symposium

Major policy issues have emerged in the Klamath River Basin during the past decade. The current or pending restoration, regulatory, statutory and legal issues in the basin include tribal fish and water rights, the Endangered Species Act listings in both Upper Klamath Lake and the mainstem Klamath River, agricultural water rights, and the allocation of water.

The magnitude, complexity, and the geographic and political scope of issues and activities in the Klamath Basin call for an integrated approach to policy, funding, data acquisition and resource management. This symposium brought together representatives from the many federal, state and local government agencies, federally-recognized tribes, landowners and citizens, private industry interests, universities, community colleges and non-profit organizations concerned with resource management in the basin.

Together we sought to share our current scientific knowledge, restoration experience, regulatory and socio-cultural perspectives, and to make recommendations to promote an integrated basin-wide approach to planning, research, restoration, management and funding efforts aimed at resolving resource issues in the Klamath Basin.

### Proceedings Contents

When presentations for the conference were solicited, the organizing committee contacted researchers and others with expertise in Klamath Basin issues. In addition, the call for presentations went out to the public at large in the Basin. In the selection process, any presentation proposed that directly focused on Klamath Basin issues and reached the selection committee before the deadline was accepted. For the conference proceedings similarly, any presentation given at the conference that was sent to us as a written document before the final editorial deadline was included. These proceedings have not undergone a scientific peer review process. Rather, they are an effort to document the wide range of contributions that were made at the Klamath Fish and Water Symposium. We have simply compiled those contributions submitted to us and reformatted them to one standard to make them easier to read. Contributions have not been otherwise edited.

We thank Georgia Trehey for her work in compiling the proceedings.

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**Klamath River Inter-Tribal Fish and Water Commission**
The Klamath River Inter-Tribal Fish and Water Commission was formed in 1995 by the federally recognized Hoopa Valley Tribe, Karuk Tribe, Klamath Tribes, and the Yurok Tribe to serve the member Tribes' common goal of restoring and protecting the Klamath River Basin's natural resources. One of the primary goals of the Commission is to enhance inter-tribal and inter-agency communication in all forums related to Klamath Basin resource management issues

## SYMPOSIUM WELCOMING SPEECH

Presented by**: Leaf Hillman**, Chairman of the Klamath River Inter-Tribal Fish and Water Commission.

Good Morning. Welcome Citizens of the Klamath Basin and visitors.

The major goal of the Klamath Basin Inter-Tribal Fish and Water Commission, and Humboldt State University in convening this Symposium is to cross all jurisdictional and political boundaries and improve communication between and among the Tribes, Agencies, stakeholders, and citizens of the Basin. It looks like this week we will make a good step towards that goal.

The issues and problems surrounding fish and water management in the Klamath Basin are not new. The River and its natural resources have been damaged, depleted and over allocated – in some cases - almost to the point of no return. The unfortunate circumstance of this year's drought, and its impact on the biological, social, and economic structure of the Basin has brought some of these problems to the forefront.

It is a well known and often stated fact, that historically the Klamath River was the third largest salmon producer on the west coast; ranked only below the huge Sacramento / San Joaquin and Columbia systems. Well, for too long, the Klamath has also played second fiddle to those systems in the world of politics and funding. It is unfortunate that the Klamath has been squeezed between, and overshadowed, by those systems to the North and South; because, of the three, the Klamath probably has the most potential for cost effective restoration.

By the end of the week, together, we will have all shared our perspectives on the issues and problems, our individual and collective goals and objectives for the Basin, and the scientific tools, knowledge and good will efforts available.

We must keep in mind that this River system is one river, a single ecosystem, regardless of where political and jurisdictional boundaries have been drawn. All of our sub-basins: The Upper Basin, the lower River, the Shasta, Scott, and Salmon, and the Trinity are all parts of the whole, and must function together.

In order for that to happen the Agencies, Tribes, and stakeholders of the Basin must also function together.

This is not meant to be just another symposium, where everyone says: "gee, that was nice" and then goes about his or her business. We are looking for solutions. Your presence here this week, and your participation is appreciated.

The Commission would also like to tell all of you out in the audience that are from agencies or organizations that contributed to the Symposium how much we appreciate those contributions. If you check the list on the back of your binder, you will see that this is indeed, a cooperative effort. With all of that help – we're probably one of the only symposiums ever held that – for one thing – can offer you all a fantastic and free traditional salmon feed we hope you will all attend.

## OPENING PLENARY

**Bill Leary**
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I'm happy to be here speaking to your symposium on the crisis facing the Klamath Basin and the opportunities that crisis may provide for resolution.

As I speak to you this morning, I feel compelled to say that what I have to express are my own views. I intend to return to Washington, D.C., tomorrow to begin the process of discussing with my colleagues at Interior, Commerce, and USDA, among others, what the Bush Administration might offer. But I am confident that the Administration stands ready to help this basin resolve the very difficult issues you face.

So, no startling new announcements today. But I do want to continue the conversation we have begun.

First, I guess I should say why I was invited.

I was sitting in my office in February, musing what new adventures might come my way under the new Administration when my phone rang. A woman introduced herself as Alice Kilham from Klamath Falls.

She had been told that I had been involved in the restoration of the Everglades in Florida and wondered if I might be interested in coming to Arcata, California to speak at a symposium on what I had learned from that experience.

Apparently there was an effort underway out here in something called the Klamath Basin and just possibly I might be helpful.

Well I know from experience that people generally don't like an outsider to come into a local problem and think they can solve it based on something they learned thousands of miles away, but I'm thinking as I look out my window on a dismal winter day in D.C., that southern Oregon and northern California in May sounds pretty good. Besides, I'm proud of what we did in Florida and I'll talk to anyone anytime about it.

So I'll tell you a little about the Everglades, but spend most of my time on the Klamath Basin.

The Everglades is really one long river, but historically it was about as wide as the state. Think of south Florida as a shallow spoon, with the edges near the coastlines. The middle was a flat, slow-moving river, so slow you could stand in it anywhere and not feel movement against your legs. I say your legs because it was mostly deep as your knees, till you sunk into the muck.

To give you a sense of the kind of place we were able to sell to the country and Congress as a place worth substantial federal investment, let me read you from the start of a book called "Red River Grass:"

> If the Devil ever raised a garden the Everglades was it. The biggest and meanest swamp you're ever likely to see – bigger than some entire states of the Union – its pineywoods and palmetto scrubs and cypress heads and tangled vines, but mostly it's a river like none other on this earth.
>
> It's sixty miles wide and a half a foot deep and runs from Lake Okeechobee to the south end of the estate over a layer of muck that's got no bottom. The whole thing covered with sawgrass sharp as a skinning razor. Not a thing else in that

> sawgrass country but here and there some hammocks – highground islands of hardwoods and palms – and most of them never been set on.
>
> Out there the whole world looks a whole lot bigger and there's no end at all to the sky. They say it's hardly another place in the world where you can look farther and see less. And all that green of one shade or another except at sunrise and in the dying light when the great grass river goes so red it looks like it's on fire or stained with blood.
>
> Only the godawful desperate or the plain godddamned could ever live out there. It's ever kind of thing in the Everglades to cut you or burn you or sting you or poison you or eat you up whole. It's quicksand and gators and panthers and snakes and mosquitoes and ever sort of bug to drive you insane. In summer the air is so hot and wet it's like trying to breathe boiled cotton.
>
> Lord only knows what-all's been swallowed up in that rotten ooze under the sawgrass and won't ever see the light of day. It's bones in that muck a million years old and bones ain't been there a week. Animal bones. Bones of men. It's ten thousand stories buried out there ain't nobody heard but the Devil.

Now if you can get people eager to save the Devil's Garden, imagine what you can do for a basin as magnificent at Klamath. Florida has no Mount Shasta; no snow covered peaks, and lush forests. No mountain lakes. No soaring redwoods. You look at the Everglades and there's no wonder people worked so hard to drain it decades ago.

But all places have their beauty and after a while you come to love the seamlessness of the sky and water and the expanses of sawgrass that glow even on a cloudy day.

Together we took this flat slow-moving swamp and turned it into a tidal wave. Many of us had never seen such a sight on Capitol Hill. Swept away were old adversarial positions. Our main challenge was indifference. No one had a funeral in his heart.

It wasn't "Florida's Everglades," it was "America's Everglades."

And so last fall, Congress signed up to a 30-year restoration plan that will cost at least $8 billion. That's billion. It is the largest restoration project ever undertaken anywhere in the world.

It has not been lost on anyone seeking to restore other areas of the country. People in coastal Louisiana, the Pacific Northwest, southern California, Bay Delta, Mississippi River, and New York/New Jersey harbor are saying, "we'd like some of that Everglades money." They all want to know how we did it.

It will not be easy for others to emulate Florida's experience. For one thing, there is not enough federal money to help fund every restoration effort, no matter how important. But perhaps equally important, Florida set a high bar by agreeing to fund half the effort. Many places will find that hard to do.

Nonetheless, it became clear to me that I needed to learn something about the Klamath Basin if I had any chance of saying something relevant to your lives. So I started reading briefing papers and talking to some of you and planning last week's trip with my colleagues. And I was soon struck by the similarities – and the differences.

There's a reason some call this basin the "Everglades of the West."

Like Upper Klamath Basin, in south Florida there is a large shallow lake, into which several rivers flow. But besides the obvious difference that there is no snowmelt, the rivers in Florida do not feed the lake or the ecosystem. Unlike any other in the world, it is fed almost entirely by rainfall.

Like the Upper Klamath Basin, the area surrounding the lake is agricultural land created by draining wetlands. Tribes were moved onto reservations. At the turn of the last century, much of south Florida was seen as worthless swamp, to be "recovered" and made valuable to the nation as farmland.

To help do that, and also to control floods and droughts, in the 1950's, miles of canals and levees and dozens of the biggest pumps you ever saw were built to drain the wetlands south of the lake and elsewhere all the way down to the south end of the state to allow farmers to grow crops. And then they invited people to come on down. Veterans of WWII. We even lured them with a new invention called air conditioning.

I think you can see some of the similarities I saw.

And over time agriculture flourished, until more people came down and large cities formed and developers started encroaching further into the Everglades that had already been sliced and diced with canals and levees and drained.

And low and behold, we started to notice that it was all beginning to impact the quality of the water and the ability of many species to continue to exist.

We discovered we had lost over 80 percent of the vast wading bird populations. We got down to two little birds called dusky seaside sparrows and moved them to Disneyworld for the remainder of their lives in a desperate attempt to save the species. And then we discovered they were both male. And so they became extinct.

In south Florida, there are now 68 different species listed under the ESA as threatened or endangered. And maybe some of that sounds familiar here as well.

And so we started to focus on the cause and discovered that maybe it hadn't been a good thing to make the ecosystem so people friendly so many years ago.

But we discovered that the people there still liked their way of life and wanted to stay. Others wanted it restored to something like it once had been.

And maybe that sounds familiar too.

There are important differences. Here you have two states. Here you have western water law. Here you do not have large cities. And that cuts both ways.

You don't have the development pressure complicating things, but you also don't have the attention and sources of revenue big cities can bring. You are more isolated and candidly, more easily ignored.

So, as I learned more about this basin, I knew I had to see it for myself and talk to people who live here form the mountains at the top to the ocean at the bottom.

And then, unexpectedly for me at least, two biological opinions were released and suddenly my office and several of my colleagues were thrust into the basin. And so for several days last week, several of us toured your beautiful basin. A real soup to nuts whirlwind tour. And we met with many of you.

We started in Klamath Falls and met with tribes and farmers and ranchers and environmentalists and local leaders. We drove into the upper basin and flew over it. We walked in wildlife refuges and dusty farm towns. We met with tribal leaders seeking the return of some of the lands taken from them in the 1950's, protective of their rights, but concerned about the plight of farmers this year.

We saw Forest Service lands so dissected with logging roads that it seemed one was built for every tree.

We met with environmentalists who saw too much demand on the system from unsustainable sources and called for federal leadership.

We saw refuges with seemingly as much agriculture as habitat.

And we met farmers fearful of their economic future and some of their school children fearful of whether they would have to move.

We met with frustrated community leaders feeling powerless to protect their community or solve problems when faced with the effects of the Endangered Species Act.

Then we flew down here following the meander of the Klamath River, over narrow rapids and still lakes created by dams. We saw the Shasta and Scott Rivers seeming to just trickle into the Klamath. We saw mountaintops and logging cuts. And we saw little towns nestled against the river and lands held by several tribes. We saw cabins so isolated in the forest that Arcata must seem foreign and too metropolitan.

And we saw the magnificent blend of the river and the ocean and the sandbars that must describe a different route to the sea every day. And we met with commercial fishermen and tribes and ranchers and local leaders.

Along the way we learned more than I have time to go into this morning. But I'll try to capture some themes.

Most everyone we met wants to see the basin restored; however they define that term. They want to protect their cultures and ways of life, whether tribal or agriculture or logging or fishing.

Most feel there is not enough water to meet every need and, predictably differ about how best to divide the pie, or whether to expand the pie.

Everyone we met is sympathetic to the plight of the farmers this year, though many point out that suffering is not new to the basin.

In the upper basin we heard a theme of fish versus people. In the lower basin we heard what's good for fish is good for people. Surely this exposes a difference of perspective, but it also highlights the extraordinary way the basin is seen as two, split roughly by the Iron Gate dam, rather than as one river system, interconnected, from the mountains to the ocean.

Everyone expressed his or her frustration with how long it is taking to find a solution.
But if there was one theme repeated in every meeting we held, it was that the basin hungers for a long term solution and for leadership to carry it out.

Even those suffering intense harm today seem willing to try to hold on if there is some hope that these difficult times can be lessened or prevented in the future, or predicted. People seek certainty and the ability to plan for their future.

They want to know that they can make a living farming or fishing or ranching or make a living from those who do. Local politicians need to know that tax revenues are more stable so they can meet the needs of their schools and of their citizens for health care, clean water, and jobs. Believe it or not, federal officials crave predictability as well, particularly those who manage a refuge or a forest.

There's nothing new about this. This basin is replete with past efforts at planning. You can't keep up with all the task forces and working groups and memoranda of understanding all designed to get agencies and levels of government and farmers and fishermen and tribes and environmentalists to sit down and figure out how to get from here to there. I got a headache trying to keep them straight and I'd still fail a test on who they are and what they do.

I don't mean to be critical of them and the fine work the participants have done over the years. I think Senator Hatfield and others had it right to try to find consensus by tapping local experience, wisdom and creativity.

It is a goal for this Administration to do just that throughout the country.

The Upper Basin Task Force has recent success with important restoration projects just north of Upper Klamath Lake that may well be helping reduce the level of nutrients in the lake. Below the dam, the Klamath River Fisheries Task Force also enjoys some success in helping us understand the needs of salmon along the Klamath River and its tributaries.

The three member Klamath Compact Commission has been around for nearly 50 years trying to coordinate federal and state activities here, but with little real authority to make things happen and with too limited a membership.

If you really want to do a long-term comprehensive plan you have to decide what you mean by that.

If you just want to deal with the operations of the Klamath Project, important though that is, you will miss most of the issues in this basin. You won't even cover all the water, not the headwaters and not the flow into the ocean.

If you really want to understand the carrying capacity of this basin, you've got to take on the whole system.

And you have to be prepared to answer some tough questions.

Such as, when do you develop a plan? Do you wait for Oregon's cumbersome adjudication process to unfold over the next ten years, or do you encourage mediation and settlement?

Do you include the desire of the Klamath tribes to get some of their forestlands back to manage? Would they do a better job than the Forest Service at managing the forests and retaining snow for better spring flow into the system?

Of course you can't think about water quantity alone. As important is its <u>quality</u>. And as soon as you go there, you are talking about land management and TMDLs and riparian zones. Even if you find the right BMPs, can the farmers all afford to implement them?

Should we allow the market to work in the basin and allow the amount of agricultural needs to evolve? Or do we expand the storage capability in the upper basin to allow all farmers who want to farm to do so?

Should the refuges be more about habitat and less about row crops? Is it possible to trade some refuge lands for existing less profitable lands?

Should we spend more money to try to restore miles of the tributaries in the lower basin or get rid of the dams and restore scores of miles at once? And if we do, what condition will we find in the riverbed for spawning habitat and how will we pay for that restoration?

How do we address the tribal issues in the lower basin? Are they not part of the mix?

How do the communities in this basin plan for the future? Some towns cannot realistically be more than fishing or farming towns because of their location. And so those industries must be restored or the towns may die.

Others, like Klamath Falls and Eureka, are trying to diversify and try new approaches. But how will they affect the needs of the basin?

In any event, how do we avoid having the Endangered Species Act come roaring in here and undo everything you're trying to do?

Many people with whom we met made clear that the ESA must be reformed, that surely it was not intended to destroy whole communities.

Some call for the God Squad. I've worked with the ESA for many years and I can tell you that the intent of the ESA is not to destroy entire communities. It is intended to save life, not destroy it.

I won't sugar coat it. The ESA is one of the strongest, unforgiving environmental laws ever enacted. It's been called the "pit bull" of environmental laws.

When it comes roaring into a place like the Klamath Basin, it's message is very clear…some has been screwing up the environment for some time without paying enough attention to the consequences, and now it looks as though one of God's creations may be headed toward extinction.

I understand the frustration with the law and I would love to have that conversation with you about reform. But solutions for this basin cannot await reform of that law. Changing that law will take a very long time. Besides, there is flexibility in its operation.

We are seeing time and time again that a single species approach does not work. As more and more people come to inhabit more and more of our wild places, we will see the ESA pop up more and more. But like here, we will see that we are impacting more than one species, even more than one endangered species. And, like here, we will see more and more times where the attempt to save one will threaten the other.

The ESA allows, but does not expressly dictate, that the needs of a species can be protected through long-term planning, even if in the short-term, that plan may cause harm. It does not require taking into account efforts a community is undertaking to restore habitat. It allows, but does not require a multi-species approach, that takes into account the often conflicting needs of several species, including other listed species, much less those whose fate may become a listing due to the actions required to save one already listed.

But understand, the ESA operates most often as an emergency room, not a preventive care program. As long as it only treats the patient on life support, it will never adequately save the diversity of life in this country that we should as a nation demand.

And that diversity of life, ladies and gentlemen, includes people.

Finally, how do we ever come to a common understanding of the basin and what it needs?

Any effort to deal with problems as complex as those facing this basin must be founded on sound science. Sadly, agreement on science tends to end with that statement.

We heard that the science behind the biological opinions was flawed and even that, being opinions, could not be certain enough to constitute real science. We heard science was not independent enough and then that it is overly dominated by foreigners to the area.

We heard that suckers can survive in mud without much water and that too much water in the lake causes fish kills. We heard that more water was flowing south into the Lower Klamath River than historically and that too much water threatened salmon by sending them into toxic tributaries. Others disagreed with all of this.

We heard complaints that we lacked baseline data on these fish and on the amount of water needed to sustain them.

One thing be came very clear, there is a critical need for someone to get scientists together to try to agree what we know and need to know about this basin. And perhaps equally important, we need someone, anyone, who can translate this information, and why it matters to fish and everything else in the basin, to community leaders, interest groups, and just plain folks.

I am astonished at the level of misunderstanding about the science of the basin. Misunderstanding fuels frustration and anger and rumor. And it is death to your ability to find common ground.

In my view, you have to be prepared to deal with those issues, and it is not easy.

A common theme we heard up and down the basin is that this is not rocket science. Until we were let in on the secret of his profession, Denver Nelson cracked his colleagues up by saying it doesn't take a brain surgeon to understand what needs to be done.

One of your local fishermen, Ken Bay asked, "How many studies does it take to show that fish need water?"

Well in the Everglades we learned indeed that restoration is not rocket science – it's much harder.

By that we did not mean that the movement and storage of water is that hard. I believe a good

engineer left unfettered could restore this basin, largely by undoing most of the infrastructure put in place over the past 100 years so that people could come here and farm and live.

But that is where it gets hard.

People and their hopes and needs are far more complex than rockets. Finding a solution that takes all of them into account, particularly where they inevitably conflict, is what is hard.

So, how to get there?

I'm not here today with an absolute answer. For one thing, my colleagues and I plan to give our bosses some advice based upon what we learned here…and some options.

But I'll share with you what experience tells me and some options you may wish to consider.

There are several models. Since I began talking about the Everglades, I'll start with the approach we used there. It was largely locally driven and consensus based.

We created a Task Force composed of federal agencies only to try to get some needed coordination. It was based in Washington and composed of Assistant Secretaries of seven different departments.

The advantage of that was that federal agencies at very high levels were suddenly going to pay attention to this ecosystem. And that was important, especially when agencies began to develop their priorities and budgets.

Obviously, these things can't be done from Washington, however, and so we created a working group in Florida, composed of every level of government involved: federal bureaus and agencies within departments, tribes, the state, regional water control agencies, counties and cities. They meet every month to try to solve problems. In time it became clear the D.C. based Task force needed to be expanded, and so Congress expanded it to include the state, tribes, and regional and local government. But the real work was still done locally, by people who live there.

But what was obviously missing was the voice of people who don't work for government. So the Governor created a group composed of every affected interest: farmers, ranchers, environmentalists, developers, educators, scientists, local leaders, fishermen, and people who just plain wanted to have something to say and a place to say it.

And then we did something there that was unusual. Instead of the government group developing the restoration plan, we asked the governor's group to do it.

And we said we'd provide them technical support, to answer their questions about what would happen if water were stored here or moved there at one level or another. And how would we clean it, and who would be flooded if we did this or deprived of water if we did that. We used a science advisory panel that was broadly represented.

One reason the whole effort worked was whenever any interest group started to balk at a detain or focus of the plan, we were always able to remind them that they had been at the table when the plan was first drawn and so long as we remained true to the principles the governor's group established, pressure from the other groups kept everyone together.

Now, frankly, that is the model I thought this basin would endorse because it relies upon the local community, rather than the federal government, to come up with the plan, to make the decisions that have to be made,

But I have been surprised, up and down the basin, by the number of times people have told me, we cannot solve this ourselves, we need leadership from Washington. Several people said it is too hard to get anything done when you have 20 to 30 to 40 people in a room representing diverse interests.

One way to get discipline into that process is with a hammer that says, for example, you have a year to craft a draft comprehensive plan. And if you cannot, then someone, like the federal government, will.

A second model has presented itself through recent litigation over the April 6 decision. The federal court hearing the case has asked the parties to mediate their disputes and try to resolve the issues. That is fine and certainly plays into the frustration favoring a decision by someone over inaction, even a federal judge. But you may have to be a party to the suit to play and it is unclear just yet if it will take a holistic approach to the myriad of issues facing the basin.

Yet another often-effective model is where a federal agency comes up with the plan, based upon consultation with affected interests.

There are lots of examples of this approach, especially where one federal agency actually has the power and authority to implement changes throughout the affected area.

One example is the operation of the entire Missouri River by the Corps of Engineers. If this basin wants to go with this approach, we can certainly take that back to D.C. It is more efficient in many ways.

Still another is an innovative approach being tried in southern California involving the use if charettes and non-binding discussions aimed at illuminating suggested solutions to various problems and relying upon voluntary compliance. They take on small projects without an overall plan.

The point is, at the end of this speech, we still need to know which way do you want to go? Has the local approach failed so miserably that there is no chance for its success, even though it never seems to have been tried on a truly basin-wide basis? Is it time for someone, anyone, even the federal government to come in and decide how to proceed? Perhaps we need one Klamath Basin forum where everyone presents their plan and we take the best of them.

Whichever way you go, I am confident we can help. The two states will have to step up to the plate. And I am confident it will require legislation.

I cannot keep myself from telling you how doable it all seems to me. A lot of planning has been done – you lack the power to pull it all together.

Part of my optimism is because in the power of restoration.

The Everglades effort was not sold because it is an ecosystem. In speech after speech, we find that talking about ecosystems causes eyes to glaze over and minds to blink out. Even worse is biodiversity. Instant death on the talk show tour. But this changes when you mention restoration.

In my travels about the country, I have noticed a third generation of environmental activism, not political activism directed at Washington, but hands-on work directed at their own communities, an activism focused at reclaiming their known heritage, their local landscapes, their sense of place which reminds them where they are and, therefore, <u>who</u> they are.

Running through this activism, is a voice announcing: "We can do better."

This is an entirely new era, literally a third great environmental movement.

The first era was the Conservation movement of Teddy Roosevelt, which created America's great parks, wildlife refuges, and national forests. It lay the legal foundation. It saw America as a patchwork of places and resources either to be protected or to be exploited.

The second generation, of Rachel Carson, saw our air and waters and soils being polluted by modern industrial society and helped pass legislation that brought us clear water and clean air.

Out of that, the current generation is awakening to a new and larger vision – to the possibilities that we can use our laws not just to stop decline, but to reverse it; not just to preserve the isolated parts, but to protect and reconnect whole landscapes and entire watersheds; not just to fence off the local greenway or trickling neighborhood stream, but to unite them with the great National Parks and the wide oceanbound rivers.

All I know is that I see restoration as optimism. Restore my faith…Restore my hope…Restore my soul.

Let me put it this way. How many of you have restored one of your grandparent's rocking chairs? An antique table? An old Ford pickup?

The restoration work involves scraping, and varnishing, reinforcing, and tuning. It's not just cosmetic , involving paint or stain, but goes past the surface, involving something deeper – bringing out something's essence, structure, and inner nature.

It's hard work. Back breaking work. But we're willing to do it because the process feels good to our hands and our spirits; it feels good to sit in, to eat on, to drive. It also looks good, and gives us an aesthetic pleasure when we see it in our living rooms or driveways.

Most of all, it is something we can do with our spouse, our sons and daughters, and become a stronger and prouder family as a result of our work.

But when we restore that dilapidated, rotting, and leaning picket fence in our back yard, we can no longer do the work by ourselves. We must choose a time with our neighbor, bringing out hammers and nails, buying fresh wood from the lumberyard, splitting the costs, the labor, and the time. We may have been strangers before this process began.

But after the mending and repair is complete, we share a sense of pride each time we go to the fence, and realize that we have become stronger friends, better neighbors, for the partnership we have forged.

The same is true when, as a community or a basin, we focus on stopping the decline of our river, the erosion of our soil, the disappearance of our open land. We can, and will, bring life out of death, we can roll up our sleeves and continue the task of cleaning the river up, bringing back native fish, reconnecting the entire landscape, reclaiming our heritage.

Look, you are a powerful force. Look around the room, there is great knowledge here…and commitment.

If we are on the verge of a new movement, the restoration movement, then it can happen here as well as anywhere. It is an integrated view of the landscape; a view which carries responsibility for every single citizen and every community, which places on us the possibility of pointing the way, illuminating the landscape, encouraging partnerships, finding the links, and putting them back together again.

If you succeed here in the Klamath Basin, you will point the way for others elsewhere in the world who right now only watch the destruction around them and wonder how to ever get it back.

Thank you.

## FACILITATED DISCUSSIONS ON KLAMATH RIVER BASIN ISSUES

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## ABSTRACT

Two facilitated discussions were held with participants during the last two days of the Klamath Basin Fish and Water Symposium with the goal of proposing next steps that could be taken to resolve the issues regarding water use and restoration in the basin. This paper is a compilation of the results from the facilitated sessions.

## FACILITATED DISCUSSIONS ON KLAMATH RIVER BASIN ISSUES

One goal of the conveners of the Klamath Basin Fish and Water Symposium was to provide a forum in which different perspectives on the water distribution and restoration issues in the basin could be shared and possible next steps toward resolving these issues could be proposed.

The symposium's keynote speaker, Bill Leary of the President's Council on Environmental Quality, was invited to open the conference because of his past experience and success with resolving regional scale environmental resource issues, most recently in the Florida Everglades. Mr. Leary, who toured the Klamath Basin for the week prior to the symposium, strongly encouraged participants in the conference to provide him with suggestions that could be carried forward in the deliberations about the Klamath Basin here in California and Oregon as well as in Washington DC.

During the symposium several sessions were designed to encourage presentations and exchange of viewpoints from a range of stakeholders, notably the sessions on "Coping with Competition on Water"; "Dividing the Harvest"; "A Tribal View: Our Tradition, Our Future"; "Coastal Communities and Commercial Fisheries";"Water and Livelihoods; River

Communities and Tourism"; "Agricultural Perspectives: Solving Environmental Problems"; "Looking for Home Where We Live"; and the "Perspectives on Water" and other Roundtable Discussions.

Toward the end of the symposium two facilitated sessions brought these voices together to discuss possible next steps. On Thursday, May 24 a group of around 100 participants met at the end of the day in a session led by facilitator Dr. Betsy Watson from the Center for Environmental Dispute Resolution. This group, including agency representatives, environmental activists, farmers, fisherman, scientists, tribal members and interested citizens, "brain-stormed" to identify "Next Steps That Can Happen This Summer". The list below, reorganized by topic resulted. This list of proposed steps was posted outside the final plenary session of the conference the next day, so that participants could add further comments and endorse the steps they agreed with. A summary of the comments provided there is included as well.

On Friday, May 25 the Final Plenary Session of the Symposium was devoted to a facilitated discussion of longer term approaches to resolving water and restoration issues. A key issue was what the institutional structure for seeking solutions would be. The discussion, facilitated by Dr. Watson, centered around three models of relative local and federal government influence on the process. Many of the comments made are captured below.[1] During the final hour of the plenary session, the over 80 people participating in the discussion unanimously agreed to support the approach of developing a locally led solution with federal help for the Klamath River Basin as a whole. It was agreed that Alice Kilham of the Klamath Compact Commission would deliver this message to Bill Leary of the President's Council on Environmental Quality and seek a summit for the immediate future.

## RESULTS FROM THE DISCUSSION ON MAY 24 OF "NEXT STEPS THAT CAN HAPPEN THIS SUMMER"

The suggestions under each heading are listed in the order received. The numbers do not indicate any prioritization of importance of suggestions made. They are numbered to allow for clearer presentation in this format. <u>The number of people who signed their name behind a suggestion and any additional comments made are included in *italics*</u>

<u>Meetings/Coordination</u>

1. Require U.S. Department of Agriculture to be involved at the same level as the Department of the Interior. (*3)*
2. Request cabinet level Klamath Summit within the basin. (*5)*
3. Broker discussion between interests to conserve water. (*2)*
4. Make sure that impacts of over-logging are integral to watershed discussions.(*3)*
5. Support the Upper Klamath Basin Working Group in developing a long term restoration plan. (*3)*

[1] Individual comments are captured but not attributed to a particular person unless they were submitted to the facilitation team in writing.

6. Have Klamath River Fisheries Restoration Task Force and Upper Basin Working Group begin holding regular joint meetings. (*4) Comment: Do away with both*
7. Restart the BOR long term operations planning process (Environmental Impact Statement) *(4) Comment: Develop multi-level operations planning to adjust to water years.*
8. Include more people from agriculture in the process (not agencies). (*4*)
9. Exploration in trying to coordinate the various management plans – get a compilation of who is doing what where (*4*)
10. Separate ERO office make is once again a multi-agency office (*1*)
11. Convene a Basin-wide Hatfield Working Group convened by federal power (*3*)
12. Buy an airplane to facilitate meetings throughout the basin (*2*)
13. Video-conferencing (*1*)

**(**<u>Influencing) Legislatures, Congress or Executive Branch</u>

1. Wilderness expansion – roadless areas become wilderness. (*2*)
2. Participate to prevent the dismemberment of Cascade Siskyou Monument. (*1*)
3. Work for re-authorization of the wetlands reserve program. (*3*)
4. Initiate federal take over and decommissioning of the dams. *(3)*
5. FERC should include decommissioning as an option when they consider options. (*4*)
6. Reauthorize the Oregon Resources Conservation Act. (*2*)
7 Determine eligibility of Klamath corridor as a traditional cultural landscape.
8. Give the Klamath Tribes their land back. (*2*)
9. Return the Shasta Cultural lands to the Shasta (cultural and village sites)
10. Return all Cultural lands (cultural and village sites) to all tribes. (*3*) *Comments: to trust status; list them all i.e. Klamath Tribes, Shasta, Karuk, Hoopa, Yurok*
11. *Ensure Actions with the Basin follow legal mandates. (2)*
12. *California and Oregon enforce laws.*

<u>Management Responses</u>

1. Continue to support the Aquatic Conservation strategy of the NW Forest Plan.
2. Provide for the appropriation of spiritual viewpoints and traditional knowledge in management in the basin. (*3*)
3. Stop herbicide spraying on timber land and preferably beyond. (*7*)

<u>Funding and Economic Support</u>

1. Funds for Klamath River Fisheries Task Force (KRFTF) as identified in recent report – needs 16 million per year
2. Provide funds for low interest loans for basin farmers to use more conservative irrigation techniques
3. ID willing sellers within the Klamath Project
4. Mitigation when federal directives cause catastrophic economic default

<u>Public Information, Education and Training</u>

1. Demonstrate resources of national (*global*) significance at risk. (*2*)
2. Provide more recognition for higher biological quality areas in the basin such as Salmon River. (*3*)
3. Annual award for good land stewardship throughout the basin. (*3*)

4. Road restoration (*and decommissioning*) training program. (*3*)
5. Provide science forums to educate the public throughout the basin. (*11*)
6. Make scientific studies available locally. (*9*)
7. Create an annotated bibliography on the basin. (*2*)
8. Make a documentary to share perspectives. (*3*)
9. Get more of the public involved in what is going on - solutions, goals, problems. (*4*)
10. More seminars like this and in the Upper Klamath Basin. (*4*)
11. Create a Klamath University that is based on biology, land health and arts available to all individuals in the watershed including children.
12. *Make scientific information understandable to <u>all</u> people. Less technical.*

<u>Science</u>

1. Fund an assessment of limiting factors in the estuary. (*5*)
2. Investigate traditional and cultural management techniques on both the landscape and in-stream (*7*) *Comment: including husbandry*
3. Cease and desist until the science being reported has been verified by peer review (*1*)
4. *Verify all Science. (2)*

<u>Fish</u>

1. Diligently enforce current state and federal laws that protect fish and fish habitat. (*8*)
2. Modify operations at basin hatcheries to meet the combined objectives of mitigation, restoration and ESA recovery. (*3*)
3. 100% fin clip hatchery spring run Chinook. (*3*)
4. Restore fish passage in all highway and road crossings. (*3*)
5. Spring Chinook Recovery Plan. (*12*)
6. Coho Recovery Plan. (*7*)
7. Prevent fish kills in the main stem and tributaries in the river. (*5*)
8. Reduce harvests of threatened fish during drought years. (*3*)
9. Request funding for major project fish screens. (*4*)
10. See that all fish are counted whether native or hatchery so that numbers are available. (*2*)
11. *Eliminate non-native fish stocks and species form the Klamath River Watershed. Shad? Do you mean all?*

<u>Water</u>

1. Stop the inter-basin transfer of water. (5) *Comment: Be sure to include transfer to Rogue Valley through Medford Irrigation District.*
2. Increase water storage in UKB *and Sprague River Watershed (4).*
3. Send enough water to UKB now to give a cover crop and preserve the species there. (*5*)
4. Funding for a long term Klamath river Flow study including major tributaries. (*2*)
5. Reduce or cut off water diversions and put them back into the basins. (*4*)
6. Provide meaningful incentives for water users to conserve, include people working on the land in the process. (*6)*
7. Stop illegal diversions from the Scott. (*2*)
8. Assess the effects of groundwater use in the basin. (*4*) *Comment: Drilling wells for farmers concerns me for two reasons: 1) depletion of aquifer (look to problems in Fresno where the aquifer cannot be refilled); 2) the electricity to pump water from 2000 ft is*

*tremendous (that 2% that the hydro-facilities will generate will be miniscule by comparison).*

9. *Reduce Demand*

Restoration

1. Support current restoration efforts that are successful and already under way. (*2*)
2. Restore wetlands in the upper Klamath Basin. *(8)*
3. Aquire and restore the riparian area throughout the mainstem of the Klamath from Klamath Falls to the Mouth. (*3*)
4. Reestablish watershed management with use of fire. (*2*)
5. Restore the sinuosity of the Scott River. (*1*)
6. Fund prescriptions for tributary restoration work. (*1*)
7. *Implement Shasta River Wetlands Restoration Work*

Agriculture

1. Provide funds for low interest loans for basin farmers to use more conservative irrigation techniques. *Comment: Loans aren't the answer. Why put more people in debt?*
2. Identify willing sellers within the Klamath Project. (*3*)
3. Mitigation when federal directives cause catastrophic economic default. (*2*)
4. Establish an emergency assistance grant for the upper basin farmers of $208 million to take care of their losses this year. (*4*) *Comment: Use Conservation Reserve*
5. Resolution that supports the economic and social importance of the family farmer to American culture. (*1*)
6. Voluntary moratorium on genetically modified products within the basin. (*2*)
7. Support family farm stewardship strategies with monetary and technical support (*4*)
8. Establish new appropriate conservation easement program. (*3*)
9. Establish basin wide water and habitat trust. (*1)*
10. *Decrease water consumption by agricultural community. (2)*
11. *Address Shasta and Scott River issues and ensure that Upper Klamath Basin (above the lake) is included. (1)*

**KLAMATH BASIN SYMPOSIUM FINAL SESSION NOTES MAY 25, 2001**

Betsy Watson facilitated this session, which began with short presentations by Ronnie Pierce, Klamath River Intertribal Fish and Water Commission; Sue Masten, Chairwoman of the Yurok Tribe; Alice Kilham, Klamath Compact Commission; and Maria Rea, California Resources Agency.

Alice Kilham, Representative of the Klamath Compact Commission opened the discussion after this session by reminding all participants of Bill Leary's charge in the opening plenary to send him concrete suggestions about how people would like Washington DC to proceed in resolving the Klamath Basin water conflict.

Alice noted that elements of a response might include a Vision Statement –addressing for example: "What would you like to see in the Klamath Basin in 10 years". It could include a list of important elements such as the following frequently mentioned issues from the previous week:

- It is one basin – people more comfortable with three parts of the river – don't forget the middle;
- Science Summit – need for good science; and science that is made clear/understandable to the public;
- State of Klamath Basin;
- The Airplane…;
- Video Conferencing capacity;
- Klamath Compact Commission Enhancement;
- ERO office enhancement – Klamath Basin Conservation and Restoration Office;
- Reduce demand – we need upfront discussion.

The response might also include recommendations to the federal government about possible models that might define the decision making and problem resolution process. For example there could be, another Science Summit; a "Zar" from Washington DC who would work with local representatives; a Klamath Basin Facilitated Forum (1/2 Upper and ½ Lower Basin Representation) – or some combination.

Bill Bennett, representative to the Klamath Compact Commission from the California Department of Water Resources spoke and shared his list for funding requests this year to be put forward to California Resources Agency.

1. Some from water supply initiative from several years ago;
2. Measurement devices for diversions;
3. Water lease programs;
4. Money for groundwater wells on the Oregon side of the border;
5. Fall irrigation enhancement;
6. Re-operation of the power dams to enhance downstream flows (timing);
7. Watershed Action Plan consolidation;
8. Plan needed for long term goal – there are already several groups in the watershed who could work together to consolidate those plans into an action plan for the basin;
9. We need to invest in restoration;
10. KRFTF/Hatfield Group have projects;
11. Jobs in the Woods employment programs;
12. Science Summit;
13. Fish screens;
14. Wetland Reserve Program.

Requests for the longer term, beyond this year:

1. Studies/completing existing studies;
2. Agency lake branch project;
3. Partial feasibility on Link river dam;
4. Alternatives for Chiloquin dam;
5. Alternative Crop studies in UKB (econ viability given water situation);
6. Biomass power generation project in UKB;
7. Technological analysis of water use efficiency to stretch existing water supply;
8. Straits drain feasibility study.

Additional Comments made by participants during this session in response to Bill:

1. Klamath Falls Lack of water for cover crops need enough groundwater now from upstream that can be piped down to areas that need cover crops. 33,000 acre feet are being set aside for this.
2. Refuges need water too bald eagles are endangered
3. Reduce demand should be under frequently mentioned issues - we need to discuss the reduce the demand part. Assess impacts
4. Science Summit good idea but science must be reviewed – when regulation takes place EIS should take place before an action takes place.
5. Ground water resources (12 very deep wells) are being drilled on the California side, away from the streams. They are being monitored carefully to assess impacts on surface streams nearby. Question: How does one monitor 0 water in the channel.
6. Provide incentives for water conservation
7. Have schools do some cultural exchanges bring kids from one high school to another
8. This speaker will write an op-ed piece for Oregon papers. We need regular reliable communication with the media and more than a web page. Rural communities don't all have phone lines or easy access to the web. Newsletters with summaries of current science and compendia of information are critical. For example, make a list of all agencies, their jurisdiction, their programs etc. The solution lies in the people who are here. The Media can act as a stakeholder and participate in and document a process and then, charged with confidentiality by the participants of the process, take an agreed upon statement to the press at large.

**THE MODELS DISCUSSION**

Betsy Watson led the group in a discussion about models of conflict resolution and governance with which to approach Klamath Basin issues. Several possible models with varying degrees of local and/or federal influence were put forward to initiate the discussion.

Model #1 – Klamath Basin stakeholder driven process plus Secretarial level Klamath appointments in the federal government with a direct line to White House (similar to approach Bill Leary described as working in the Everglades). This would be a locally led forum that would not overshadow local participants.

Model # 2: Have a federally appointed decision maker lead the process to resolve Klamath Basin issues. Have local involvement to some degree but leave decision power at the federal level.

Model # 3: Mixed approaches, including for example, a Conservancy like the Tahoe Conservancy or the California Coastal Conservancy

Comments from Participants on the Models:

1. Prefers choice with Federal Hammer involved to stop the status quo – we have to have results now and not have fish go extinct.

2. Federal Policy Level People need to be involved.

3. As an Upper Basin Farmer, I put in a vote for extremely complete transparency – we are responsible for objectivity.

4. Magnify Option 1: We need to change the structure of the Federal government. There are a number of assistant secretaries who should be listening here. They are very busy Department heads, Regional level agency folks. Our issues don't go beyond the middle level bureaucrats. Now there is an opportunity to fix the federal government. With the new administration, everything is new, many positions are still not filled. Recommendations: Appoint high level officials in each major department (DOI, Commerce, USDA) assigned specifically to the Klamath Basin – with a lead coordinator for the federal team with a red telephone on her desk to call Mr. Cheney. They need permanent staff for continuity into next administration. Below that federal team would come our multi-agency, stakeholder group task force that would tell them what to do. If we agree now we can get this done.

5. Local level needs adequate representation of the common man working the land or fishing (avoid having agency people/ political leaders dominate) – involve people who are directly affected.

At this point in the discussion the facilitator called for a "Show of Hands". The group was coming together with a high number of hands raised in favor of an approach similar to Model 1; few participants supporting Model 2; and a number of voices favoring a mixed version of Model 3. Betsy asked the next few respondents to situate their proposals within the context of the models.

6. Conservancy idea: we need something that can deliver funding, put projects on the ground and communicate – a joint CA/OR Klamath Basin Conservancy funded by federal government matched by bonds from both states and staffed by representatives from existing state and federal agencies, the tribes and other interests. An agency tasked with getting projects funded and on the ground should be housed all in one place. This would avoid duplication and be more cost effective. The focus would be a project implementing and problem solving entity with the capacity to prioritize projects. <u>Questions:</u> Would this package be able to fit under Model 1? Response: YES

7. Whatever results come here is going to need to go into consultation with the agencies – we are not going to be able to change the ESA process so quickly. <u>Questions:</u> Does it fit within any of these models? Ccould be # 1 or #2. #1 bottom up process preferred.

8. Facilitation and process to sort things out among stakeholders will be needed – we need to keep in mind that a locally driven process will require facilitation.

9. I want to make sure that we are discussing DEMAND as part of the process and Legal Mandates.

10. The tribes have certain legal rights. We can waste lots of time fighting this or move forward by acknowledging this reality, and then moving forward toward solutions.

11. If we can figure out how to work together, we can bypass 10 years of pain.

12. It keeps coming up because trust is built on behavior not words. Where is the role of the states in these models? –It's not only a federal- local discussion, it must include the state and the/tribes. Model #3, a facilitated forum with representatives who are empowered to speak would be a useful hybrid approach. This is a first step to making a process work.

13. Let us look harder at the existing models, talk to people find out if process worked, was fair, yielded ecologically significant results.

14. We need to ask models for what? A model for consensus from a group is one area of concern. A model to get money from DC is going to be different. We need dollars and a facilitated process to get there. Good points and pieces are emerging. We need to think big now and we need money at a scale of- $20 million per year for 20 years. We need to staff the 20/20 plan – the amount needed is still only 1/10 of what the Columbia River Basin gets. This is a suggestion for a mix of Model # 1 and #3.

15. There was supposed to be a state of California match of $ 1 million per year.

16. We need a consistent basin wide approach including the Scott, Shasta, and Trinity Rivers. The Trinity River has a planning model, an adaptive management process to try to develop a consistent approach to look at all of the issues involved. It resembles the #1+#3 model now (other models were looked at to get here).

17. It is important to protect this eco-region. It has a large portion of federal land and thus there are also urban interests involved. What role for stakeholders beyond local interests?

18. RE: Case of California Conservancies. The Klamath is a black hole. A model that works is the Coastal Conservancy. Many other states use this model. It needs to be tailored to the people here– the tribes, the watershed groups. Putting the Northwest Forest Plan people under one roof did help make the agencies work together.

19. Collapse the PAC, the Task Force, the Working Groups – collapse the many parallel processes and retool them. It would free up energy to be more effective.

20. We don't have much time left. We need to get plans for future meetings and decide what is going forward.

21. We need a hybrid with policy level people from government at the table so they can see how decisions are being made and buy into them. We need another session like this one but in the Upper Basin. This is not a representative group. Response: Yes, this is simply a response on the part of participants of this symposium to a federal government staff person's request (Bill Leary, Presidents Council on Environment).

22. These policy people have to come here or provide funds for all of us to move.

23. We need something as suggested for getting the federal government involved (#4 above) plus the Conservancy idea. If there is a task force, it needs to move around for travel

There has been an increase in government getting people involved from the beginning and this has to happen here too.

24. There is not much time left here. A conservancy is an interesting idea and a 2 year process – we already have the Klamath Compact Commission which bridges the two states. It can do more than it has to date. We should look there to help organize and implement a process. The Klamath Compact Commissison could fit into these models. We have worked with stakeholder processes before. It could begin under #1 without precluding the longer term effort to get a conservancy set up. Meanwhile lets use what we have now in enhanced form…

25. Task force after task force can happen with no results unless we have a strong federal level ear when we do agree on something. We should ask for appointments in Washington DC of people whose job is focused on the Klamath. Can we agree to ask for this now? Model #1.

26. Strong support for #1 – We need to have the federal government involved but unless we have a locally led effort we will not get the buy in from the people who are not here today. Yes we need funding too. Yes, county supervisors will endorse this.

27. Groups will always take as much time as they have to solve their problem. By the end of the summer we need a legislative package for appropriations. If the Klamath Compact Commission or the administration could convene the stakeholder group this could happen quickly. Refuge issues; farmer issues; rancher issues; worker issues; willing sellers; this must happen before the end of the summer.

28. In the long term we should negotiate easements along the riparian corridors and work on riparian vegetation restoration.

29. How are we going to take these ideas and put them on paper and hand them to Bill Leary and have him report to Washington DC? One call to send Betsy back to present the paper in DC.
30. Betsy's response: maybe not me but someone else, perhaps Alice?

31. This is a longer process. But what we need is to help Bill Leary understand how this basin wants to relate to the federal government. I think we are saying that we want to write the plan.
32. I agree with Model #1, but not with the idea of a federal government task force. We need to define the order but ask government to appoint someone to assist us.

33. USFS needs to be involved to work toward parity between UDSA and DOI and COMMERCE and EPA.

34. We are now trying to summarize and come out with a deliverable. Let's not get caught in the details.

35. Upper Klamath Basin Tribes ask that this message be delivered to DC. We need participation from Washington D.C., Salem, Sacramento. We need to be able to come together very soon to really work these matters through. We need a summit at the end of June. We need to get Federal(with Cabinet level support) and California and Oregon state policy makers out here then to work with us in the long run. This is not just crisis management.

## CONCLUSION: UNANIMOUS SUPPORT FOR A LOCALLY LED SOLUTION

During the final hour of the session, the discussion returned to which models of local and federal cooperation might best lead to resolution of the issues at hand. The over 80 people participating in the discussion facilitated by Dr. Watson unanimously agreed to support the approach of developing a locally led situation for the Klamath River Basin as a whole with federal help. It was agreed that Alice Kilham of the Klamath Compact Commission would deliver this message to Bill Leary of the President's Council on Environmental Quality and seek a summit for the immediate future.

There were also strongly supported calls to protect the Upper Basin people now in this time of need; to have more fora like this; and to develop a list showing where people came from to demonstrate that there were many people from the Upper Basin participating.

## FINAL NOTE:

Several participants submitted written comments for inclusion in the discussion of next steps – they are included as transcribed below:

1. Pat Higgins wrote: Klamath Basin Crisis Response

Tier #1 Priority: For Immediate Action

- Ask federal legislators to convene cross interest panel of stakeholders along the lines of expanded Hatfield Group as suggested by Marshall Stanton
- Compensate Klamath Project farmers to offset losses for this year's production
- Accelerate acquisition from willing sellers of lands in the Project area that would help reduce water demand in the long run.
- Fund emergency implementation of water conservation measures to increase water supply and water quality. Use the crisis of the Klamath Project farmers to win cooperation of farmers and ranchers in tributaries above Upper Klamath Lake (Sprague, Williamson, Sycan, Wood, etc.) as well as Shasta and Scott.
- Begin comprehensive study immediately on basin-wide water conservation for full implementation in less than five years.
- Begin a comprehensive basin wide study immediately on sediment supply and its relationship to water supply (i.e. Lower Klamath, Scott shallow or underground as a result of aggradation).
- Set up a Klamath Basin Conservancy as a California government entity to allow funding from bonds and legislation (similar to Tahoe or Santa Monica Mountains Conservancies).
- Work immediately to set up cost share or similar (to conservancy) status for Oregon.

Tier #2: Everglades Scale for Long Term Klamath Basin Solutions

- Negotiate easements along the riparian corridor of the Klamath and its tributaries and begin aggressive reforestation using cottonwoods or other native species (particularly Scott, Shasta, Sprague and other tributaries to Upper Klamath Lake).
- Buy back farmed lands immediately adjacent to Upper Klamath Lake and return to marsh land to restore acid/base balance of the lake.
- Buy out Scottish Power and replace existing Hydro Power with wind and solar power.
- Acquire Yurok Ancestral territories below the Trinity River for the Tribe to manage on a 1% of inventory harvest maximum per annum in perpetuity and fully fund their restoration (erosion control).
- Acquire Fruit Growers Supply and cede to Karuk for management similar to that described for Yurok above.
- Get States to agree to cost share.
- Fully fund the NW Forest Plan in the Klamath Basin for road restoration and erosion control and forest health to prevent catastrophic fire.
- Fund monitoring for adaptive management.

2. Paula Yoon wrote: What Would You Like to See Happening in the Klamath Basin 10 Years from Now?

1. The Klamath Basin Coalition/Unified Working Group – whatever the group ends up naming itself – continues to meet on a regular basis
2. There are no ESA listings in the entire watershed (which means we've done a good job in dealing with water quantity and quality).
3. There have been no lawsuits filed (which means we've learned to communicate).
4. There are both tribal river and ocean commercial fisheries and both have excellent long term markets (which means the pen reared salmon industry of the world has ceased its negatively impacting practices).
5. Mid and Upper Basin farmers and ranchers have long term contracts with large companies for their superior value- added products.
6. We celebrate together annually to honor what we have been able to accomplish in our basin.

3. Ann McGill wrote: A Response to Comments made on the Economic Importances of Agriculture in the Klamath Basin

- Online Human Events: Sucker Fish is Killing Klamath County by Joseph A. D'Agostino, May 7, 2001:…"With the irrigation cutback, the county of 69,000 will lose $300 million a year out of the local economy" John Elliott, Klamath County Commissioner said. Stephanie Bailey, Executive Director of the Klamath County Chamber of Commerce put the price tag at "$250 million annually or a 16% hit" and said "This will push unemployment up to 20%".
- *In response to a comment made that agriculture contributes .05% of the economy in Klamath County* : If current Klamath County farm sales were the conservative 1996 amount listed by the State of Oregon Department of Agriculture as $103 million, the local economy would have to equal $20.5 billion for agriculture's portion to be only .05% of the total. The assessed value of the entire county as given in the Oregon Blue Book is only $3.2 billion.

- Realize these figures relate only to the Oregon side of the Klamath Falls – Tule Lake Basin. Another 38% of the total Klamath Project acreage lies in California with a related economic figure. Together, agriculture accounts for much much more than the .05% of Basin economy suggested.
- From the Oregon Extension Service: Klamath County agricultural income was $104 million in 1996. This generated a more than $218 million impact on the Basin economy.

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# PART 1: GEOLOGY, HYDROLOGY, AND WATER QUALITY IN THE KLAMATH BASIN

## BEDLOAD MEASUREMENT AND PREDICTION IN THE UPPER KLAMATH BASIN

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The U.S. Forest Service has been collecting streamflow data on stations in the Upper Klamath Basin for some seven years. In addition, bedload data have been collected on six stations. Those data have been analyzed using a variation of the Parker-Klingeman bedload transport model, which is calibrated to site-specific bedload data. The model contains two parameters for calibration: A characteristic Shields stress related to the bed material $D_{50}$ ($\tau^*_{r50}$) and an exponent which relates the Shields stress for any other size to that of the $D_{50}$. The calibrated model can then be used to predict annual loads, bedload rating curves, and conditions for initiation of motion by individual size class. Examples of streams from the Upper Klamath Basin are used to illustrate the use of the model.

## EFFECTS OF THE 1997 FLOOD ON THE KLAMATH NATIONAL FOREST: INTERACTIONS BETWEEN GEOMORPHIC PROCESSES, TIMBER HARVEST, FIRE AND ROADS
## (POSTER)

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The storm of December 12, 1996 through January 3, 1997 delivered up to 17 inches of precipitation to parts of the Klamath National Forest. At the onset of the storm, the snow pack was slightly above average and extended down to about 3500 feet in elevation. The warm storm produced rain at elevations as high as 7200 feet. One station recorded 5 inches in the last 18 hours of December 31. Total precipitation for December ranged from 1.7 to 4.2 times the norm for that month. Estimates of recurrence intervals for 1997 peak stream flows range from 9 to 37 years, and peak flows ranged from 51-84 percent of those measured for the flood of 1964, the largest on record for this area.

Damage to infrastructure exceeded $27 million, and flood effects were greatest in the Walker, Grider, Elk, Tompkins, Kelsey, Deep, and Ukonom Creek watersheds. Debris flows were typically initiated by landslides at elevations in excess of 3,600 feet. These flows scoured upper channel reaches, removed riparian vegetation, and deposited sediment and large logs in lower reaches.

Physical characteristics of the landscape, as well as roads, timber harvest, and wildfire appear to have had an important influence on the density, distribution and effects of landslides. Ancient slump and earthflow deposits experienced a landslide density (landslides per square mile) of 0.80, and also produced most of the large debris flows. Landslides were concentrated in a particular elevation band, with the highest density (1.46) observed between 5,000 and 5,500 feet. The average landslide density for all lands (disturbed and undisturbed) in the study area was 0.59. On harvested land it was 1.86, within areas burned by wildfire, it was 2.03, and in road corridors, it was 7.34. Landslide density on undisturbed land was 0.27.

Findings from this study are being used to: a) Better understand how the flood modified channel conditions; b) Improve road repair and decommissioning methods; c) Improve the design of road sediment source inventories (see abstracts by Zack Mondry and Don Elder respectively, this symposium).

## SUMMARY OF CURRENT ONGOING GEOLOGIC INVESTIGATIONS IN THE KLAMATH BASIN IN OREGON

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### GEOLOGIC MAPPING IN THE KLAMATH BASIN OF OREGON

1. In nature, groundwater and surface water are interconnected, even though they are not commonly viewed that way. Understanding the geology in the Klamath Basin will help to understand groundwater.

2. Geologists of the Oregon Department of Geology and Mineral Industries are currently producing new, 7.5-minute quadrangle (1:24,000 scale) geologic maps and conducting related investigations in the Klamath Basin in Oregon in conjunction with scientists of the Oregon Water Resources Department, U.S. Geological Survey, University of Oregon, and Portland State University. Further support has come from the U.S. Bureau of Reclamation, the U.S. Fish and Wildlife Service, and the Hatfield Group.

3. This volcanic terrain provides the framework for movement and storage of groundwater. Effusive lava, such as this lava flow encased in pyroclastic surge deposits, contain a surprisingly large proportion of large, open, and connected voids, conducive to the transmission of large quantities of groundwater. These highly transmissive units act as aquifers. From 1997 to 2000, 22 quadrangles were mapped and are in various stages of completion. Four more quadrangles

are planned for 2001, for a total of 26 quads, shown here. Prior to now, the best mapping available was 1:250.000 scale, or ten times less resolution.

Geology controls both the movement and storage of groundwater at local and regional levels. Mapping helps to delineate those controls.

4. The Klamath Basin in Oregon, encompasses more than 5,000 square miles. The basin also lies at the junction of the Cascade Range, a geologically active volcanic arc, and the Basin and Range Province, an actively extending but uplifted back-arc basin. Volcanic rocks in the basin are as old as 8 million years.

5. Tectonically active faults in the basin have produced a series of northwest-trending to north-south trending ranges over the past several million years, which can be seen as linear ranges on this colored-relief digital elevation model. Faulting has also influenced the distribution of volcanoes, cinder cones, and source dikes within the basin.

6. This volcanic terrain provides the framework for movement and storage of groundwater. Effusive lava, such as this lava flow encased in pyroclastic surge deposits, contain a surprisingly large proportion of large, open, and connected voids, conducive to the transmission of large quantities of groundwater. These highly transmissive units, as aquifers, have high rates of recharge and discharge.

7. Pyroclastic rocks, such as these near Olene, tend to be less transmissive to groundwater movement.

8. Sedimentary rocks, such as these at Collier Grade, are frequently fine-grained, are typically <u>the least</u> transmissive though they may contain substantial interstitial void space. Faults often juxtapose units of differing transmissivity.

9. DOGAMI studies feature integrated geologic, geochemical, and geophysical methods and have included installation of the double-completion Lorella Deep Well, a monitoring well east of Klamath Falls, shown here at sunset. These integrated studies have yielded new insights on how <u>ancient</u> hot spring alteration and faulting affect groundwater movement and storage, information that is vital for groundwater modelers.

10. The LDW is an example of our multi-disciplinary form of study:

- Site selection was driven by geologic and geohydrologic criteria
- The study involved a surface geophysical magnetotelluric survey
- Geologic sampling of drill hole cuttings
- Downhole geophysical, video, and caliper logs
- And currently involves long-term water-level monitoring

11. Project design required that ideally the site would have the following components within close proximity

- Major range-bounding fault
- Contrasting lithologies across the fault

- Sediment-filled intermontane basin
- Probable lower basalt <u>and</u>
- Nearby wells drawing from the same depth and rock types with vastly different yields

12. The one site meeting these criteria is in a small intermontane basin on the Cheyne Ranch. The Lorella Deep Well project is located 1 mile northeast of Lorella, about 25 miles east of Klamath Falls.

13. Construction of the LDW serves three main purposes:

- It provided a glimpse at subsurface strata by both visual and geophysical means
- The detailed geological and geophysical logs would provide control for the surface geophysical surveys
- The well would provide a means of long-term monitoring of groundwater level at two vastly different depths, thus allowing geohydrologists to determine whether deeper aquifers are distinct from shallower ones.

14. This schematic shows the details. A 6-inch diameter hole drilled to 1005 feet. An inner 1.5-inch diameter steel tube lowered to 990 feet and encased and supported by 50 feet of gravel. A plug of 435 feet of concrete separating the bottom of the hole from the upper 500 feet. Both lower and upper intervals can be monitored simultaneously and are currently the object of long-term research by the Oregon Water Resources Department.

15. A geologic schematic map of the site shows the major components that came into play for selecting the site.

- Major range-bounding fault
- Contrasting lithologies across the fault, of greatly differing ages, confirming the fault's presence.
- Sediment-filled intermontane basin. A thin veneer of Quaternary sand overlying 25 to 50 meters of Pliocene mudstone and sandstone.
- Nearby wells drawing from the same depth and rock types with vastly different yields.

Geophysicists from the UO laid out their sensors along the lines 1 and 2 shown on the map.

16. These sensors would measure the conductivity of the strata beneath, after having been induced with an electromagnetic field.

17. Looking at the east-west line, geologists would compare the geophysical signature with the surface geology and the geologic logs of the Lorella Deep Well and the Cheyne 1500 well.

What we see is that the sedimentary units near the surface,  containing significant clay, are highly conductive as show as the bright, warm colors.

The basalt layers beneath are much less conductive and show as the deep, cool colors.

Below that, as confirmed from drill cuttings, are pyroclastic rocks that show as greens and warm hues.

Geologists noted with some satisfaction that the geologic contacts between units, as seen in drill cuttings, corresponded well with the geophysical contacts in the first 500 feet.

Beneath about 500 feet, the geophysical data becomes increasingly less discriminate, because of distance dampening and overprinting effects from overlying layers. Nevertheless, rocks are increasingly conductive at depth, an effect due to increasing alteration with depth. Importantly, the Lorella Deep Well penetrated several hundred feet of basalt beneath a depth of 500 feet.

Mineral alteration occurs as clay and zeolite mineralize, an alteration of the basalt and pyroclastic layers, and is seen both in drill cuttings and downhole video.

The cause of alteration is deduced to be low-temperature geothermal fluids, in other words, warm water related to hot springs. This deduction is supported by the presence of pale aqua green celadonite in the drill cuttings, a clay mineral that forms from the alteration of basalt in the presence of warm hydrothermal waters.

It should be noted that virtually the entire stratigraphic section is water-saturated, although the water table during drilling ranged from 30-40 feet.

Three basalt intervals from the LDW were subjected to detailed analysis: the 87-foot level, the 680-685 foot interval, and the 905-910 foot level. These 3 were selected to obtain a broad perspective of the basaltic rocks in the hole and because these intervals were relatively unaltered. The 87-foot basalt returned an isotopic age of 4.6 Ma. It is chemically a tholeiitic basalt. The 680-foot basalt is slightly more alkaline and classified as calc-alkaline. It was not subjected to isotopic dating. The 905 basalt yielded an Ar-Ar age of 5.8 Ma and a tholeite chemical signature. We were satisfied that many layers of basalt are represented and that the dating techniques yielded a normal stratigraphic section.

18. An examination of the north-south geophysical line shows many of the same features. Note that the line crossed nearby the Cheyne 1500 gallon-per-minute well and Cheyne 150 gallon-per-minute well. We were hoping to determine why these 2 wells of approximately the same depth (about 450') and penetrating the same units, according to the driller's logs, had such vastly different yields.

Note the warm hues of the sedimentary rocks in the upper interval. This line was run parallel to the irrigation ditch and we see evidence of cation-rich canal leakage as shown by the bright red interval at the very top. Even though the ditch was empty, although not dry, when the survey was run, we surmise that leakage from the canal introduced highly conductive electrolytes into the sediments—we see their bright red signature.

Beneath the sedimentary section, driller's logs indicate a basalt section in both holes which is represented by the cooler hues in the geophysical profile.

Near the bottom of each well, the drillers indicated they entered dark sand and sandstone, which is what geologists interpreted as pyroclastic rocks in the Lorella Deep Well. Some pumice was encountered in the pyroclastic zone in both the LDW and the Cheyne 150, adding credence to the pyroclastic interpretation.

Drillers reported that most of the production in the Cheyne 1500 well came from the basalt and lower zones. Total depth is 465 feet. Similar results were encountered while drilling the LDW. Water production increased progressively drilling through the upper basalt, rapidly increased as the drill bit encountered the pyroclastic interval and, within about 100 feet of the top of the pyroclastic zone, water production exceeded the capacity of the 6-inch drill stem, or about 150-200 gpm.

Drillers reported less water in the Cheyne 150 well and that most of it occurred in the bottom 150 feet. The driller also noted more than 50 feet of soft brown rock in the bottom third of the hole.

Although the driller's logs are not descriptive enough to determine the extent of alteration in Cheyne 150 well, an alteration signature is clearly evident in the geophysical profile. *(POINTER)*

Video profiling of a nearby (within a mile) abandoned low-production well shows extensive clay veining of the basalt aquifer, effectively sealing the well.

The evidence is rather strong that clay alteration has a significant effect on aquifers. We have seen it in cuttings, in downhole video, and in geophysical profiles.

19. In conclusion,

- Water is a contentious issue in the Klamath Basin
- Understanding geology is important to understanding groundwater movement and storage
- Geologic mapping studies have identified geologic controls on groundwater including:
  - Distribution of rock types
  - Faults
  - Alteration

Integrated geology, geochemistry, and geophysics provide local high-resolution profiles of water-bearing strata.

**Paper presented in reduced sized images of PowerPoint slides below. To view full sized slides using Microsoft PowerPoint (.ppt file), click here. To view full sized slides using Adobe Acrobat Reader (.pdf file), click here.**

## GEOLOGIC MAPPING IN THE KLAMATH BASIN IN OREGON

Ground water and surface water are inextricably connected and future solutions to the vexing water problems in the basin will benefit greatly from increased understanding of the geologic and hydrologic relationships.

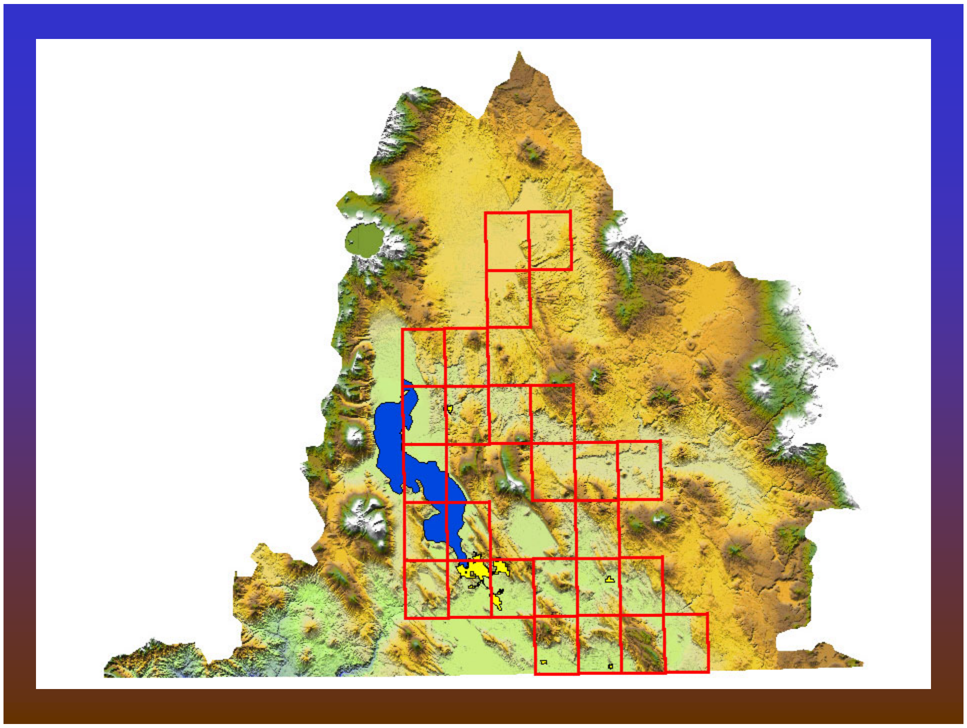
## GEOLOGIC MAPPING SUPPORTS GROUNDWATER MODELING STUDIES

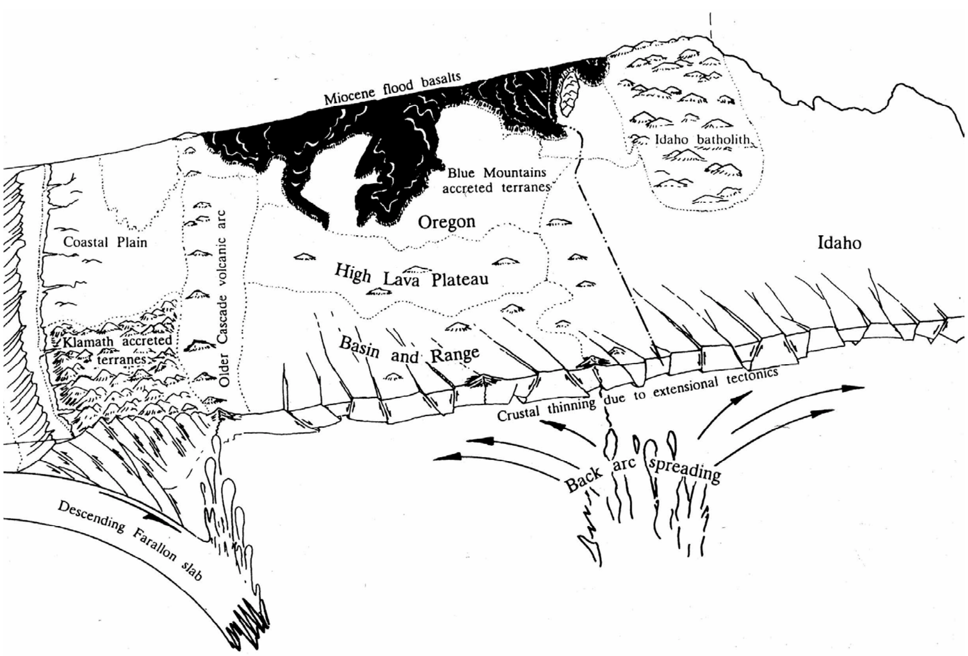
Mapping & Geophysics:

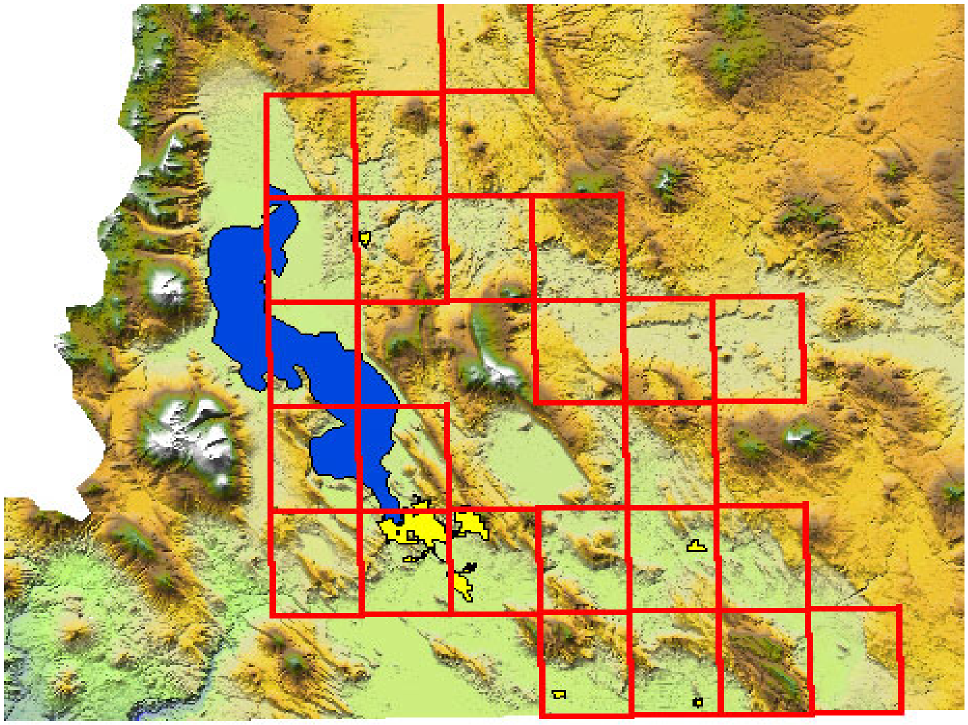
- Oregon Dept of Geology & Mineral Industries
- Portland State University
- University of Oregon

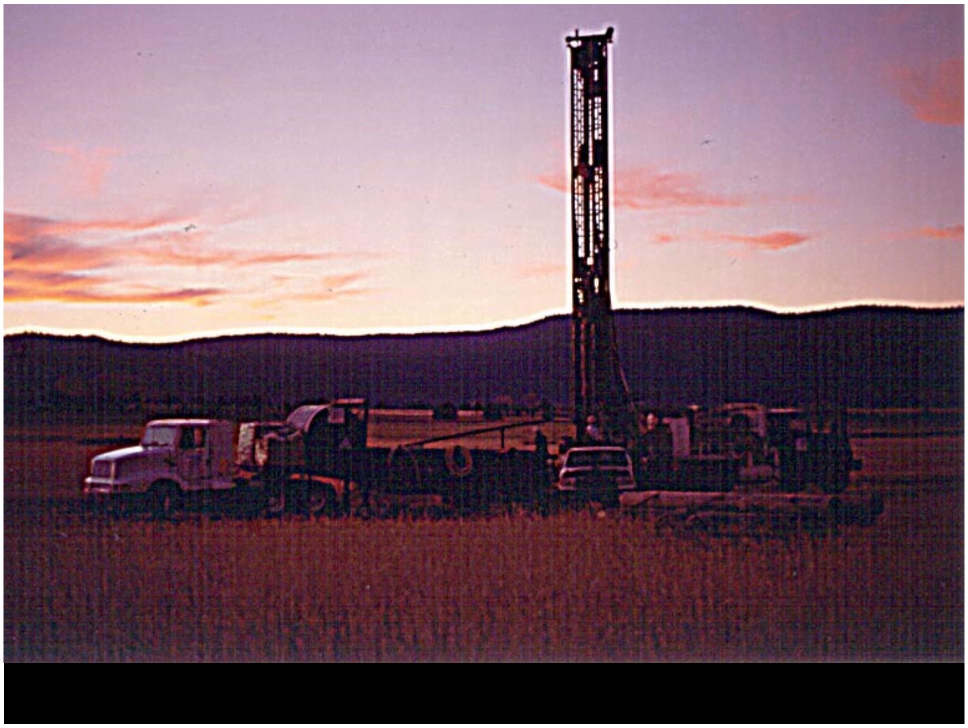
Groundwater modeling:

- Oregon Water Resources Dept.
- U.S. Geologic Survey Water Resources Division




Miocene flood basalts
Idaho batholith
Blue Mountains accreted terranes
Oregon
Coastal Plain
Older Cascade volcanic arc
High Lava Plateau
Idaho
Klamath accreted terranes
Basin and Range
Crustal thinning due to extensional tectonics
Back arc spreading
Descending Farallon slab





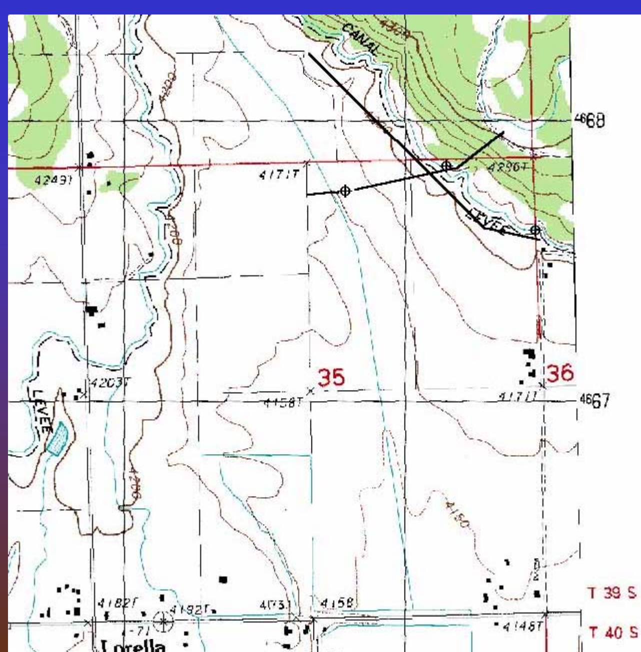
## COMPONENTS OF THE LORELLA DEEP WELL PROJECT

| | |
|---|---|
| • Site selection driven by geologic and geohydrologic criteria | • DOGAMI, OWRD |
| • Geophysical magnetotelluric survey | • UO |
| • Geologic sampling of drill hole cuttings | • DOGAMI, Schneider Drilling |
| • Downhole geophysical, video, and caliper logs | • USGS |
| • Long-term monitoring | • OWRD |

# LORELLA DEEP WELL SITE CRITERIA

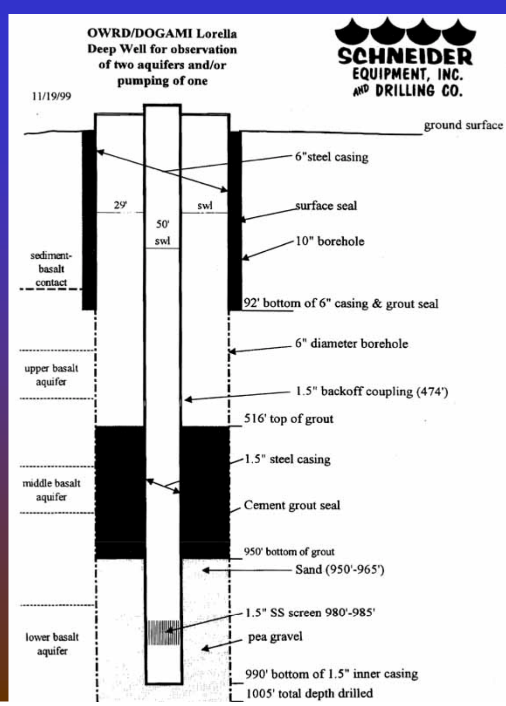
Ideally the site would have the following components within close proximity:

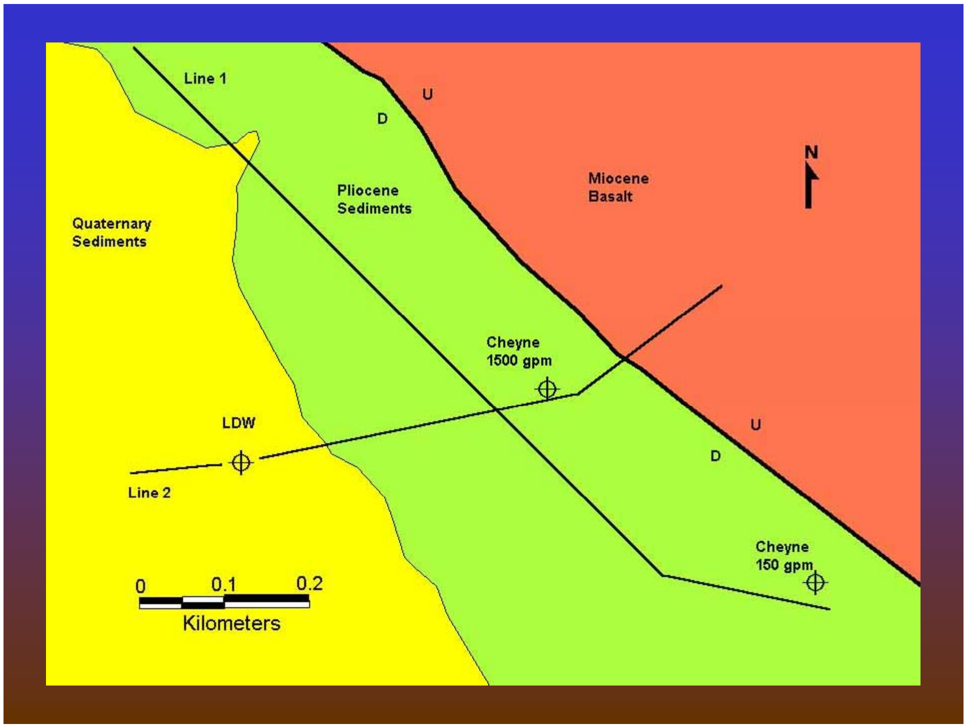
- Major range-bounding fault
- Contrasting lithologies across the fault
- Sediment-filled intermontane basin
- Probable lower basalt
- Nearby wells drawing from the same depth and rock types with vastly different yields

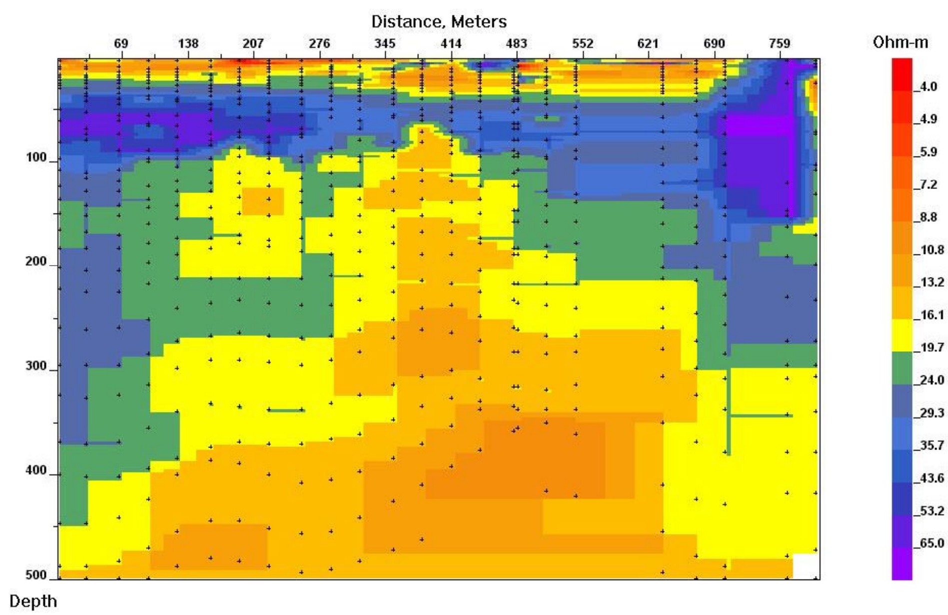


## LORELLA DEEP WELL OBJECTIVES

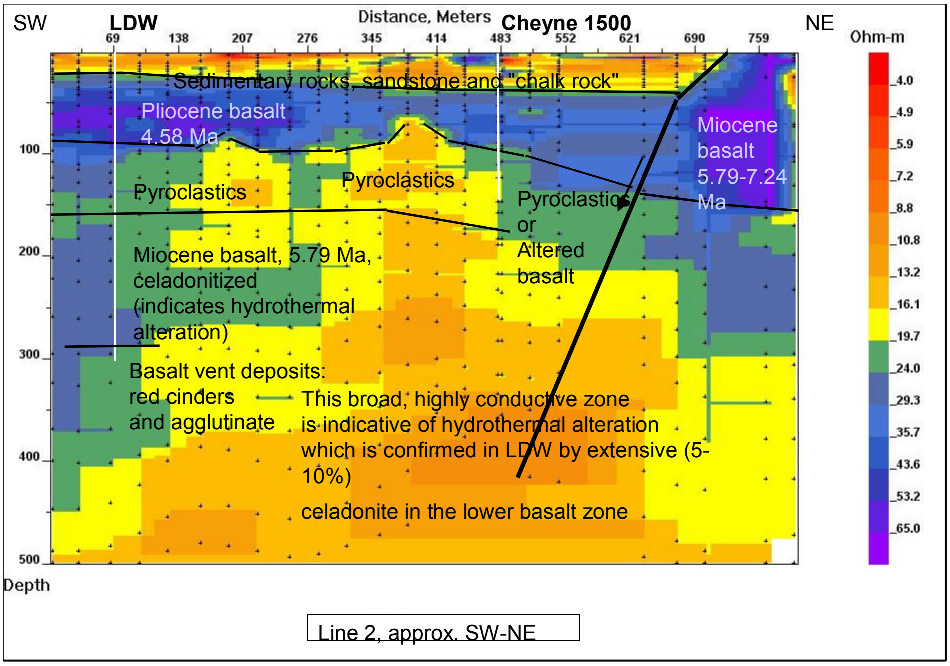
- Provide a glimpse at subsurface strata by both visual and geophysical means
- Provide geological and downhole geophysical control for the surface geophysical surveys
- Provide for long-term monitoring of groundwater level at two vastly different depths, thus allowing geohydrologists to determine whether deeper aquifers are distinct from shallower ones.

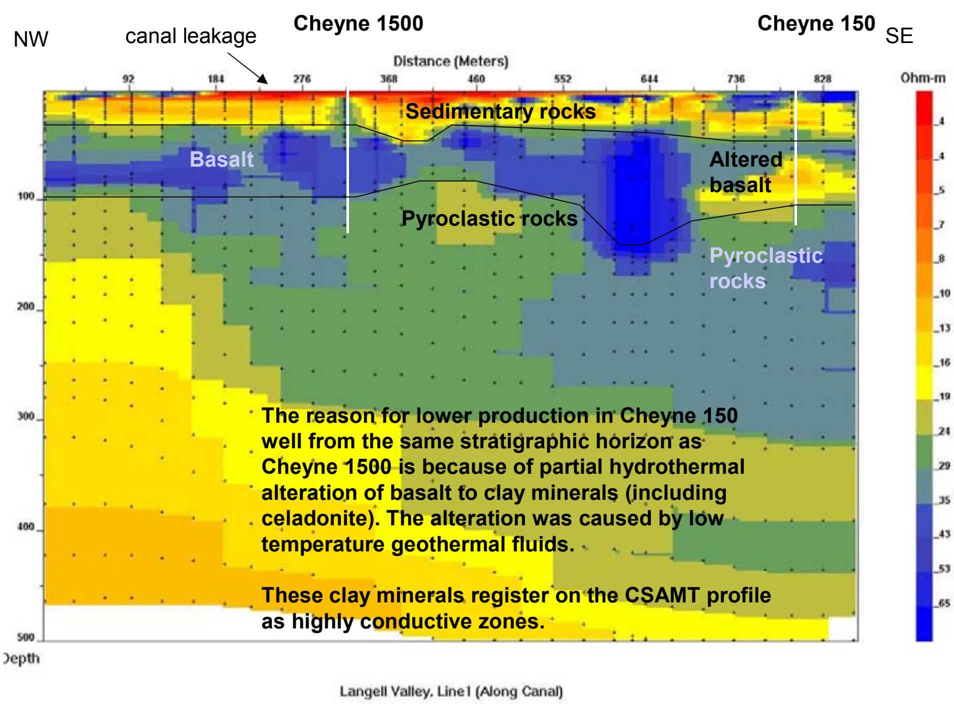





2-D Resistivity


SW
LDW
Distance, Meters
Cheyne 1500
NE
Ohm-m
69 138 207 276 345 414 483 552 621 690 759
Sedimentary rocks, sandstone and "chalk rock"
Pliocene basalt
4.58 Ma
Miocene
basalt
5.79-7.24
Ma
Pyroclastics
Pyroclastics
Pyroclastics
or
Altered
basalt
Miocene basalt, 5.79 Ma,
celadonitized
(indicates hydrothermal
alteration)
Basalt vent deposits:
red cinders
and agglutinate
This broad, highly conductive zone
is indicative of hydrothermal alteration
which is confirmed in LDW by extensive (5-
10%)
celadonite in the lower basalt zone
100
200
300
400
500
Depth
4.0
4.9
5.9
7.2
8.8
10.8
13.2
16.1
19.7
24.0
29.3
35.7
43.6
53.2
65.0
Line 2, approx. SW-NE


NW
canal leakage
Cheyne 1500
Cheyne 150
SE
Distance (Meters)
92 184 276 368 460 552 644 736 828
Ohm-m
Sedimentary rocks
Basalt
Altered
basalt
Pyroclastic rocks
Pyroclastic
rocks
The reason for lower production in Cheyne 150
well from the same stratigraphic horizon as
Cheyne 1500 is because of partial hydrothermal
alteration of basalt to clay minerals (including
celadonite). The alteration was caused by low
temperature geothermal fluids.
These clay minerals register on the CSAMT profile
as highly conductive zones.
100
200
300
400
500
Depth
Langell Valley, Line1 (Along Canal)

## SUMMARY

- Water resource availability is key to contentious issues of use and resource management
- Understanding geology is important to understanding groundwater movement and storage
- Geologic mapping studies have identified geologic controls on groundwater including:
  - Distribution of rock types
  - Faults
  - Alteration
- Integrated geology, geochemistry, and geophysics provide local high-resolution profiles of water-bearing strata

## INFLUENCE OF RIPARIAN VEGETATION ON THE LEGACY OF DEBRIS FLOODS IN THE KLAMATH MOUNTAINS

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High-magnitude storms in the Klamath Mountains commonly generate landslides that result in sediment- and wood-charged debris floods, which are apparently responsible for much of the long-term flux of wood and sediment in 1$^{st}$ to 5$^{th}$ order tributaries. Annual surveys of reaches of Walker and Grider Creek near Seiad Valley, California, following debris floods of January, 1997, show minor changes in channel morphology and bed texture. Moderate peak flows since 1997 have winnowed an inner portion of the bed surface affected by the debris flood, but channel courses remain nearly unchanged and bar-pool sequences are poorly developed. From observations of unaffected channels, we predict that, other than the establishment of riparian alder stands in debris-flood deposits, the legacy of 1997 debris floods will dominate channel condition until the next debris flood. Advanced riparian stands, as well as woody debris incorporated in debris floods from landslides and scoured channels, increase the resistance to debris-flood runout; debris floods reduce this resistance. We hypothesize that debris floods in the latter half of the 20$^{th}$ century have enhanced the runout potential of subsequent debris flows, and the recovery of resistance provided by riparian and upland forests will require several decades.

## UNDERSTANDING AND TREATING GRANITIC SEDIMENT IN THE SCOTT RIVER SUB-BASIN.

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Progress in our understanding of sediment sources as well as sediment reduction methods within the Scott River Sub-basin will be reviewed. In 1989-90, the author produced the “Scott River Basin Granitic Sediment Study”, the first project funded by the Klamath Basin Fisheries Task Force. That initial report identified granitic sediment sources, instream sediment storage, and sediment impacts on spawning gravels. Since then, numerous sediment-related efforts have taken place in the

watershed. Most notable is the collaborative work by the French Creek Watershed Advisory Group since 1990 and the Scott River Watershed Council (formerly CRMP) since 1992.

## HYDROGEOLOGY OF THE KLAMATH MARSH, KLAMATH COUNTY, OREGON
(PAPER AND POSTER)

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**Jason M. Melady (poster presenter)**
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### ABSTRACT

Klamath Marsh is an extensive wetland complex in the Williamson River sub-basin of the Klamath River basin. The marsh lies directly east of Crater Lake in an area mantled by pyroclastic-flow and -fall deposits from the climactic eruption of Mount Mazama. A NNW- striking, down-to-the-west, normal fault zone, the Wildhorse Ridge-Military Crossing fault zone, separates the marsh into two hydrogeologic systems. The area east of the fault is underlain by early Pliocene pyroclastic flows (~40 m) and lava flows (>30 m). Low-yield (20-100 gpm) water wells and perched unconfined aquifers in pumice deposits suggest low permeability and low ground water potential in areas underlain by the pyroclastic flows. The area west of the fault is underlain by at least 170 m of interbedded sand, gravel, and stacks (17 m to 50 m) of thin (3-5 m), porous basalt flows. Moderate to high yield (100 to 2500 gpm) water wells, springs and flowing wells suggest high permeability and ground water potential.

### INTRODUCTION

The Klamath Marsh, a 100 km$^2$ wetland in the central Williamson River basin, lies directly east of Crater Lake National Park, Oregon (Figure 1) and bore the brunt of the middle Holocene eruptions of Mount Mazama. This hydrogeologic investigation examines how the space and time distribution of bedrock and unconsolidated units in the vicinity of the Klamath Marsh impacts surface and ground water flow paths. Geologic mapping has been completed in approximately 570 km$^2$ to determine the age, three-dimensional distribution and origin of geologic units. At the same time, hydrologic investigations have been conducted within the Williamson River basin. In this paper, we examine the distribution of rock and unconsolidated units, infer their hydrogeologic characteristics, and propose a preliminary model for surface and ground water flow paths within the Williamson River basin.

### BACKGROUND AND PREVIOUS WORK

Previous studies have either concentrated on the geology or hydrology of the Williamson River basin and fall into three general groups, geology, paleohydrology, and hydrology.

**Geologic mapping**

Reconnaissance geologic mapping at 1:250,000 scale and age dates from prominent geologic units in the vicinity of the Klamath Marsh were reported by Sherrod and Pickthorn (1992). The information from this mapping was partially incorporated into the Geologic Map of Oregon by Walker and MacLeod (1991). Hering (1981) conducted geologic mapping at 1:62,500 scale and completed a petrologic study of Yamsay Mountain located east of the Klamath Marsh. Merewether (1953) mapped the geology of the lower Sprague River a tributary of the Williamson River with confluence south of the Klamath Marsh. Many aspects of the middle Holocene eruption of Mount Mazama have been studied, but the framework of the eruption sequence is presented by Bacon (1983). Young (1990) described the characteristics and distribution of pyroclastic-fall deposits from Mount Mazama. The Klamath Marsh lies within the Cascade regional neotectonic zone defined by Pezzopane and Weldon (1993) where Pleistocene and younger units are offset by normal faults (Klamath, Chemult, and LaPine grabens).

Geologic mapping at 1:24,000 scale in the Wocus Bay (Conaway and Cummings, in press), Soloman Butte (Lee and Cummings, in press), Wildhorse Ridge (Cummings et al., in review), and Military Crossing (Melady and Cummings, unpublished mapping, 2000) quadrangles (Figure 1) provides the stratigraphic and structural framework for bedrock units and for unconsolidated units including pyroclastic-fall deposits from the eruptions of Mount Mazama (Conaway, 2000; Conaway and Cummings, in press). Lee (2000) studied the textures, mineralogy and geochemistry of volcanic rocks from the Wocus Bay and Soloman Butte quadrangles and determined the magmatic processes within a transition zone between the Cascades volcanic arc and the Basin-and-Range province. The volcanic rocks within this zone reflect magmatic processes that have produced complex interfingering of diverse geochemical types.

**Paleohydrology**

Williams (1942) observed large blocks of pumice in the Wocus Bay area and suggested that water levels in the Klamath Marsh had once been much higher than at present. However, he proposed that these higher levels were attained during the climactic eruption of Mount Mazama as water levels were raised by large volume of pumice entering the marsh.

Conaway (2000) examined the impact of a large lake that ponded behind a dam in the Williamson River canyon composed of pyroclastic-flow debris from the climactic eruption of Mount Mazama. The lake reached an elevation of approximately 1400-m and a surface area of approximately 560 $km^2$ before catastrophically draining after overtopping the debris dam. The estimated discharge using a physically based dam-break model (Walder and O'Connor, 1997) was $1.3 \times 10^4$ $m^3s^{-1}$. Pyroclastic-flow and –fall deposits from Mount Mazama were partially eroded and reworked in the lake. Variation in sorting in reworked pyroclastic deposits, the subtle morphology of the strand line, lack of a shore facies at the elevation of the strand line and lack of clastic debris mixed with the reworked pyroclastic deposits suggest water levels were maintained at the high stand of the lake for only a short time, too short for sorting of the pyroclastic-fall deposits to occur and a distinct topographic bench to be cut into the loose pumice.

In addition, two other terraces were described in the Wocus Bay quadrangle (Figure 1) (Conaway, 2000). The most prominent terrace is a strath terrace cut into bedrock. The tread ranges from 10 to 70 m wide and is approximately 9.3 m (δ±0.9 m) above the modern marsh level defined as the local limit of lush hydrophilic vegetation. This terrace is believed to have developed during the Pleistocene when a lake occupied the area of the Klamath Marsh. The lowest terrace is developed in a few places and is cut into organic-rich marsh sediments. This terrace is approximately 4.5 m (δ±0.8 m) above the present marsh at an elevation of approximately 1380 m.

**Hydrology**

The Williamson River is the predominant surface water feature east of Crater Lake. We have subdivided the course of the river into five segments of differing hydrologic character (Figure 1). The source of the Williamson River lies southeast of a group of springs located southwest of Yamsay Mountain at an elevation of 1402 m. From the springs, the river meanders northward (segment 1) to Wildhorse Ridge where it swings westward. In this area (segment 2), the river has been modified by diversions for agricultural purposes and within the eastern part of the Klamath National Wildlife Refuge the river flows within a ditch. At Military Crossing (elevation 1377 m), the channelized river discharges into the Klamath Marsh (segment 3) where a channel is not defined. Near Kirk (elevation 1372 m), the character of the river dramatically changes (segment 4) and forms prominent rapids across lava flows before entering a canyon that is up to 60 m deep and cut into lava flows and basalt hydrovolcanic deposits. After leaving the canyon (elevation 1280 m), the river forms a meandering channel (segment 5) to its delta built into Upper Klamath Lake (elevation 1262.8 m).

Hydrologic and hydrogeochemical studies have been conducted as part of broader studies of the Klamath basin. Illian (1970) proposed a three-part flow system for the Klamath basin. Local, intermediate, and regional circulation patterns are described in relation to water temperature, recharge and discharge characteristics, and source of water. Leonard and Harris (1974) described the water-bearing properties of general geologic units of the Klamath basin and general movement and quality of ground water. Perdue et al. (1981) examined the hydrogeochemistry of the Williamson River and the influence of the Klamath Marsh on water quality in the river.

Conaway (2000) presented preliminary hydrologic data for parts of the Williamson River basin including discharge measurements on the Williamson River in the canyon (segment 4) and examined the hydrogeologic characteristics of bedrock units from driller's logs for water wells. Discharge at Kirk was measured at 0.013 $m^3s^{-1}$ (0.46 cfs) and at Bridge 9730 at the mouth of the canyon at 0.87 $m^3s^{-1}$ (30.72 cfs) on October 10, 1998. Conaway (2000) concluded that the increase in discharge downstream was due to the addition of groundwater because no tributaries enter the river in segment 4. Flow may cease in the Williamson River during late summer at Kirk, however groundwater discharge restores flow as the river passes through the Williamson River canyon. All other streams display surface flow during the spring snow melt before water levels retreat into the pyroclastic deposits.

## HYDROGEOLOGIC OVERVIEW

Before examining the hydrogeology of the Williamson River basin, a brief overview of the dynamics of volcanic environments that may impact water flow paths is provided. When volcanic eruptions occur, their products are distributed across the surrounding landscape in response to the dynamics of the eruption and the pre-eruption topography. As examples, basalt lava flows may erupt relatively quietly and flow across the surface guided by topography, filling in valleys or forming pillow deposits where the lava flows into lakes or rivers. The products of explosive

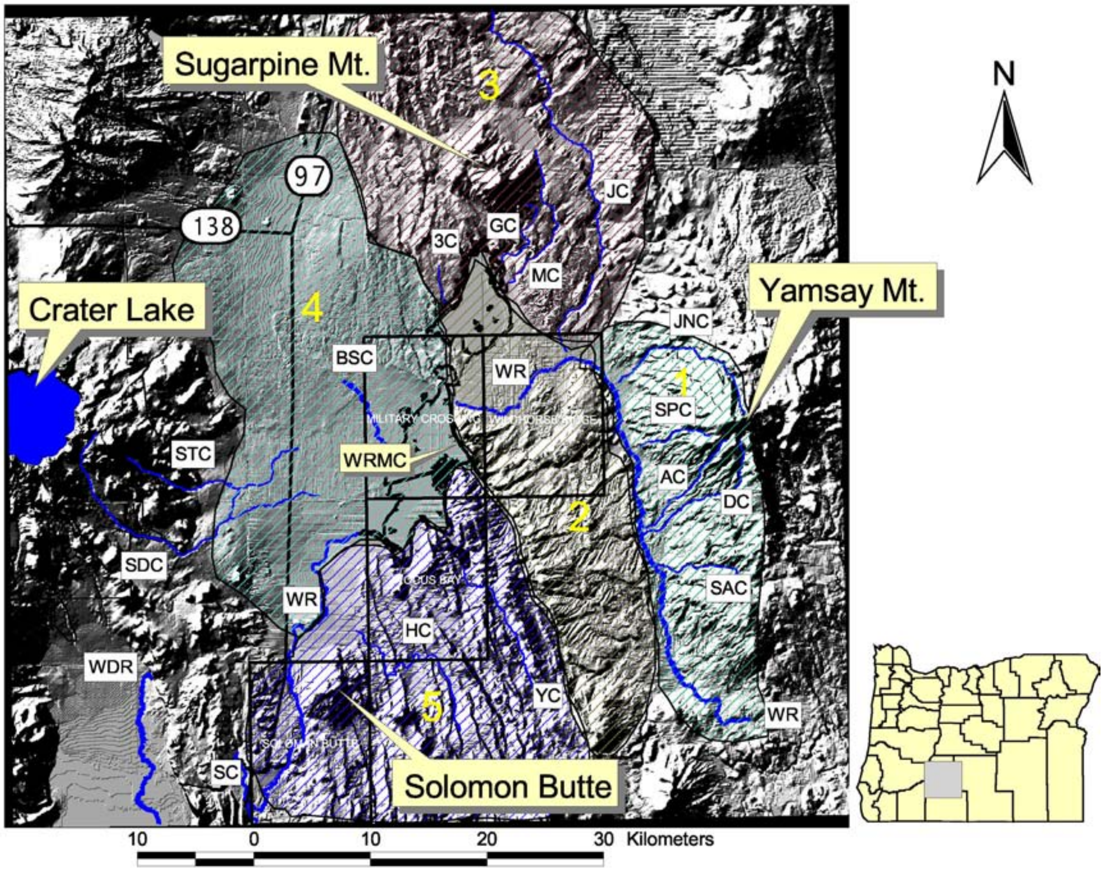


Figure 1: General location map of the Klamath Marsh, Klamath County, Oregon. WDR = Wood River, SDC = Sand Creek, STC = Scott Creek, BSC = Big Springs Creek, 3C = Three Creek, GC = God Creek, MC = Mosquito Creek, JC = Jack Creek, WR = Williamson River, JNC = Jackson Creek, SPC = Sheep Creek, AC = Aspen Creek, SAC = Sand Creek (Yamsay Mountain), YC= Yoss Creek, HC = Hog Creek, SC = Spring Creek.

eruptions may include pyroclastic-fall deposits that mantle the downwind topography, or pyroclastic-flow deposits that reflect the features of the pre-eruption topography. Debris flows also move down the flanks of the source volcano and are deposited in the pre-eruption valleys. After an eruption, erosion of the primary volcanic products may be rapid. The debris is transported and deposited within the surrounding landscape where it may accumulate in lakes and river valleys or be transported considerable distances from source to be deposited in the ocean. Volcanism is associated with faulting and the location of volcanic vents may be closely related to zones of active faulting. Fault-bounded depressions evolve as volcanism progresses and may continue to evolve long after volcanism has ceased. These depressions may become profound valleys in which primary volcanic materials and volcaniclastic sediment accumulate. The end product of these inter-related processes is a complex three-dimensional architecture produced by the stratigraphy of volcanic and sedimentary rocks and cut by faults of different ages, size and orientation.

Hydrogeologic studies in volcanic environments examine the relation between surface and ground water flow paths, stratigraphy, and faults to ascertain how water moves within a system. In the vicinity of the Klamath Marsh the stratigraphic framework of the volcanic and sedimentary rocks and the distribution of faults are reported by Lee and Cummings (in press ), Conaway and Cummings (in press), Cummings et al. (in review), and Melady and Cummings (unpublished mapping, 2000). Hydrologic studies extend beyond the area covered by geologic mapping at 1:24,000 scale. However, the geologic framework can be generally extended from areas covered by detailed mapping and from the reconnaissance regional mapping by Sherrod and Pickthron (1992) at 1:250,000 scale.

The most prominent hydrogeologic changes take place at the north-northwest-trending Wildhorse Ridge-Military Crossing (WRMC) fault zone (Figure 1). The fault zone separates lava and pyroclastic-flows deposited during the early Pliocene to the east from lava flows and sedimentary rocks deposited during the late Pliocene to early Pleistocene to the west. The total down-to-the-west displacement across this fault zone is not known. However, movement has occurred at least twice since the middle Holocene eruption of Mount Mazama (Melady and Cummings, unpublished mapping, 2000). The older fault scarp suggests displacement of approximately 7 m and the most recent scarp suggests approximately 5-m displacement.

**Hydrogeology in areas East of the Wildhorse Ridge- Military Crossing fault zone**

The Williamson River flows through a north-south valley at the foot of Yamsay Mountain (segment 1) before swinging west around the eastern edge of Wildhorse Ridge (segment 2) to eventually flow into the Klamath Marsh (segment 3) at Military Crossing (Figure 1). Throughout this area (Area 1, Figure 1), the oldest rocks are late Miocene to early Pliocene lava flows and pyroclastic flows. An age date for a relatively young dacite flow found within the ring fracture zone of a caldera that occupies the summit of Yamsay Mountain (Hering, 1981) is provided by McKee et al. (1976; Fiebelkorn et al. 1983) at $4.79 \pm 0.17$ Ma. An age of $3.68 \pm 0.08$ Ma is reported by Sherrod and Pickthorn (1992) for an intracanyon basaltic andesite lava flow that caps Wildhorse Ridge in the Wildhorse Ridge quadrangle (Cummings et al., in review). After eruption of this lava flow, the area was partially eroded before the eruption of basalt lava flows and cinder cones north of the Williamson River in the vicinity of Sugarpine Mountain. Age dates are not available for these units, but their geochemical characteristics suggest they may be time related to lava flows in the Wocus Bay quadrangle with ages of 1.62 Ma (Conaway, 2000; Conaway and Cummings, in press).

This gaging point is approximately 8.5 km downstream from the U.S. Geological Survey gaging station. The lowest discharge was measured on dates between July 12 and October 21, 2000 with values ranging between 1.61 and 1.81 $m^3s^{-1}$ (57 and 64 cfs). These data suggest that discharge at base flow conditions is similar between these two gaging points.

A second prominent volcanic feature lies north of segment 2 of the Williamson River and the Klamath Marsh (Area 3, Figure 1). The area is divided topographically into an area southeast of Sugarpine Mountain and an area south and southwest of Sugarpine Mountain. The southeastern area is underlain by thin (3 to 4 m) basalt flows that dip parallel to the slope of topography toward the south and west. The south and southwest area forms a low-relief topographic bench with an abrupt south-facing scarp that rises 100 m above the Klamath Marsh. This bench is cut locally by north and north-northwest striking faults. Reconnaissance investigation of this area indicates thin (4 to 5 m) basalt flows. Although the basalt flows in the two areas are probably of different age, they have in common high porosity within the body of the flows and between flows.

Four streams were selected for monitoring. Jack and Mosquito Creeks have headwater northeast of Sugarpine Mountain and flow south through wetland-lined valleys cut into basalt flows. Jack Creek flows south toward segment 2 of the Williamson River while Mosquito Creek swings west to flow into Klamath Marsh. Both creeks are incised into the southeast topographic area. Three Creek and God Creek flow south across the bench south and southwest of Sugarpine Mountain before flowing down canyons cut into the south-facing scarp that bounds the bench. Three Creek flows through wetlands that have developed along a down-to-the-east fault. The God Creek valley lacks flanking wetlands.

God Creek, the shortest stream (~3.5 km), starts at Sheep Springs and flows southward across the scarp before swinging westward to discharge into Klamath Marsh. A piezometer was placed in the creek bed on 21-June-2000 and water levels were monitored through the rest of the summer. By 14-August-2000 the water level had dropped 67 cm and below the bottom of the piezometer (1.2 cm/day).

Discharge was measured in both Jack and Mosquito Creeks before the water levels dropped below the streambed into pumice. Gaging of Jack Creek at the bridge on Silver Lake Highway (section 4, T. 30 S., R. 10 E.) was conducted on 30-April-2000 with measured discharge of 0.57 $m^3s^{-1}$ (20 cfs). However, by June 3, flow had ceased, but water remained ponded in the creek bed at the bridge. A piezometer was installed on 12-July-2000 and by 18-November-2000 water levels had dropped below the piezometer. The water levels dropped 59 cm for a rate of 0.45 cm/day. A second piezometer was installed in the floodplain of Jack Creek in section 27 (T. 29 S., R. 10 E.) approximately 3.6 km upstream from the bridge. Installation took place on 30-April-2000 and water levels fell 2.24 m by 18-November-2000 (dry). The rate of decline in water level was 1.1 cm/day. Discharge on Mosquito Creek was measured at 0.004 $m^3s^{-1}$ (0.14 cfs) on 16-June-2000 when monitoring began. A piezometer was installed on 12-July-2000. Water levels declined 65 cm by 18-November-2000 for an average rate of decline of 0.5 cm/day. Water has not been detected in streambed piezometers during 2001 (January, March, April) at Jack and Mosquito Creeks.

The highest discharge on Three Creek was recorded on the first measurement date of 16-June-2000 at 0.012 $m^3s^{-1}$ (0.42 cfs). This declined steadily to 0.0014 $m^3s^{-1}$ (0.05 cfs) on 18-November-2000. Discharge on 27-April-2001 was measured at 0.003 $m^3s^{-1}$ (0.10 cfs), a flow rate similar to that measured on 9-September-2000. Three Creek is the only creek that maintained surface flow between April 1, 2000 and April 28, 2001, the period of the study.

A piezometer was placed in a forested topographically low area within 0.45 km of the Klamath Marsh and 0.9 km west of the fault scarp that terminates the Sugarpine Mountain platform. There is no intervening scarp between the piezometer and the marsh. A piezometer was installed on 19-June-2000. Water levels declined 36 cm by 18-November-2000 for a daily rate of 0.23 cm/day.

In the area (Area 2, Figure 1) between the WRMC fault zone and the segment 1 of the Williamson River (Military Crossing, Wildhorse Ridge, and Gordon Lake quadrangles), the stratigraphy is composed of early Pliocene lava flows, at least two pyroclastic flows, and thin and discontinuous areas of sedimentary rocks. The tuff of Skellock Draw is a pyroclastic flow that underlies most of this area and is also present in the Wocus Bay (Conaway and Cummings, in press) and Buckhorn Springs quadrangles. The unit appears to thicken westward and may have a source near Wocus Butte. The age is greater than 4.09 ± 0.05 Ma, the age of a lava flow that directly overlies the tuff in the Wocus Bay quadrangle (Conaway and Cummings, in press). A driller's log for a water well suggests the tuff may be up to 30 m thick. The tuff of Meadow Creek underlies the eastern half of the Wildhorse Ridge quadrangle and extends into the Buckhorn Springs and the Gordon Lake quadrangles. This tuff is characterized by blocks of black trachyandesite pumice that in places are up to 1 m in diameter (Cummings et al., in review). The source of this tuff is not known. Thickness and the distribution and size of blocks of trachyandesite pumice suggest that the pyroclastic flow advanced from south to north along a paleovalley located near the present day segment 1 of the Williamson River valley. The tuff is overlain by a well-rounded coarse-grained conglomerate which, in turn, is overlain by a basaltic andesite lava flow that yields a K/Ar age of $3.68 \pm 0.08$ Ma (Sherrod and Pickthorn, 1992). The Williamson River has cut through this tuff in segment 1 in the Gordon Lake quadrangle.

Skellock Draw was selected for hydrologic study because the two tuffs are believed to underlie much of the watershed, the stratigraphy is cut by only a few faults, and wetlands are common along Skellock Creek and its tributaries. Skellock Creek flows westward into Klamath Marsh. Water levels in piezometers were monitored between 1-April and 18-November-2000 and on 17-March-2001 and 27-April-2001. During 2000, water levels in the wetlands associated with Skellock Creek and its tributaries declined at a rate of 0.7 cm/day. Water levels measured in March and April, 2001 were similar to those measured in November, 2000 indicating little change through the winter and spring snow melt. However, in spring, 2001, the wetlands in Skellock Draw are the only wetlands monitored during this study that were partially flooded in April.

In the lower reaches of Skellock Draw, the creek cuts through the tuff of Skellock Draw and into underlying lava flows. At this point, the creek becomes incised and the flanking wetlands disappear. The creek normally sinks into the pumice just before crossing the Silver Lake Highway. However, in 2001, water was not flowing in this lower reach of Skellock Draw.

The Klamath Marsh is divided by a ridge of basalt flows (The Peninsula) into a northern and southern area. The surface elevation of these two marsh areas is similar (1375.9 m). The basalt flows are similar in thickness (2 to 4 m), porosity, and geochemistry to flows west of the WRMC fault zone. Driller's logs for water wells near The Peninsula indicate sedimentary rocks underlie the surrounding topographically low areas. In a few places basalt directly overlies the sedimentary rocks. One well (KLAM 619) near the center of The Peninsula penetrated "broken basalt" and "basalt" between 3.5 and 138.7 m, suggesting a vent, possibly located along a fault zone. East of The Peninsula the surface elevation of the marsh rises slightly to topographically isolate this part of the marsh from the Williamson River and the rest of the marsh. However, orthophoto quadrangles indicate that water seeps to the southeast through the pumice that forms this topographic high before discharging into the Williamson River.

Discharge measurements at the west bridge on the Military Crossing road indicate flow reversal during the year. During the spring runoff period, water flows southward and out of the marsh area that lies between Military Crossing and The Peninsula. In summer, the flow reverses and water from the channelized Williamson River flows northward into this marsh area. We believe this pattern may indicate limited groundwater flow through the sedimentary rocks that underlie the basalt flows on The Peninsula.

**Hydrogeology in areas west of the Wildhorse Ridge-Military Crossing fault zone.**

The hydrogeology in areas west of the WRMC fault zone is considered in two parts. The Klamath Marsh to the foothills of the Cascades Range (Area 4, Figure 1) is discussed separately from areas south of the Klamath Marsh including the canyon of the Williamson River (Area 5, Figure 1).

Klamath Marsh to foothills of the Cascades. The bedrock geology of the Klamath Marsh (Area 4, Figure 1) is known from sparse outcrops and driller's logs from water wells. The marsh area is underlain by basalt flows interbedded with sandstone/conglomerate and fine-grained sedimentary rocks. Basalt flows crop out in two areas. One extends from Military Crossing westward at least 9 km. Throughout this area, porous, thin basalt flows (2 to 3 m) similar to those exposed on The Peninsula crop out.. Driller's logs for wells located in the marsh areas south of the basalt outcrops report sedimentary deposits. One high production irrigation well (Klam 10202) penetrated sedimentary rocks (21.6 m to 25.9 m) over basalt flows (25.9 m to 91.4 m E.O.H.; producing zone 45.7 to 91.4 m). A second high production irrigation well (Klam 11478) encountered coarse sand (6.4 m to 21.3 m) above a thick section of basalt (21 to 149 m). The bottom of this well penetrated 3 m of sedimentary deposits (E.O.H. 152 m).

The second area of basalt flows is along the southern edge of the marsh near where the Williamson River forms a channel as it leaves the marsh (Figure 1). These flows are similar in physical characteristics to flows near Military Crossing, but are geochemically distinct. These flows are present in the topographically high areas south of the marsh (Area 5, Figure 1) where Conaway and Cummings (in press) report an age of 1.62 ± 0.47 Ma. There are no water wells in this area.

The sedimentary rocks interlayered with the lava flows are not exposed. The greatest thickness of sedimentary rocks is reported in driller's logs in section 1 (T. 31 S., R. 8 E.). Here, gravel, sand, and thin clay-rich layers were penetrated to a depth of 141 m without encountering basalt flows. Driller's logs suggest poorly indurated interbedded sandstone and conglomerate and infrequent 1 to 2 m thick silt/claystone beds.

The bedrock units between the WRMC fault zone and the Cascades Range foothills are overlain by unconsolidated sand and gravel and the pyroclastic-fall and -flow deposits from the early to middle Holocene eruptions of Mount Mazama. Throughout the Williamson River basin, the cataclysmic eruption of Mount Mazama to form Crater Lake at 6,845 $C^{14}$ yr (Bacon, 1983; 7,627±150 cal yr B.P., Zdanowicz et al., 1999) deposited the uppermost layer of pumice on a landscape already blanketed by thick pumice deposits from earlier eruptions of Mount Mazama (Cleetwood eruption, slightly earlier than climactic eruption, Llao Rock eruption at 7015±45 $C^{14}$ yr, Bacon, 1983). Late in the climactic eruption, pyroclastic flows moved eastward down the flanks of the volcano and formed deposits that underlie the gently sloping (1.7 m/km) surface between the foothills of the Cascade Range and the WRMC fault zone. Some pyroclastic flows migrated southward and entered the Williamson River canyon where they became trapped and formed a dam composed of pumice and ash. The lake that formed behind this short-lived dam rose to an elevation of approximately 1400 m before catastrophically draining (Conaway, 2000). Pyroclastic deposits below 1400 m were reworked and blocks of pumice from the pyroclastic flows were rafted throughout the lake basin. The thickness of the pyroclastic-flow deposits estimated from driller's logs for water wells located immediately west of the Klamath Marsh is 20 m. The deposits are approximately 30 m thick near the foothills of the Cascades Range.

Water wells between the foothills of the Cascades and the Union Pacific railroad were examined for stratigraphy and hydrogeologic characteristics of the pyroclastic flow deposits. Near the foothills (sections 16 and 17, T. 31 S., R. 7 E.) the pyroclastic flows are estimated at 25 m and overlie the Cleetwood deposits and, at a depth of about 30 to 35 m, sand and gravel. During drilling, water was first encountered in the unit below the pyroclastic flows. The static level in these wells is generally 2 to 5 m above the level where water was first encountered.

Approximately 5.6 km to the east between Highway 97 and the Union Pacific railroad (sections 1 and 12, T. 31 S., R. 7 E.), the pyroclastic flow deposits are estimated at 12 m thick and overlie deposits of the Cleetwood eruption or reworked pumice mixed with sand. Here, water was first encountered in the unit immediately below the pyroclastic flow deposits (10-12 m). Static water levels are within 4-6 m of the surface. A domestic well in section 1 (Klam 10615) penetrated 10.7 m of pyroclastic material before entering gravel (E.O.H. = 12.2 m). Water was first encountered at 3 m but static level was at 5.5 m below the surface. The estimated flow rate between 3 and 10.7 m, the interval within the pyroclastic deposits, was 1 to 2 gpm. A flow rate of 5 gpm with over 2.2 m draw down after one hour was recorded from the gravel layer beneath the pyroclastic deposits.

Sand and Scott Creeks flow eastward through this area and are diverted in a series of unlined ditches from where the creeks emerge from the foothills to over 7 km to the east. Well-sorted medium-grain sand up to 2 m thick overlies the pyroclastic flow deposits in much of this area. Peak discharge in diversion channels at Highway 97 measured on 21-June-2000 was 0.41 $m^3s^{-1}$ (14.3 cfs) for Scott Creek and 0.44 $m^3s^{-1}$ (15.7 cfs) for Sand Creek.

A piezometer was placed in a dry streambed in section 16 (T. 30 S., R. 8 E). This site is located approximately 0.6 km from Big Springs, the source of Big Springs Creek and the most prominent hydrologic feature northwest of the marsh. The water levels in the piezometer declined 10 cm between 16-June-2000 and 18-November-2000 for a daily rate of decline of less than 0.1 cm/day. Big Springs Creek and the dry streambed where the piezometer is located lie in a northwest trending zone of active and paleochannels cut into pyroclastic flow deposits. The largest of these features is 0.5 km wide and crosses Highway 97 in section 1 (T. 30 S., R. 7 E.).

**Bedrock areas south of the marsh.**

Lee and Cummings (in press) and Conaway and Cummings (in press) mapped the bedrock geology of the Soloman Butte and Wocus Bay quadrangles (Area 5, Figure 1). Lee (2000) subdivided the stratigraphy into six volcanic bedrock sequences based on field relations, stratigraphic position, textures, relative and absolute ages, and major and trace element geochemistry. The stratigraphy is cut by several north-northwest striking normal faults with down-to-the-east and down-to-the-west senses of movement. Faulting is more common here than in areas located east of the WRMC fault zone and this area lies within the Cascades regional neotectonic zone as defined by Pezzopane and Weldon (1993).

The two oldest stratigraphic sequences are believed to be of greatest hydrogeologic importance and underlie much of the Soloman Butte and Wocus Bay quadrangles The oldest stratigraphic sequence was erupted between about 4.1 and 3.8 Ma (Conaway and Cummings, in press; Lee, 2000). Rocks of this sequence underlie areas both to the east and west of the WRMC fault zone. The sequence includes interfingering alkali-rich and alkali-poor lava flows and alkali-rich tuff.

Wocus Butte and Little Wocus Butte are volcanic centers of the alkali-rich volcanic suite and the tuff of Skellock Draw is present (Conaway and Cummings, in press).

A second sequence underlies much of the southern half of the Soloman Butte quadrangle (Lee and Cummings, in press). These rocks are exposed in the Williamson River canyon and extend east and south into the Applegate Butte and Chiloquin quadrangles. Basalt flows and tuff cones line the canyon and interfinger with fine-grained, poorly lithified sedimentary rocks that extend to the southeast into the Chiloquin and Agency Lake quadrangles. The age of these rocks is unknown. They are believed to be about 3 Ma. These stratigraphic sequences are overlain by relatively thin sequences consisting of interbedded flows and sedimentary rocks or, as in the case of Soloman Butte, a stratovolcano and associated flow field.

Hydrologic studies have been conducted along Yoss Creek and Yoss Creek Meadow. This valley was selected because of the relation between Yoss Creek, bedrock stratigraphy, and faults. The headwaters of Yoss Creek are located in the Calimus Butte quadrangle. The creek first flows northward in a fault bounded valley in the Buckhorn Springs quadrangle, but cuts abruptly westward through a prominent fault-bounded ridge in the Wocus Bay quadrangle to form a bedrock-floored canyon that is 80 m deep and 0.6 km long. From here the creek passes through a series of meadows within another fault-bounded valley before entering Wocus Bay. The bedrock includes dense, jointed lava flows, and locally, the tuff of Skellock Draw. Discharge on Yoss Creek was measured where it enters the largest meadow, Yoss Creek Meadow. The discharge quickly sinks into the pumice-filled meadow and the stream channel disappears. In 2000, disharge on Yoss Creek entering the meadow decreased from a 0.025 $m^3s^{-1}$ ( 0.88 cfs) on April 30 to 0.001 $m^3s^{-1}$ (0.04 cfs) by August 14. Except for barely measurable discharge on October 21 (0.00068 $m^3s^{-1}$, 0.02 cfs), no flow was recorded in September, November, 2000, January, March, and April, 2001. Water levels in a piezometer placed near the stream declined 2.16 m between April 30 and October 21. Daily rates of decline were between 1.6 and 2.3 cm/day between April 30 and July 12 and approximately 1 cm/day between July 19 and October 21. The piezometer that indicated the least change in water levels was located at the lower end of Yoss Creek Meadow where water levels declined only 0.93 m during the same time period and rates of decline of water levels were between 0.1 and 0.6 cm/day before July 12 and 0.8 cm/day between July and October. The difference in behavior at opposite ends of the marsh suggests water moves northward through the pumice-filled Yoss Creek Meadow from sources other than Yoss Creek.

The discharge and water level data for the Yoss Creek system suggest a more complex interaction between surface water and ground water in this area than was encountered in the Skellock Draw study area. The main differences between these two study areas reflect more faulting and lava-flow rather than tuff dominated stratigraphy in the Yoss Creek area.

Discharge measurements on the Williamson River in segment 4 are available for the U.S. Geological Survey gaging station near Kirk (U.S. Geological Survey number 11493500) and have been measured at U.S. Forest Service Bridge 9730 near the mouth the Williamson River canyon. Figure 2 contains discharge data for these two sites for the same day during 2000-2001. Conaway (2000) interpreted the increase in discharge between these two points as due to ground water discharge to the river within the Williamson River canyon.

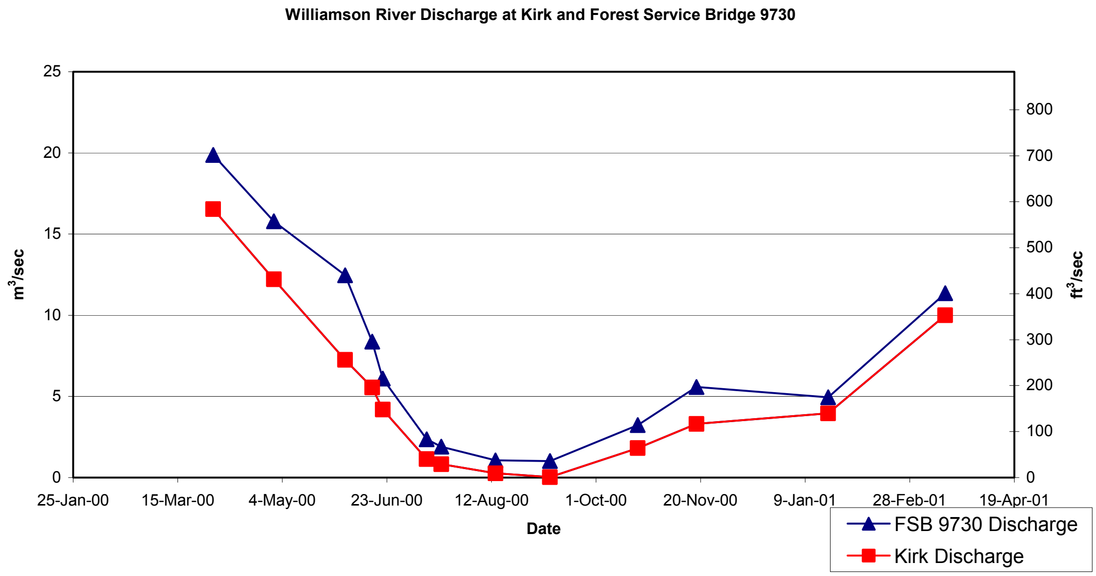


Figure 2: Williamson River discharge at USGS gaging station number 11493500 at Kirk and PSU gaging point at USFS Bridge 9730. Discharge at each location measured on the same day.

## DISCUSSION

The hydrogeologic investigation of the Klamath Marsh has identified important elements of the regional system that impact the availability of ground and surface water resources.

Yamsay Mountain (Area 1, Figure 1) provides runoff during spring snowmelt to segment 1 of the Williamson River. Yamsay Mountain receives about 110 cm of precipitation per year. Runoff enters the river during mid to late April and in some years continues to be an important component until mid June. The mountain is likely an area of recharge of the ground water system that provides a base flow of approximately 1.70 $m^3s^{-1}$ (60 cfs) during late summer and early fall. Similar discharge values at the U.S. Geological Survey gaging station (No. 11491400) and at the PSU gaging point in section 15 (T. 30 S., R. 10 E.) suggests that there is neither significant gain nor loss to the groundwater system in this segment of the river.

Sugarpine Mountain (Area 2, Figure 1) is primarily an area of recharge for the ground water system. Runoff during snowmelt is minimal (e.g. 20 to 30 cfs for Jack Creek). Water levels in piezometers suggest slow discharge of groundwater through stream-flanking wetlands developed on pumice-filled paleovalleys. This discharge continues into mid to late summer. The porous, thin basalt flows that underlie this area provide ample pathways for water to migrate into the volcanic pile and recharge either the shallow or intermediate ground water system. The average precipitation for the crest of Sugarpine Mountain is approximately 100 cm/year. However, the summit area is relatively small and the flanks receive between 60 and 85 cm/year.

Discharge at Three Creek has been continuous during the study period. However, discharge is low (~0.4 cfs). Water appears to rise along a down-to-the-east fault that cuts the lava flows and discharges into wetlands that have developed on the downthrown block. The low rate of decline in water levels in the piezometer located off Three Creeks Road in section 32 (T. 29 S., R. 9 E.) may reflect groundwater discharge into pumice deposits along the down thrown side of prominent north-northwest striking faults in this area.

The area that lies between the WRMC fault zone and segment 1 (Area 2, Figure 1) of the Williamson River appears to have minimal impact on surface and ground water systems. The relatively impermeable tuff of Skellock Draw and tuff of Meadow Creek that underlie this area preclude groundwater recharge and water from snowmelt is believed to migrate along the pumice/bedrock interface into pumice-filled drainages such as Skellock Draw. Where these tuffs are present, groundwater producing zones are found in lava flows that underlie the tuffs. This pattern is present in the Wildhorse Ridge quadrangle and is believed to present in the Buckhorn Springs quadrangle.

Driller's logs from water wells and sparse outcrops indicate that the area west of the WRMC fault zone (Area 4, Figure 1) is underlain by interbedded basalt lava flows and coarse- to fine-grained sedimentary rocks. Flow thickness ranges from 3 to 5 m, vesicles are abundant throughout the flows, inflation structures, and local cinder rubble are either observed in outcrop or inferred from driller's logs. These flows probably erupted from small shield volcanoes. Locally, flows may have blocked rivers and streams causing short-lived lakes to form and accumulate fine-grained sediment. High-yield irrigation wells produce from packages of lava flows interlayered within the sedimentary deposits. The age of this stratigraphic section is interpreted to be latest Pliocene to early Pleistocene and the thickness appears to be greater than 170 m. In the foothills of the Cascades, the sedimentary rocks appear to interfinger with lavas with sources from the Cascades.

The pyroclastic flow deposits from the climactic eruption of Mount Mazama have relatively low permeability as indicated by discharge patterns of Scott and Sand Creeks, the water transporting capacity of unlined diversion ditches cut into the top of the deposits, and water levels in water wells drilled through the tuff. The tuff is interpreted as a relatively low permeability layer into which surface water slowly sinks and which confines underlying more permeable layers of sand, pyroclastic fall, and sedimentary rock aquifers. The water table in the pyroclastic-flow deposits intersects the surface at the western edge of the Klamath Marsh where a narrow fringe of artesian wells and springs is located.

Northwest-trending stream valleys cut into the pyroclastic flows enter the Klamath Marsh from the northwest. These valleys may be channels cut by streams flowing away from large springs located along this trend since the eruption of Mount Mazama. Big Springs, the source of Big Springs Creek, is located within this zone at an elevation of approximately 1383.5 m. The most northwesterly valley system is at an elevation of approximately 1400.6 m. Big Springs (section 16, T. 30 S., R. 8 E.) appears to be the most recent spring. This model suggests decline in spring levels of approximately 17 m since the eruption of Mount Mazama.

The Williamson River is a gaining stream between Kirk and the mouth of the canyon (segment 4). Ground water enters the river in the canyon and may be guided by an erosional unconformity cut into relatively impermeable basalt hydrovolcanic deposits. The groundwater discharge is estimated at 1 $m^3s^{-1}$ (35 cfs).

## ACKNOWLEDGEMENTS

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## METHODOLOGY AND CONCEPTS USED TO DETERMINE INSTREAM AND OUT – OF – CHANNEL FLOW REQUIREMENTS FOR U.S. FOREST SERVICE STREAMS IN THE UPPER KLAMATH BASIN OF OREGON

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Healthy fish populations are dependent on streamflow to protect the integrity of their habitat. Stream habitats are the consequence of the interactions of the stream, its floodplain, and uplands. Fluvial-geomorphic process form and maintain habitat. We present a conceptual methodology for determining the stream flow regimes necessary to maintain fisheries resources and their habitats. Using data from streams on USFS lands in Klamath Basin of Oregon we demonstrate how the methodology was used to develop flow recommendation.

## QUANTITATIVE INVESTIGATION OF THE REGIONAL GROUND-WATER HYDROLOGY OF THE UPPER KLAMATH BASIN

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Shifting priorities in water management have resulted in surface-water shortages in the upper Klamath Basin. These water shortages have generated considerable interest in the use of ground water to supplement surface water supplies. A substantial increase in ground-water use, however, could potentially affect existing ground-water users and diminish baseflow to streams. Current

knowledge of the ground-water hydrology of the upper Klamath Basin is insufficient to predict the possible consequences of increased ground-water development. Quantitative aspects of the ground-water/surface-water connection are poorly understood in much of the basin. The dynamic behavior of the regional ground-water system, for example the time it takes for stresses to propagate, is also poorly understood.

This presentation describes a project to improve the quantitative understanding of regional ground-water hydrology in the upper Klamath Basin being conducted cooperatively by the us Geological Survey and the Oregon Water Resources Department. The project includes collection of data pertaining to the hydrologic budget, hydraulic head distribution, ground-water/surface-water connection, and geologic controls on ground-water flow. These data will be used to develop a numerical model to simulate regional ground-water flow. The increased quantitative understanding and simulation capability should provide water managers with additional insights and the ability to quantitatively evaluate various ground-water management alternatives.

## HYDROLOGIC SIMILARITY OF SMALL MOUNTAIN STREAMS IN THE UPPER KLAMATH RIVER BASIN

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A frequently occurring problem in hydrology is the estimation of long-term discharge statistics at locales that have only a short period, or no record of flow. Until recently flow records from the Klamath River above the Upper Klamath Lake were quite sparse. Essentially no records exist prior to 1992 from small streams in the Williamson and Sprague River basins or direct tributaries to Upper Klamath Lake. The Forest Service Region 6 Water Resources Team (WRT) has developed several procedures to derive estimates of long-term flow statistics using data and analysis from a short-term flow-gaging network and miscellaneous low measurements. This presentation demonstrates how the WRT iteratively determined hydrologic similarity between small mountain streams in the Klamath River Basin and how WRT used this knowledge to compute estimates of long-term monthly means at sites.

## 1997 FLOODING IN THREE NORTHERN CALIFORNIA KLAMATH MOUNTAIN STREAMS: INFLUENCES OF SEDIMENT AND WOOD INPUT MAGNITUDE ON FLOOD EFFECTS

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### ABSTRACT

The 1997 flood produced a range of effects in valley bottoms of the Klamath Mountains of northern California. We assessed disturbance along three streams by examining valley forests and morphology on pre- and post-flood air photos and cross sections. We then linked valley disturbance to volumes of sediment and large wood input during flooding. Major landsliding in Walker Creek produced large debris flows that stripped riparian forests and mobilized floodplains along the entire valley network. Tompkins Creek also experienced large landslides and debris flows, but valley disturbance was patchy and decreased downstream as sediment and large wood deposited at valley bends and on unmobilized floodplains. Indian Creek experienced water flooding (not sediment-laden) that resulted in modest reworking of the channel and minor recruitment of riparian trees. We attribute the degree of valley disturbance primarily to the volume of sediment input to stream reaches during flooding. We also documented intermediate-level flood disturbance (e.g. Tompkins Creek) that increased valley complexity within and among reaches. In managed Klamath Mountain lands, debris flows often originate from roads or deforested hillslopes. Such debris flows may not have sufficient mature conifer large wood to moderate disturbance run-out distance or to promote complexity in the receiving channel.

### INTRODUCTION

#### Floods in the Pacific Northwest

In steep Pacific Northwest streams, large floods and debris flows control routing of sediment and large wood and thus strongly influence valley bottom morphology (Benda, 1990; Grant and Swanson, 1995). Lisle (1981) suggested that infrequent large floods (rather than moderate flows) define channel and valley form in larger northern California streams. Within and across streams, flood effects are highly variable depending on complex interactions between storm characteristics and landscape susceptibility to disturbance (Swanson, et al. 1998; Johnson, et al. 2000). Such patchy valley disturbance provides for relatively undisturbed "refuges" that facilitate biological recovery (Swanson, et al. 1998). In the Klamath Mountains of northern California, historic debris flows have significantly modified valley bottoms (Tom Lisle, personal communication). The 1997 flood caused widespread landsliding and debris flows across the west side (west of the I-5 corridor) of the Klamath National Forest (KNF) resulting in a range of effects in geographically and geologically similar streams (de la Fuente and Elder, 1998). Our objective was to compare flood effects within and among streams and to investigate valley response to different volumes of input sediment and large wood.

**1997 Flood Precipitation and Discharge**

From 12/26/96 through 1/3/97, large amounts of rain were recorded at the towns of Seiad Valley (43 cm) and Happy Camp (27 cm) on the Klamath River in northern California (de la Fuente and Elder, 1998). Rainfall totals for December 1996 were about 3 times greater than normal at these sites. Anecdotal accounts indicate snow pack in the area extended below about 1200 m elevation at the start of the storm period. Peak discharges of the Klamath River at Seiad Valley and Indian Creek near Happy Camp were 71% and 54% of the 1964 flood (largest of record) peak discharge, respectively. The estimated recurrence intervals of these peak flows were about 15 years based on a record of about 50 years (de la Fuente and Elder, 1998).

**Study Streams**

We evaluated 1997 flood effects along three Klamath River streams in northern California (Figure 1). Walker Creek (31 $km^2$) and Tompkins Creek (38 $km^2$) near Seiad Valley (Figure 1) have steep mainstem valley gradients of 5 % to 10 %. Indian Creek (349 $km^2$) near Happy Camp (Figure 1) has much wider mainstem valleys with gradients less than 2 %. Prior to the 1997 flood, these valleys were forested with stands of white alder (*Alnus rhombifolia*) and bigleaf maple (*Acer macrophyllum*) dating to floods in 1974 and 1964. Extensive headwater areas of these streams are underlain by erosive earthflow-like deposits developed on metasedimentary and metavolcanic rocks of the Rattlesnake Creek bedrock terrane (de la Fuente and Elder, 1998). These streams also have areas of erosive plutonic bedrock that contributed relatively less sediment in 1997. The study watersheds have been disturbed by road building, timber harvest, wild fire, and previous large floods. On air photos, we surveyed long (about 10 km), continuous reaches of Walker and Tompkins Creeks and shorter, disconnected reaches spread across the much larger Indian Creek watershed. We performed field surveys in tributary and mainstem valley reaches in all three streams.

## METHODS

**Sediment Inputs**

Landslides were inventoried on post-flood 1:40,000 color infrared air photos across the west side of the KNF and on 1:10,000 air photos from a sub-sample area that included Walker and Tompkins Creeks. Field surveys of landslide depths and percents of total landslide volumes delivered to channels were concentrated in Walker Creek. From these data, general landslide area-to-depth (and thus volume) and delivery-ratio (percent of total volume input to channels) relations were developed. These relations were then applied to the landslides that were only assessed with air photos. We used these combined field and photo data to estimate total volumes of sediment input to the study streams.

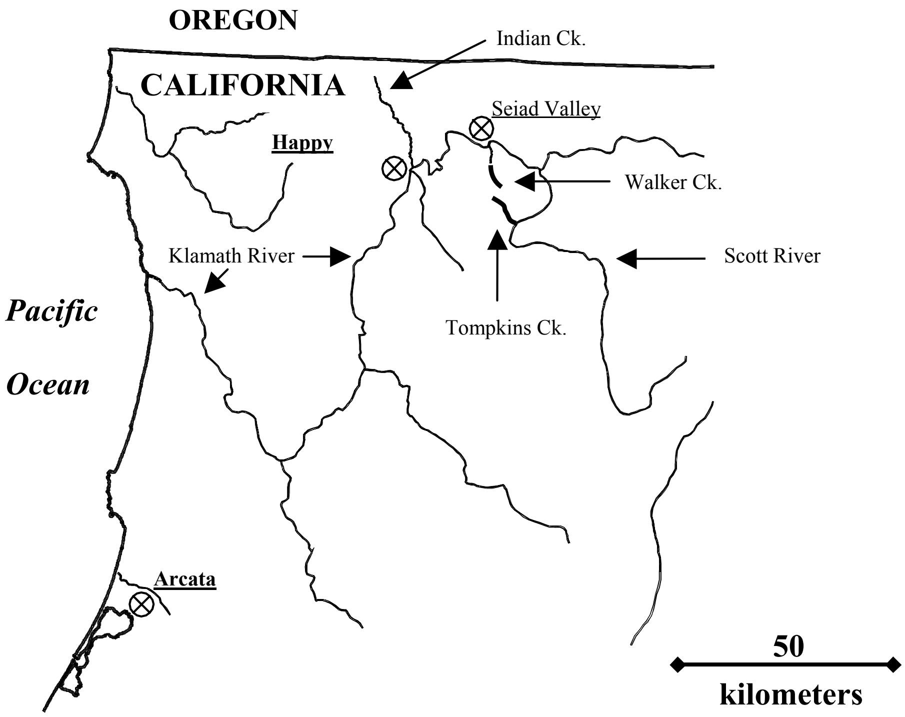


Figure 1 Map of northern California showing Indian, Tompkins, and Walker Creeks and the towns of Happy Camp and Seiad Valley on the Klamath River.

**Large Wood Inputs**

For Walker and Tompkins Creeks, recruitment of large wood (pieces at least 0.13 m diameter and 1 m long) to channels was estimated in two categories: mature conifers from hillslopes and valley terraces, and smaller (mainly hardwood) pieces from young riparian forests. On pre-flood (1995) air photos (1:16,000), we identified patches of mature conifers on hillslopes and on valley terraces. In the upper watersheds, these areas were relatively small and discontinuous. We then located the same areas on post-flood 1:10,000 and 1:3,000 air photos. Where the patches had been impacted by landslides or debris flows, we estimated numbers of mature conifers input to channels by counting conifer crowns on air photos before and after flooding. In the field, we measured lengths and diameters of toppled mature conifers to compute an average volume input by a representative mature conifer in each watershed. We were not able to assess recruitment of "old" large wood that was already downed on hillslopes or in channels prior to 1997.

To estimate volumes of hardwood recruited from valley forests in 1997, we first computed the areas of canopy openings (gaps) on the post-flood 1:3,000 air photos. We then surveyed a sample of these stands in the field and determined an area-to-volume relationship. We did not quantify mature conifer or hardwood inputs to Indian Creek, but observations of hillslope and valley disturbance suggest they were minor.

**Sediment and Large Wood Transport**

We used a budgeting method (Dietrich, et al. 1982) to estimate the volumes of sediment and large wood transported through Walker and Tompkins Creeks by estimating input, stored, and exported volumes for a series of individual reaches. For each reach, we first estimated volumes input from upstream. We then added inputs from streamside landslides and floodplain and terrace scour within the reach. From this total, we subtracted volumes of sediment (channel or floodplain aggradation referenced to in-place trees or stumps) and large wood (jam and disaggregated piece deposition) stored within the reach. These computations were performed for a series of about 5 contiguous reaches totaling about 10 km down to the mouths of Walker and Tompkins Creeks. However, our budgets differ from that of Dietrich, et al. (1982) because we could not quantify volumes of sediment and old large wood stored in reaches prior to 1997. For Indian Creek, we estimated sediment inputs but did not attempt sediment or large wood budgets.

**Flood Effects in Valleys**

We assessed riparian forest disturbance, valley sediment scour and fill, and deposition of large wood on post-flood air photos (scales from 1:3,000 to 1:16,000). In the field, we performed reconnaissance and cross section surveys to evaluate depths of scour and fill, and to assess the composition (conifer/hardwood, 1997 input/old wood) and volumes of logjams. We measured total volumes of a sample of logjams that were measured (areas, $m^2$) on the 1:3,000 air photos. With these data, we developed area-to-volume relations for jams made predominantly of either hardwoods or mature conifers. We also resurveyed a series of about 20 valley cross sections in Indian Creek that were originally surveyed in 1992.

## RESULTS

**Volumes of Input Sediment and Large Wood**

We estimated about 650,000 $m^3$ of sediment was delivered to Walker Creek, about 75 % of which was conveyed out of the watershed to the Klamath River. Considerably less sediment was delivered to Tompkins (180,000 $m^3$) and Indian (70,000 $m^3$) Creeks. Large fractions of the total volume of sediment input to Walker and Tompkins Creeks were derived from a few large landslides that initiated at the "toes" of earthflow-like deposits. We estimated about 30 % of the total volume of sediment input to Tompkins Creek was exported to the Scott River. Scaled by watershed area, volumes of sediment input to Walker Creek were about 4 and 20 times greater than inputs to Tompkins and Indian Creeks, respectively.

The total volume of large wood (conifer and hardwood) input to Walker Creek (about 5,000 $m^3$) was about 3 times more than that input to Tompkins Creek (about 2,000 $m^3$) when scaled by watershed area. We estimate Walker and Tompkins Creeks exported 40 % and 10 % of these large wood volumes, respectively. Estimates of total volumes of large wood recruited to Walker and Tompkins Creeks were approximately 100 times less than volumes of sediment input to the streams. This is largely because many landslides initiated from roads or deforested hillslopes.

**Disturbance of Riparian Forests**

We documented contrasting patterns of flood inundation and canopy gap widths (on 1:3,000 air photos) along Walker and Tompkins Creeks (Figure 2). Inundation and canopy gaps were coincident along all of Walker Creek. In Tompkins Creek, a downstream reduction of canopy gaps was documented below sharp valley bends that hastened deposition of significant volumes of sediment and large wood. Effects on riparian forests along Indian Creek were much more subdued (Figure 2). Unlike Walker and Tompkins Creeks, Indian Creek reaches had some canopy gaps prior to the 1997 flood because the stream channel was wider in this larger watershed. Canopy gaps were widened up to about 20 m in the upper Indian Creek reach compared with maximum gap widths over 40 m in Walker Creek.

**Valley and Channel Morphologic Change**

Along mainstem Walker Creek, most or all of the floodplain was mobilized and is now characterized by fresh, unsorted flood deposits with broad channel incisions (Figure 3). Although parts of upper Tompkins Creek had similar effects, many inundated floodplains were not mobilized in lower Tompkins Creek below the sharp valley bends. Scour and fill was limited to the active channel and side channels while many remnant terraces retained their riparian forests (Figure 3). Valley bottom form along Indian Creek was not significantly modified by the 1997 flood (Figure 3). Flood effects were limited to modest active channel scour and fill, channel widening (sometimes recruiting riparian large wood), and some overbank deposition.

**Patterns of Large Wood Deposition**

We estimate that Walker Creek valley had about twice the volume of large wood (including old wood) deposited in jams as Tompkins Creek valley (2,400 $m^3$ and 1,300 $m^3$, respectively). However, Tompkins Creek had a greater volume (about 300 $m^3$) of large wood jams deposited in or directly adjacent to the bankfull channel than Walker Creek (about 100 $m^3$). In both cases, most of the volume of large wood jams was deposited on floodplains and is not interacting with the channel. Streamside landslides along mainstem Walker and Tompkins Creeks contributed significant large wood to valleys that was not mobilized downstream. Valley segments with adjacent landslides had about 5 times the volume of large wood (per floodplain area) in disaggregated pieces than areas without adjacent slides. Indian Creek lacked significant deposits of large wood (jams or disaggregated pieces). The few deposits seen were mostly small collections of hardwoods.

## SUMMARY AND DISCUSSION

**Walker Creek**

Disturbance was severe along all of Walker Creek (Figure 4), and most of the total volume of sediment input by landslides and debris flows was routed long distances and exported from the watershed. Here, the 1997 flood resulted in simplified morphology and forest structure along the entire valley, and disturbance was transmitted to the Klamath River. We attribute the severity of this disturbance to the overwhelming volume of input sediment and the relatively low resistance of young floodplain forests along straight valley reaches.

May (1998) found that debris flows initiated from clear-cuts affected a greater length of stream than debris flows originating from forested sites. Similarly, Lancaster, et al. (2000) suggested large wood can moderate debris flow run-out distances, particularly for the largest events. We estimate the volume of sediment input was over 100 times more than the volume of large wood input for Walker Creek, an apparently high ratio of sediment to large wood. However, more mature conifer large wood in debris flows might not have reduced disturbance run-out (Mondry and Hilton, 2000) given the steep gradients, relatively unresistant valley forests, and low-angle tributary junctions (Benda and Cundy, 1990). Nonetheless, greater mature conifer large wood inputs may have had beneficial effects on sediment storage and future development of channel morphology (Keller and Swanson, 1979). Since mature conifer forests are mostly gone from headwater slopes and valley terraces, recruitment of large wood to mainstem valleys will depend more on streamside landsliding. This will require the preservation of some mature forests on streamside slopes.

**Indian Creek**

Flood effects were modest along most of Indian Creek (Figure 4) owing mainly to the relatively small volumes of sediment input to the channel network. Debris flows were uncommon in Indian Creek and many of our survey reaches were in wide, gentle valleys where debris flows are not expected. The observed flood effects resulted from water flooding that was not sediment-laden. However, the channel filling, channel widening, partial removal of riparian canopy, and the scarcity of large wood suggest channel complexity was reduced by this flood. Although channel morphology was affected by the 1997 flood, terrace morphology that dates to the larger 1964 flood was not significantly changed. Indian Creek may be incising and narrowing after the 1997 flood as documented by Lisle (1981) after the flood in 1964.

**Tompkins Creek**

Upper Tompkins Creek experienced severe disturbance, but impacts attenuated downstream (Figure 4) as sediment was removed from flows by deposition at sharp valley bends and on unmobilized hardwood terraces. Within and among reaches, disturbance was patchy as flood energy moved between the main channel, side channels, terraces, and the bases of valley walls. Many stream banks and some channel pools withstood flooding, as did large areas of riparian forest, particularly in downstream reaches. As well, this stream also had the greatest volume of large wood interacting with the bankfull channel after the 1997 flood. An accounting of these remnant and "new" (post-1997) valley and channel elements suggests increased morphologic complexity. We may expect positive effects on valley biological systems to follow.

## CONCLUSIONS

Large floods are natural elements that shape long-term valley form and significantly influence channel morphology and valley forest structure in steep watersheds of the Pacific Northwest. We documented a range of 1997 flood disturbance in three Klamath Mountain streams that was primarily dependent on the volumes of sediment delivered to valley segments. Forest management activities have likely altered flood disturbance processes in the Klamath Mountains of northern California. This is manifest in large landslides from roads and deforested hillslopes that generate debris flows with relatively small volumes of mature conifer large wood. These types of debris flows may be expected to have longer (and perhaps more severe) paths of disturbance. However, large landslides and debris flows can promote valley complexity given smaller sediment input volumes, more mature conifer large wood, and such variability as sharp valley bends. These observations highlight the importance of balancing sediment and large wood inputs during future (inevitable) erosional events by maintaining sources of mature conifers in the Klamath Mountains of northern California.

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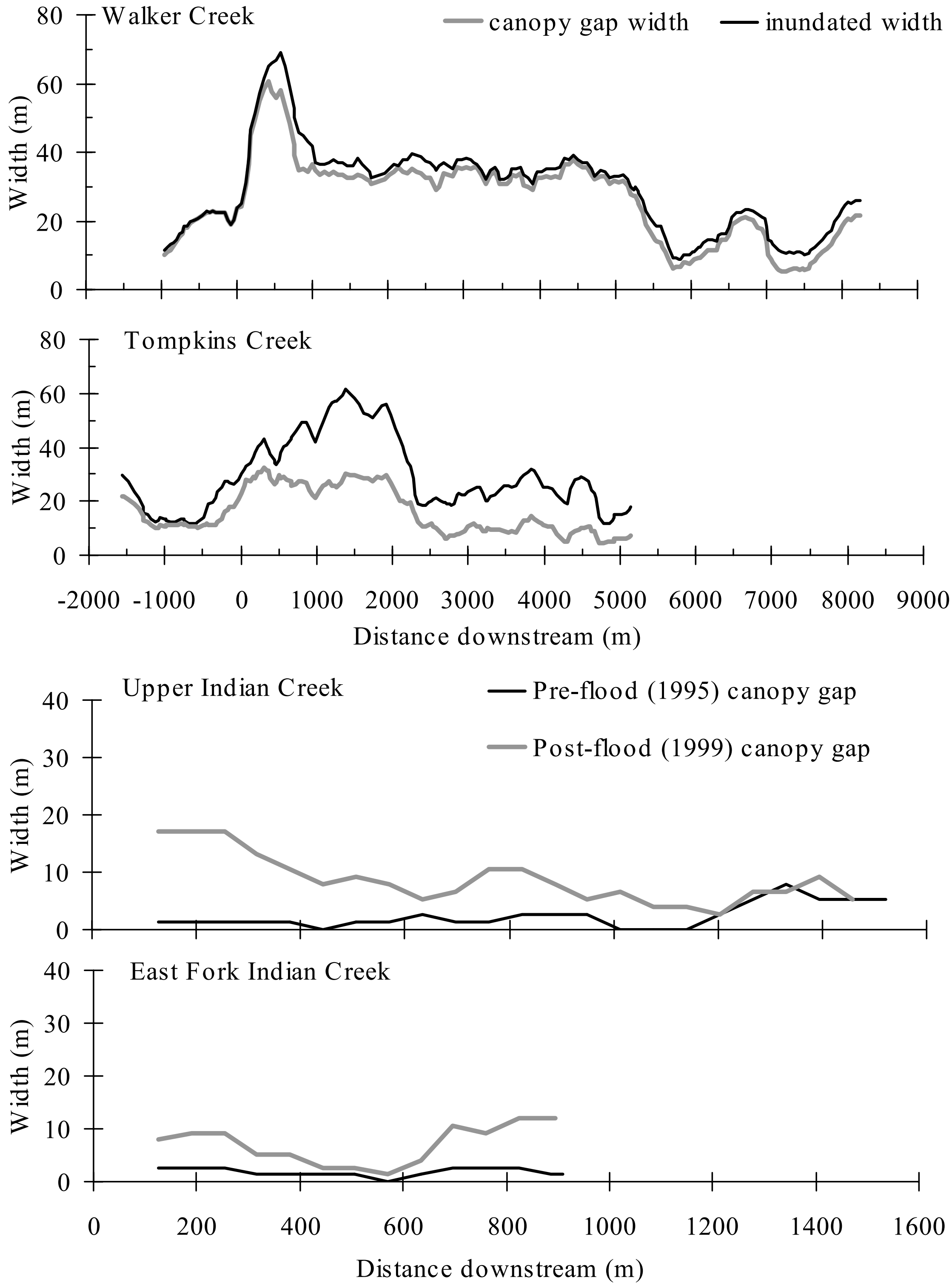


Figure 2 Effects of the 1997 flood on riparian forests along the study streams. The top 2 plots summarize inundation and canopy gaps along the Walker and Tompkins Creeks air photo (1:3,000) survey reaches with 10-point moving average trend lines. Note the separation of inundation and canopy gap widths in Tompkins Creek downstream of the valley bends. The bottom 2 plots illustrate subdued effects on Indian Creek canopy cover (3-point moving average trend lines). The Indian Creek plots do not show inundation and are at a much different scale than the upper plots.

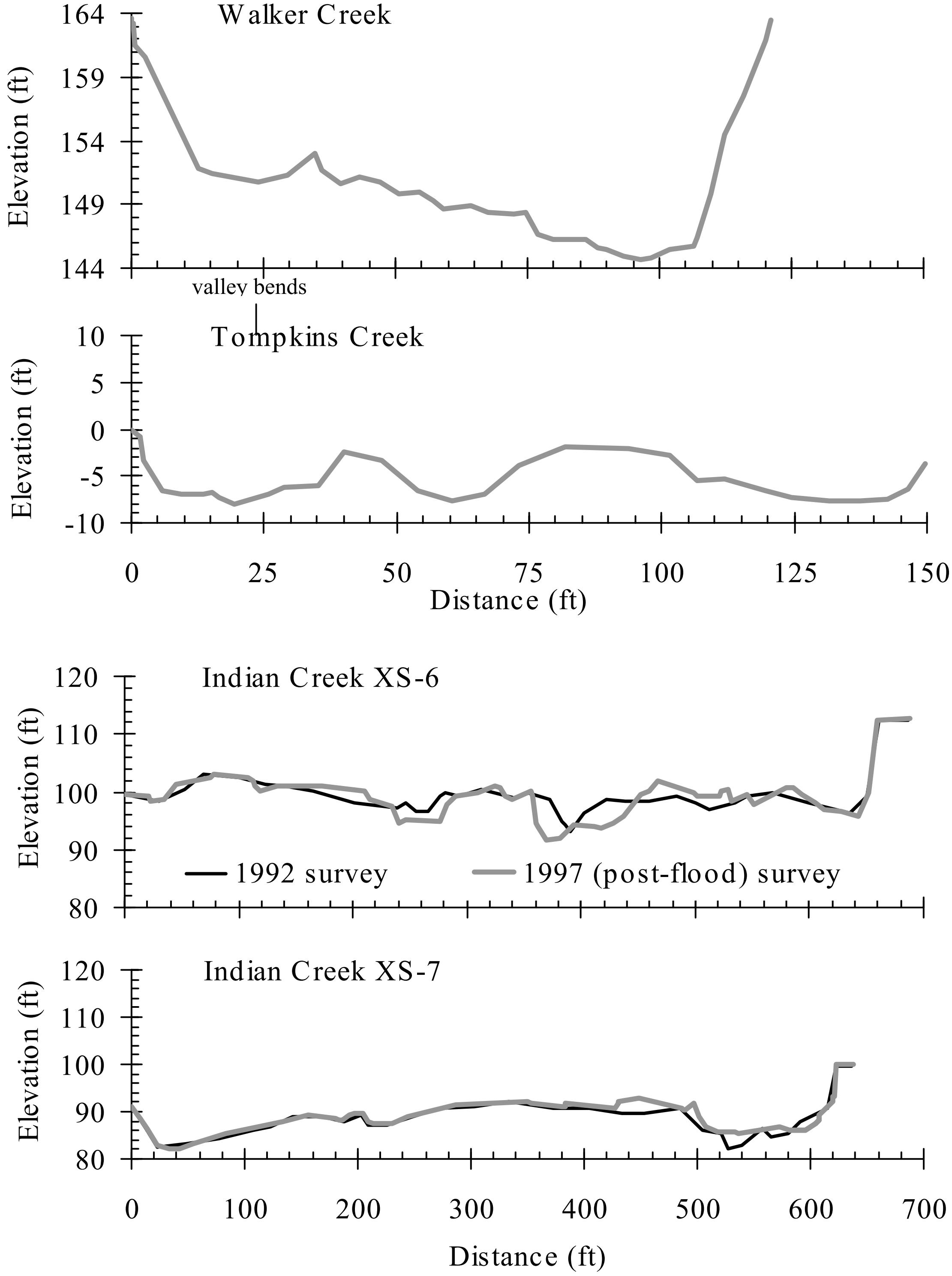


Figure 3 Cross sections of representative valley morphology. The top 2 plots are post-flood surveys in mainstem Walker and Tompkins Creeks. The entire Walker Creek valley was mobilized by flooding, but some alder terraces and channel banks remain along Tompkins Creek. The bottom 2 plots show pre-and post-flood surveys in mainstem Indian Creek. Scour and fill were mostly limited to the active channel while gross valley morphology was unchanged. Some channel widening and riparian tree recruitment occurred here. Note scale differences.

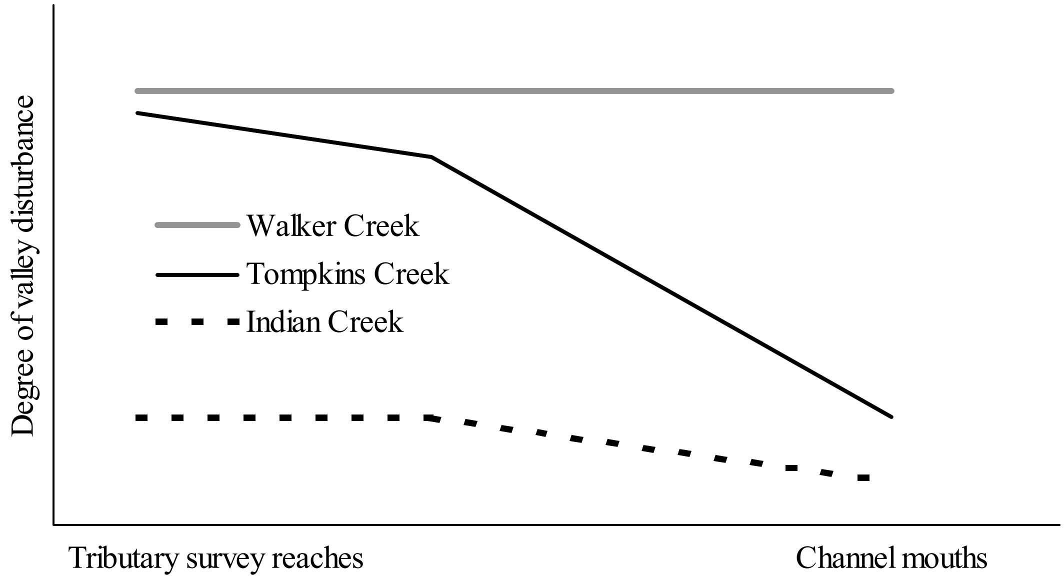


Figure 4 Conceptual view of flood disturbance along the three study streams. Valley disturbance was measured by the degree of riparian canopy removal and scour and fill of floodplain deposits. Severe disturbance did not reduce downstream in Walker Creek due to overwhelming sediment input volumes and low resistance of floodplains. Effects were relatively subdued in all of the surveyed Indian Creek reaches. Disturbance to upper Tompkins Creek was severe, but effects were attenuated significantly downstream. Disturbance in Tompkins Creek spans the range of effects documented in the other two study streams.

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## HYDROGEOPHYSICS IN THE KLAMATH BASIN OF OREGON

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The Langell Valley, in the eastern Klamath Basin, is lithologically typical of high desert valleys in the northern Basin and Range Province. Annual rainfall is 10 inches and groundwater is the primary source for irrigation, with wells yielding 10 to 6,000 GPM. Little is known about sighting wells or the capacities and extents of aquifers.

Geophysics was conducted here for hydrologic characterization and comparison of results with known well production. Electrical resistivity versus depth was profiled over 2 kilometers of lines using high frequency magnetotellurics with controlled and natural source fields. Field data were spatially wavelength filtered and modeled in 2-D.

Several profile features correlate very favorably with well information. High resistivity zones correlate with the depths of two separate production zones at a high yield well. The tops and bottoms of these zones are within 15% the high resistivity zones. A strong lateral resistivity contrast was observed here at all depths below surficial sediments, indicating a probable normal fault, likely contributing to the high yield. At a low production well, resistivies within its production zone were lower than those in the high production well. At the Lorella Deep Well, drilled by the DOGAMI, the depth to alteration beneath permeable basalts was well determined by low resistivity. At all three sites, sediment depth over permeable zones was determined within about 10 percent.

# RELATIONSHIP BETWEEN FLOWS IN THE KLAMATH RIVER AND LOWER KLAMATH LAKE PRIOR TO 1910

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## ABSTRACT

By 1910 efforts of the Reclamation Service to convert the bed of Lower Klamath Lake and the surrounding marshes to farmland had drastically altered the area's hydrology. There is considerable interest in restoring the natural hydrology of Lower Klamath Lake to pre-project conditions, but important questions remain about the historical relationship between the river and the lake. Although it is clear that water flowed into the lake from the river during times of high flows, the subsequent fate of that water is less clear. Hydrological data, historical accounts, and descriptions of soils and vegetation prior to 1910 were used to investigate this question. The evidence examined suggests that Lower Klamath Lake was neither an undrained basin nor a thoroughly drained floodplain. As peak river flows subsided in spring, lake waters flowed into the Klamath River, yet this drainage was only partial, and some salts accumulated. Thus, the lake was ecologically intermediate between the wetlands of California's northern river valleys and those of the Great Basin.

## INTRODUCTION

Prior to 1910, Lower Klamath Lake was a vast expanse of open water and marsh lands sustained by seasonal flows from the Klamath River. Water flowed from Upper Klamath Lake, through the Link River into Lake Ewauna, and then into the Klamath River (Figure 1). Between Lake Ewauna and Keno, the river meandered through "a flat, marshy country" (Henshaw and Dean 1915:655) for about 20 miles before descending over a natural rock barrier that stretched across the river at Keno. Water in the river periodically backed up behind the reef at Keno and spread out over the nearly level landscape upstream, flowing into Lower Klamath Lake through Klamath Straits. Water also flowed into Lower Klamath Lake from a number of springs.[1] These flows into Lower Klamath Lake and the adjacent marsh supported a complex of wetlands that covered more than 80,000 acres and provided habitat for many species of fish and waterbirds.

Beginning in the latter half of the nineteenth century, however, the hydrology of the Klamath Basin was altered by activities associated with white settlement. At first water was diverted for small, private irrigation ventures, but in 1906 the Reclamation Service began work on a massive reclamation project designed to drain Lower Klamath Lake and convert the lake bed and marshes to farmland. To accomplish this, the federal government signed an agreement in which the railroad companies agreed to construct an embankment across the marshes with a gate that would close Klamath Straits. The gates were permanently closed in the fall of 1917; this cut off all inputs from the Klamath River to Lower Klamath Lake (Jessup 1927). In the first year after the gates were

[1] Quinton (1908) concluded that springs contributed 130,000 acre-feet of water to the lake. This was based on the following calculations: (1) he estimated that evaporation removed 3 feet of water annually, (2) he assumed that 1.25 feet of this was contributed by precipitation and the rest (1.75 feet) by inflow, and (3) he multiplied 1.75 feet by 74,000 acres. Additional data on inputs from springs can be found in Hall (1908). (See discussion of hydrology data below.)

closed, the flooded area of the lake decreased by about 53% (from 76,600 acres to 36,000 acres). It took about 5 years for most of the waters of the lake to evaporate (Darr 1923).

President Theodore Roosevelt set aside 81,619 acres of lake and marsh habitat in 1908 (Executive Order No. 924), to serve as a "preserve and breeding ground for native birds," but within a decade and a half the lake had been drained, and reclamation had converted the preserve to a virtual "desert" (Nelson 1924:2). Eventually, flows were restored to Lower Klamath Lake, but the area's hydrology today is dramatically different from pre-project conditions (Hecht and Kamman 1996, Weddell et al. 1998).

Many parties are now interested in restoring pre-project conditions to the Klamath Basin, but detailed information on some aspects of hydrology prior to 1910 is lacking. In particular, many questions remain about the hydrological relationship between Lower Klamath Lake and the Klamath River prior to irrigation.

Although it is clear that water flowed into the lake from the river during times of high flows, the subsequent fate of that water is less clear. We know that the lake could not have been completely drained by the river as the lake elevation dropped, because much of the lake bed lies below the elevation of the reef at Keno, but many questions remain. Did the waters of the lake remain connected to the river throughout the year, or was a surface water connection severed in summer? If water flowed from the lake to the river, did that occur in summer, when flows were low, or in spring, when flows were high but declining? As temperatures rose and evapotranspiration consumed a considerable amount of lake water, did this loss of water lower the level of the lake enough to pull water from the river in late summer?

**SOURCES OF INFORMATION**

This report uses several sources of evidence to explore these questions, including hydrological data, historical accounts, and descriptions of the area's soils and vegetation. Each type of information has its advantages and disadvantages (Swetnam et al. 1999).

First, if reliable, long-term records of hydrological parameters such as stream flow were available, they could help answer the questions of concern in this investigation. Unfortunately, however, by the time stream gage records became available for the Klamath Basin, diversions had already begun. For this reason, it is not advisable to rely solely on this type of data to reconstruct the natural hydrology of the area. Another problem is that even when reliable information is available for some parameters, data on important other features is often missing. This makes it difficult to construct a model of the historical water budget.

Second, there are written and oral accounts of observations made by people who were in the area prior to reclamation. This source of information is direct and useful, but it must be interpreted cautiously because such accounts are subjective and reflect the biases, cultural context, and observational skills and memory of the informant. An additional problem is that it is sometimes hard to tell whether an account reports an actual observation or just repeats conventional wisdom.

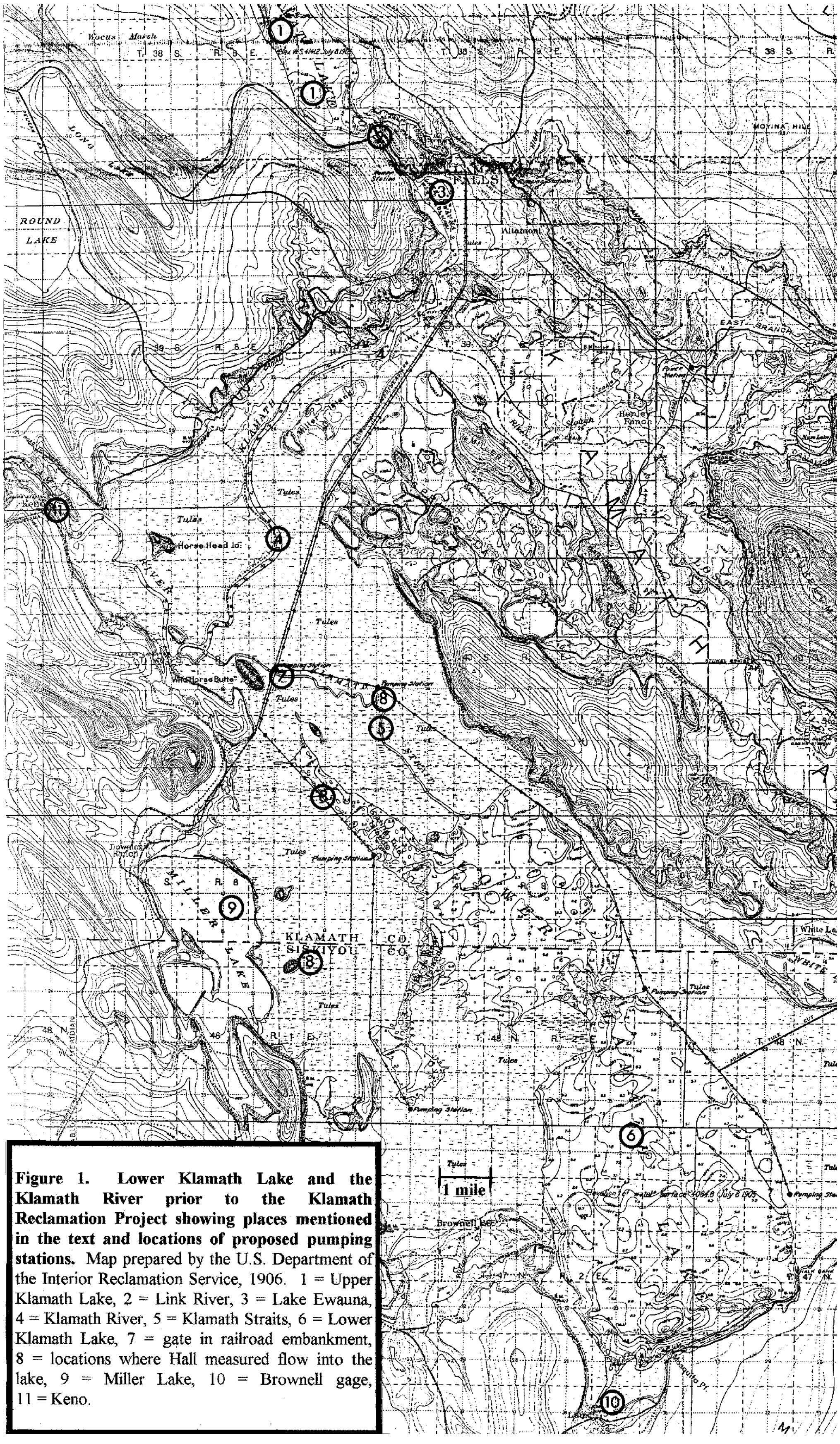


**Figure 1. Lower Klamath Lake and the Klamath River prior to the Klamath Reclamation Project showing places mentioned in the text and locations of proposed pumping stations.** Map prepared by the U.S. Department of the Interior Reclamation Service, 1906. 1 = Upper Klamath Lake, 2 = Link River, 3 = Lake Ewauna, 4 = Klamath River, 5 = Klamath Straits, 6 = Lower Klamath Lake, 7 = gate in railroad embankment, 8 = locations where Hall measured flow into the lake, 9 = Miller Lake, 10 = Brownell gage, 11 = Keno.

Finally, soils and vegetation integrate information about environmental conditions, including hydrology. Plants and animals are useful as environmental indicators because each species is able to tolerate specific conditions. If we have information on what plants grew in and around Lower Klamath Lake before it was drained, we can infer much about the hydrological regimes and water conditions at that time. Soils, on the other hand, reflect environmental conditions during the period when they were formed. This means that they provide information about conditions over a longer period of time than plants.

If all the water that entered Lower Klamath Lake and its adjacent marshes were consumed by evapotranspiration, we would expect to find soils and plants characteristic of an undrained basin. The soils should contain salts accumulated through evaporation, and the plants should be able to tolerate high concentrations of salts. If, on the other hand, water returned to the Klamath River after flowing through the lake and marshes, then salts would be flushed into the river, and we should find soils and plants typical of a well drained freshwater ecosystem. Intermediates between these 2 extremes are, of course, possible.

Taken together, information on soils and vegetation can supplement hydrological data and historical accounts. Like those sources of data, however, the value of this information depends upon how accurately it was recorded and how well it was preserved.

Evidence from these sources of information is reviewed below.

## EVIDENCE

### Historical accounts: 1850-1915

On August 12, 1855, Lieutenant Robert Williamson and a small group of men left a party of surveyors exploring Lost River and made a side trip to explore Lower Klamath Lake (Klamath Basin Historical Society 1984). Lieutenant Henry Abbot reported that in Williamson's opinion, "in seasons of high water the marsh is overflowed and the river can properly be said to flow through the lake. In the summer, however, its bed is very distinct, and it does not join the sheet of water forming the lake" (Abbot 1857).

In a report on the Klamath Indians published in 1890, the ethnographer Albert Gatschet concluded that the lakes of the Klamath Basin were partially drained by the Klamath River. He suggested that "the supply of water received during the year" exceeded evaporation, and "the excess flow[ed] off in the streams which drain the basin." The drainage was not complete, however, and many large lakes remained. "Those which possess no visible outlet necessarily contain brackish water, as the alkaline materials in them are not removed by evaporation" noted Gatschet (1890:xvii-xviii).

A somewhat different picture is painted in the recollections of U. E. Reeder, captain of the steamship *Canby*. In 1888, steamboat traffic began on the Klamath River and Lower Klamath Lake (Farnell 1980), and beginning in 1905 daily trips were made between Klamath Falls and Laird's Landing on the south end of Lower Klamath Lake (Drew 1974). When interviewed in 1948, U. E. Reeder reported that they

> always tried to haul lumber to the Lower Lake in the spring when the water was running through the Straits into Lower Klamath lake. And in the fall, we hauled hay from

> Oklahoma [Landing] through the straits into the river, when the water was draining out of the Lower Lake. We also tried to time it right so we would reach the straits at night. After entering the straits we would go to bed and let the boat float and the next morning wake up in Lower Klamath Lake, in the fall when the lake was draining into the river and we were hauling hay out we did the same, enter the straits and go to bed and the next morning we would be on Klamath River (Helfrich 1965:18-19).

These accounts leave unresolved the question of whether the lake supplied water to the Klamath River in the summer and autumn. Some observers implied that much of the water that entered the lake evaporated and that the surface waters of the lake were not connected to the river in summer. On the other hand, Captain Reeder suggested that water flowed from the lake to the river in autumn and that these flows were deep enough to permit steamship navigation. Reeder's comments seem to imply fairly thorough flushing of the lake, whereas Williamson's and Gatschet's suggest the opposite.

In the first decade of the twentieth century, a number of investigations of Lower Klamath Lake were undertaken in connection with the Reclamation Service's plans to drain it. Although the writers of these reports agreed that water flowed into the lake from the river in spring and subsequently flowed in the reverse direction, they disagreed about when the reverse flows occurred.

In a report on water quality, Sheldon Baker wrote that a "large part of the water of the lake is contributed during flood season by Klamath River, during dry seasons there is said to be a current in the opposite direction" (Baker 1905:2). According to Baker, the reverse flow "is also indicated by analyses of water in the channel," but I did not find any data on flow direction associated with his report. Baker concluded that "the alternate renewal of fresh water and summer overflow to the river tends to keep the lake water fresh" (Baker 1905:2).

Henshaw and Dean concurred with Baker's interpretation. They wrote in their report on the surface water supply of Oregon, published in 1915, that during "high stages water flows from Klamath River into Lower Klamath Lake, and during low water the direction of flow is reversed" (Henshaw and Dean 1915:655).

On the other hand, some observers concluded that water did not flow from the lake into the river in summer. Thomas Means, for example, reported in 1905 that the principal outlet of the lake was evaporation and therefore the concentration of soluble salts was constantly increasing (summarized in Darr 1923). Arthur Sweet and I. G. McBeth surveyed the soils of the Klamath Reclamation Project in 1908. They concluded that water flowed into the lake from the end of the dry season through midwinter, but that it reversed its direction when peak flows subsided in the spring:

> The outlet [for Lower Klamath Lake] is Klamath River. . . . During seasons of heavy rainfall or during the long dry summers, the Klamath River flows southward through these straits, but at certain seasons when the river begins to fall this channel carries considerable water northward from the lower lakes into the Klamath River, thus presenting the anomaly of a river flowing in one direction during a portion of the year and in the opposite direction at other times (Sweet and McBeth 1910:8; emphasis added).

Louis Hall, who obtained data on the margins of the lake and marsh in September and early October of 1908, concluded that with the exception of a few freshwater creeks, the direction of flow in the straits in early fall was from the river into the marsh and lake. After exploring "the entire margin of the lake, bays, and straits, all inlets and bayous," he reported that "I have on each of my visits found the current in the straits to be inward, or toward the lake" (Hall 1908:1,5):

> The only fresh water creeks discharging directly into the lake are Sheepy Creek and Willow Creek, the fresh water character of each of which is plainly discernible [for] some distance out from shore. Dorris Creek discharges directly into Miller Lake, and Cottonwood Creek is lost in the marshes. In all of the other bayous the water is filled with duck grease, and is either stagnant or has a slight flow inward, or toward the marsh. Particular attention was taken of the inlet into the straits in Section 19, Tp. 40 S., R. 9 E., and the inlet into shallow bay in Section 36, T. 40 S. R. 8 E . . . . In the first case the flow on two different days was inward, and in the second case the water was absolutely stagnant. . . .
>
> In low water season the bayous noted, instead of being outlets for spring water, as so considered by some persons, are really inlets whereby water is supplied to the marshes. One particular case in Sec. 14, T. 48 N. R. 1 E. was noted in which the inward current on a perfectly calm day was nearly 1/4 foot per second on a cross-section of about 50 sq. ft. (Hall 1908:1-2; emphasis added).

The geological setting of the Klamath basin is similar to that of California's Pit River Basin: "both form elongated troughs, and the waters escaping from them reach the lowlands through deep cuts in resistant material" (Gatschet 1890:xviii). In a report prepared in 1911, William Heileman compared the marshes of Klamath Lake to the McArthur Marshes in California's Pit River Valley. He concluded that although the soils of the 2 marshes were similar in some respects, the soils of the McArthur Marsh were more thoroughly drained (summarized in Darr 1923).

Again, the evidence pertaining to the direction of summer flows is contradictory. Baker, as well as Henshaw and Dean, claimed that water flowed out of the lake into the river during "dry seasons" or "periods of low water." This implies that the lake was fairly thoroughly flushed each year. On the other hand, Sweet and McBeth, Means, Hall, and Heileman reached the opposite conclusion: water flowed southward into the lake in late summer or early fall, rather than flowing from the lake to the river; the chief outlet for lake water in periods of warm weather was evapotranspiration, and therefore salts were not thoroughly flushed from the lake and surrounding marshes. Of these sources, the most complete data are provided by Hall. It is also worth noting, however, that flows were unusually low in the autumn of 1908, when Hall made his measurements, so it is possible that the situation he encountered was not typical.

**Soil and vegetation data**

In arid and semiarid climates, salts that are carried into soil by water can accumulate when soil water is lost by evaporation and transpiration. This may create conditions that are saline, sodic, or a combination of the 2. In current usage, the term saline refers to soils with excess soluble salts, and the term sodic denotes soils with excess exchangeable sodium (Hausenbuiller 1978).

The terminology that was formerly used for these conditions is somewhat confusing. The phrase "black alkali" denoted sodic conditions in which the dominant salt was sodium carbonate. The name stems from the fact that high levels of sodium carbonate can cause black deposits to accumulate at the soil surface. Early soil scientists also sometimes lumped the concepts of salinity and sodicity together under the concept of "alkali," a term they used to denote any situation in which salts were present in concentrations deemed harmful to crops (Heileman 1901, Breazeale 1917, Scofield and Headley 1921).

At the outset of the Klamath Reclamation Project, Bureau of Reclamation scientists conducted numerous soil investigations to determine if the soil of Lower Klamath Lake was suitable for agriculture. They concluded that the levels of alkali or black alkali at Lower Klamath Lake were potentially injurious to crops (Quinton 1908, Sweet and McBeth 1910, Scofield and Briggs 1911).

In 1908, Sweet and McBeth prepared a soil survey of the Klamath Project. The information in their report can be used to make inferences about which areas of the lakes and marshes dried out most frequently. They reported finding "considerable quantities of black alkali" in the "ooze" beneath the open waters of Lower Klamath Lake (Sweet and McBeth 1910:32). In addition, "alkali" was prevalent in areas that dried out seasonally, such as poorly-drained depressions and the margins of the lake and marsh. The Klamath loam soil "along the margin of the marsh lands of Lower Klamath Lake," carried "alkali" in most places, "but only in the small basinlike depressions and in the areas along the margins of the marshes" was the quantity "sufficient to be injurious" (Sweet and McBeth 1910:29). "At almost all points along the edge of the marshes" they found "a strip of soil so highly charged with alkali that it [wa]s unfit for crop use." This accumulation "resulted from circumstances favorable to the evaporation of alkali-charged water" (Sweet and McBeth 1910:38).

This evidence on the distribution of "alkali" suggests that Lower Klamath lake was intermediate between an undrained basin and a freshwater floodplain. When water flowed from the lake back into the river as flows receded in spring, some salts were flushed from the system, but in areas such as the lake margin and poorly drained depressions, both of which dried out in most summers, salts accumulated.

This conclusion is supported by information about the distribution of plant species in and around Lower Klamath Lake. The dominant vegetation in the lake was "tules," or hardstem bulrush (*Schoenoplectus acutus*) (Finley 1907, Bryant 1914), along with "an admixture of cattails [*Typha* sp.], flags [probably *Acorus calamus* or *Iris pseudacorus*], mint [*Mentha* sp.], sawgrass, and yellow pond lilies [*Nuphar lutea* ssp. *polysepala*]" (Sweet and McBeth 1910:7). It is not clear what species Sweet and McBeth meant when they referred to "sawgrass." None of the other plants in their list are characteristic of highly saline or alkaline conditions (Ungar 1974, Hickman 1993), although hardstem bulrush is moderately tolerant of salinity (Kaushik 1963, Christensen and Low 1970). The "native growth" on the Klamath loam soils at the edge of the marsh, however, was principally "sagebrush [*Artemisia tridentata*], which was usually rather stunted, accompanied by large rabbit brush [*Chrysothamnus* spp.], salt grass [*Distichlis spicata*], and other alkali-resistant plants" (Sweet and McBeth 1910:29). Sagebrush is not tolerant of salinity, but the "stunted" character of the lake margin sagebrush suggests that it was not growing in ideal conditions. Rabbit brush grows in a wide range of habitats, and salt grass is tolerant of saline and alkaline soils (Ungar 1974, Hickman 1993).

Isolated lakes had higher concentrations of salts and more salt-tolerant vegetation. For example, Miller Lake (Figure 1) was "separated from the tule or swamp land by a high sandy reef" (Sweet and McBeth 1910:7). Its inflow, which came from Dorris Creek and a few springs, "was insufficient to overcome the evaporation" (Hall 1908:4). As a result, the water was "quite alkaline,"[2] and tules did not "grow on its shores" (Jessup 1927:8).

**Hydrology data**

Stream gage data are potentially an important source of information about the timing of return flows. Daily stream gage records are available for flows at the Link River at Klamath Falls and for the Klamath River at Keno, beginning in 1904. If other inputs to and outputs from Lower Klamath Lake could be estimated, the difference between flows at Link River and at Keno could be used to determine the direction of flow in the Klamath Straits. A net gain in water between the Link River and Keno gages (after inputs, such as groundwater, precipitation, and other sources of surface water, and outputs, such as evapotranspiration, were adjusted for), would indicate that water flowed from the lake into the river; a net loss of water between these 2 stations would indicate that water flowed into the lake.

Unfortunately, however, there is a great deal of uncertainty about those parameters. Data on precipitation are available, but little reliable information is available on other inputs and outputs. We do not know how much water left through evapotranspiration. Quinton (1908) estimated that about 3 feet of water per unit of area was lost annually through evaporation from the surface water of Lower Klamath Lake, but Hall (1908) concluded that the lake's annual rate of evaporation was 5 feet. The amount of water that was diverted is not known, nor do we know the magnitude of inputs from groundwater recharge or from tributary creeks between Link and Keno. Much of the stream gage data is also open to question. Henshaw and Dean (1915:664-665) considered the records for the Link River gage unreliable for the period prior to June 6, 1908 and also after "some time during the summer of 1909."

An alternative approach is to compare simultaneous surface water elevations for the lake and the river. When the elevation at Keno was higher than the elevation of the lake, water would have flowed from the river to the lake, and conversely, when the elevation of the lake surface was greater than that of the river, water would have flowed from the lake to the river. Daily readings are available for a gage located on the lake 4 miles east of Brownell, California, for the period from January 23, 1907 to July 15, 1909, and for the Klamath River at Keno from May 31, 1904 through September 30, 1910 (Henshaw and Dean 1915).

Differences in mean monthly elevations at the Keno and Brownell gages for the period when data are available for both gages are plotted in Figure 2. These data suggest that water flowed into the lake when flows were increasing and out of the lake as peak flows subsided.

In the water year of 1906-1907, which was a relatively wet year (with a peak lake elevation of 4,087.06 feet), the elevation of the Klamath River was greater than the elevation of Lower Klamath Lake during January and February of 1907 (Figure 2). Water would have flowed into the lake from the river during this period. In other words, as the elevation of the river increased, the lake filled

[2] According to data provided by Sweet and McBeth (1910), the total concentration of salts in Miller Lake was more than 10 times that of Lower Klamath Lake.

up.  On the downward part of the hydrograph (April through July of 1907), the elevation of Lower Klamath Lake was higher than the elevation of the Klamath River, so water would have flowed back into the river from the lake at this time.  Thus in a relatively wet year, the lake stored some of the river's water and released it gradually.

This effect was less pronounced in 2 relatively dry water years, 1907-1908 and 1908-1909. Peak lake elevations in these years were lower than in 1906-1907 (4,085.86 and 4,086.18 feet respectively), and the difference between lake elevations and river elevations during the period when elevations were declining was slight.  On the other hand, the hydrographs for these years clearly show that river elevations exceeded lake elevations on the upward part of the curve.  During those periods, water flowed from the river into the lake.

Thus, the overall effects of the lake were to lower the peak of the Klamath River hydrograph and shift it to the right, compared to what the hydrograph would have been if the river had flowed through a steep canyon that prevented water from spreading out over the landscape.  Hecht and Kamman (1996:Figure 2) noted just such an effect on the Klamath River hydrograph.  A graph of _mean monthly flows over several decades as a percentage of mean annual flows for the Trinity, Eel, and upper Klamath Rivers reveals that the Klamath River hydrograph has a lower peak and is shifted to the right relative to the hydrographs of the other 2 rivers.  Hecht and Kamman attributed these differences to groundwater recharge in the area drained by the Klamath Basin, but they also noted that prior to the Klamath Project, "the lake and wetlands retained much of the water from the first storms of the year" (Hecht and Kamman 1996:8, 21).  By storing and subsequently releasing this water into the river, Lower Klamath Lake would have augmented the effects of groundwater in shifting the Klamath River hydrograph to the right.

The data on lake and river elevations do not provide any evidence that water flowed from the lake back into the river in late summer or fall (the troughs of the hydrograph).  River elevations were equal to or greater than lake elevations in August and greater than lake elevations in September and October for the 2 years for which data are available, so water would have flowed from the river into the lake at those times.

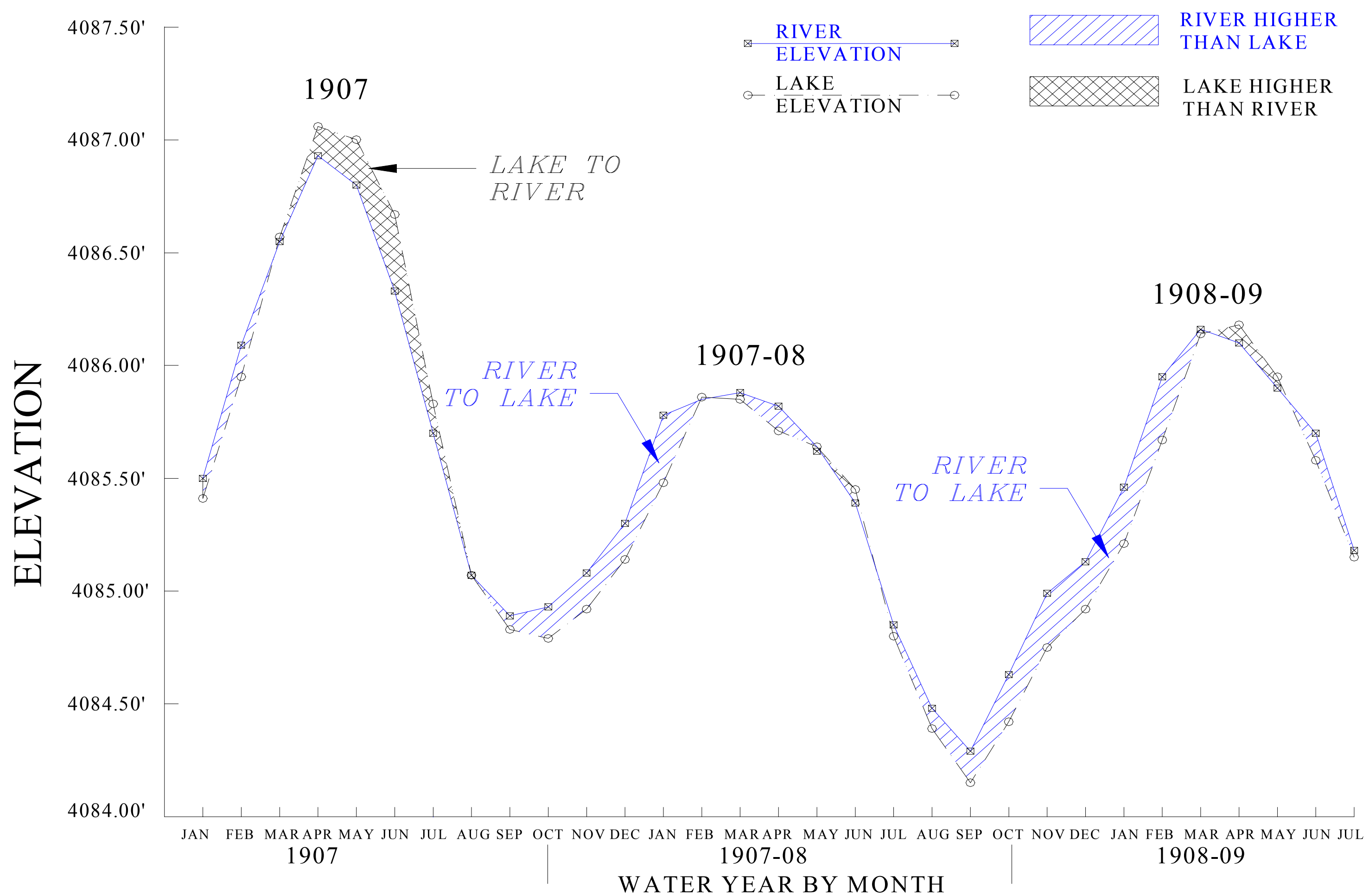


**Figure 2. Comparison of Klamath Lake elevations at Brownell and Klamath River elevations at Keno from January 1907 through July 1909, showing major flows from the river to the lake and from the lake to the river.** Cross-hatched areas indicate periods when the elevation of the lake surface at Brownell was higher than the elevation of the river at Keno and water flowed from the lake into the river. Single-hatched areas indicate periods when river elevations at Keno exceeded lake elevations at Brownell and water flowed into Klamath Lake. (Based on information in Henshaw and Dean 1915:681-686.)

## CONCLUSIONS

Lower Klamath Lake was neither an undrained basin nor a thoroughly drained floodplain. At times, its waters flowed into the Pacific Ocean via the Klamath River, yet this drainage was only partial, and some salts accumulated in dry seasons and years. Thus, the lake was ecologically intermediate between the wetlands of California's northern river valleys and those of the Great Basin.

Most of the evidence from historical accounts and hydrology suggests that prior to 1917 water flowed from Lower Klamath Lake into the Klamath River as peak river flows subsided in spring. This evidence also supports the conclusion that water did not typically flow from the lake to the river in late summer or early fall. Instead, if there was any flow at that time, it was from the river into the lake.

A few accounts support the opposite interpretation, however. There are 2 possible explanations for this. One possibility is that some of the accounts are inaccurate. The most specific of the anecdotal accounts asserting that water flowed from the lake to the river in the fall is Captain Reeder's testimony about the steamship *Canby*. This narrative was recorded in 1948 as part of an oral history project. Because the interview took place nearly half a century after the events Reeder describes, it is possible that his recollections were inaccurate or embellished. Other accounts suggesting that water flowed out of the lake in summer or fall may have been based upon speculation about the actual timing of return flows. Many people were aware that some of the water which flowed into the lake in winter later flowed back into the river, and they may have simply assumed that those return flows took place in summer.

Another possibility is that the discrepancies reflect different conditions in different years. Because the timing and amount of flows in the Klamath River varied from year to year, more water flowed into the lake in some years than in others. In years when a lot of water entered the lake and lake elevations rose considerably, the period when water flowed from the lake back into the river would have lasted longer into the summer (Figure 2).

Although there are some discrepancies in the historical accounts, other sources of information support the conclusion that in many years the lake was not drained by the river throughout the summer. Data on historical soils and vegetation are particularly important in this connection, because they reflect conditions during preceding years and decades rather than a single water year. These data indicate that evaporation and transpiration during hot, dry periods allowed salts to accumulate, especially in poorly drained basins and shallow areas such as the margins of Lower Klamath Lake and the adjacent marsh. This is not what we would expect to find if salts were flushed from the lake in late summer.

The wetlands of the Klamath Basin have been termed the "Everglades of the West," but they were a truly unique ecosystem that combined characteristics of Pacific coast and inland wetlands. Like the Everglades, however, they have been profoundly altered by changes in hydrology. An understanding of the relationship between the flows in the lake and the Klamath River provides valuable information on reference conditions that can be used as a template for restoring this valuable ecosystem.

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## THREE CHALLENGES FOR INSTREAM FLOW MODELING

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Efforts to model instream flows face numerous challenges, some so severe that the scientific defensibility of instream flow modeling has been challenged (Castleberry et al. 1996). Here I discuss three distinct challenges that face users of PHABSIM, the most commonly used method for evaluating instream flows. (1) Flow fields in natural channels are highly complex, and fine-scale patterns in the flow field can be important to fish such as salmonids that hold feeding positions in streams; modeling the flow field at these length scales is exceedingly difficult at best. (2) Salmonid habitat extends down into the hyporheic zone, especially for spawning and incubation, but existing instream flow models do not deal with the hyporheic zone or with patterns in hyporheic flow. (3) Methods for developing habitat suitability criteria from observations of fish involve implicit assumptions, for example that the stream is "fully seeded," that are poorly defined and biologically dubious. At the least, these challenges require users of PHABSIM or other instream flow models to adopt a critical attitude, to test the predictions of their modeling efforts carefully, and to report the uncertainty in their predictions to decision makers.

## PHYSICAL AND CHEMICAL WATER QUALITY MONITORING IN THE KLAMATH RIVER BASIN: 2000

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A comprehensive, basin-wide water quality monitoring program for physical and chemical water quality constituents was implemented during the April through November period during 2000. The primary project objective was to gather water quality information to improve baseline characterization of Klamath River water quality for anadromous fish restoration measures. Sub-objectives included identifying seasonal trends in water quality, sampling physical parameters continuously (e.g., hourly) to characterize diurnal response of selected parameters, estimating reservoir water quality response, and obtaining additional information for existing flow and water quality models.

The monitoring program consisted of six related tasks, including: (1) semi-monthly grab river sampling, (2) continuous water quality probe deployment, (3) water temperature monitoring, (4) synoptic water quality surveys, (5) a reservoir sampling program, and (6) an attached algae investigation. The project covered approximately 210 miles for river from Link Dam (upper Klamath Lake) the Klamath River downstream of the Trinity River. Not all project elements spanned the entire project area.

A primary goal of the project was to maintain quality assurance throughout the project and

deliver data that would support scientific analyses. As a result an invaluable project result was quality assurance plans for water quality grab samples, water quality probe deployment, and temperature logger deployment. Program data/findings will be discussed, but the focus of the presentation will address the importance of water quality sampling program design, planning, and implementation, and the challenges that face those individuals, organizations, and agencies undertaking such work. The work was sponsored by the United States Bureau of Reclamation and completed in cooperation with the Unites Stated Forest Service, California Department of Fish and Game, PacifiCorp (both field support and funding), Yurok Tribe, Hoopa Valley Tribe, as well as several individuals who assisted in field support and access.

## RECENT PALEOLIMNOLOGY OF UPPER KLAMATH LAKE, OREGON

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Sediment cores were collected from Upper Klamath Lake in October , 1998 and analyzed for $^{210}$Pb, $^{14}$C, $^{15}$N, N, P, C, Ti, Al, diatoms, *Pediastrum*, and cyanobacterial akinetes. These results were used to reconstruct changes in water quality in Upper Klamath Lake over the last 150 years. The results showed that there was substantial mixing of the upper 10 cm of sediment, representing the previous 20 to 30 years. However, below that, $^{210}$Pb activity declined monotonically, allowing reasonable dating for the period from about 1850 to 1970. The sediment accumulation rates (SAR) showed a substantial increase in the 20$^{th}$ century. The increase in SAR corresponded with increases in erosional input from the watershed as represented by the increases in sediment concentrations of Ti and Al. The upper 20 cm of sediment (representing the last 150 years) also showed increases in C, N, P, and $^{15}$N. The increases in nutrient concentrations may be affected to various degrees by diagenetic reactions within the sediments, although the changes in concentrations were also marked by changes in the N:P ratio and in a qualitative change in the source of N as reflected in increasing $\delta^{15}$N. The diatoms showed modest changes, particularly in the upper sediments, with increases in *Asterionella formosa, Stephanodiscus hantzschii*, and *S. parvus*. *Pediastrum*, a green alga, was well-preserved in the sediments and exhibited a sharp decline in relative abundance in the upper sediments. Total cyanobacteria, as represented by preserved akinetes, exhibited only minor changes in the last 1000 years. However, a taxa which was formerly not present in the lake 150 years ago, *Aphanizomenon*, has show major increases in recent decades. Although the mixing in the upper sediments prevents high-resolution temporal analysis of the history of Upper Klamath Lake, the

results demonstrate that major changes in water quality have likely occurred leading to a major modification of the phytoplankton assemblage. The changes in sediment composition are consistent with land use activities during this period that include substantial deforestation, drainage of wetlands, and agricultural activities associated with livestock and irrigated cropland.

## REASSOCIATING WETLANDS WITH UPPER KLAMATH LAKE TO IMPROVE WATER QUALITY

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### ABSTRACT

This paper explores the role of in-lake wetlands in regulating water quality of Upper Klamath Lake and Agency Lake (UKL). The open water surface area of UKL is approximately 77,590 acres (maximum pool elevation). Prior to diking and draining there were approximately 51,510 acres of wetlands at lake elevation at the edges of the lake. Including the wetland littoral area as part of the lake would mean that approximately 46.2% of the presettlement lake area was wetland. The relatively atypical extent of the presettlement littoral wetland area of UKL suggests that well-known wetland functions associated with nutrient uptake and wetland plant decomposition may have regulated the quality of the lake. Approximately 34,140 acres of in-lake wetlands were isolated from the lake through diking and draining. This was a 66.3% reduction in in-lake wetlands and a 30.4% reduction in total lake area. Support for a hypothesis is presented that the isolation of former wetlands from UKL by diking and draining has degraded the water quality of this lake primarily by the resultant deprivation of wetland functions and not by subsequent agricultural drainage discharges. Nearly 17,553 acres of agricultural land has been purchased for reclamation to wetlands behind dikes, below lake level since 1995 to improve the quality of UKL. Recommendations are made for reassociating reclaimed wetlands with the lake, along with farmed wetland areas, and optimizing performance of in-lake wetlands, to improve lake water quality.

### INTRODUCTION

The role of littoral area marshes in regulating lake water quality will depend on a variety of factors, including the size of the marsh relative to the lake area and volume, location of the marsh in the lake or adjacent to inflowing streams, and seasonal changes in the marsh. Littoral marsh areas do influence lake quality (Wetzel 1975). The uncertainty is related to the extent of the influence on the lake. The need to understand the interaction between the wetlands associated with lakes and lake water quality has been stated in early wetland literature (e.g. Prentiki et al. 1978) and is still being emphasized in recent wetland publications (e.g. Lodge *et al*. 1988; Keogh *et al*. 1999).

Upper Klamath Lake, which is the largest freshwater lake in Oregon and notable for its extensive marshes, has achieved additional notoriety for its extensive blue-green algae growth occurring in summer and early fall (Johnson, *et al*., 1985). The excessive growth of microscopic blue-green algae (cyanobacteria), dominated by *Aphanizomenon flos-aquae*, is linked to seasonally degraded lake water quality and the poor condition of sucker fish populations that once flourished in the lake and are now listed as endangered species.

Recent investigations and analyses by the U. S. Geological Survey (Bortleson and Fretwell, 1993; Laenen and LeTourneau, 1996; and Snyder and Morace 1997) and Humboldt State University (Gearheart, *et al.*,1995) have concluded that the conversion of wetlands to farmland and the discharge of agricultural waters from these lands have accelerated eutrophic lake conditions and affected fish and waterfowl. A recent sediment investigation by Eilers *et al*. (2001) has documented changes in sediment quality during the past century that reflect accelerated eutrophic lake conditions. The appearance of *Aphanizomenon flos-aquae* reproductive cells in Upper Klamath Lake may also have occurred for the first time in the past 150 years.

In an attempt to compensate for wetland losses, both the federal government and privately funded organizations have, with support of some wetland scientists (e.g. Gearheart *et al*. 1995), purchased former farmed and ranched wetlands areas and are reclaiming these areas as wetland. The present total of this intended reclaimed wetland area is 17,553 acres, a combination of Agency Lake Ranch (Bureau of Reclamation, 7,159 ac), the Wood River Ranch (Bureau of Land Management, 2,880 ac), the Williamson River Delta Preserve (The Nature Conservancy, 6,960 ac), and portions of Caledonia Marsh (Running Y Ranch/Resort, 554 ac). The land surfaces of these areas to be reclaimed are at elevations six or more feet below maximum lake elevations. The total investment to acquire these former wetland areas has been $19-20 million. The cost of reclaiming and developing wetlands is additional. The reassociation of these reclaimed wetlands with the lake is proceeding very slowly.

Other than defining which wetlands were lost over the past 100 years, there has been no attempt to assess the function of the extensive wetland component of the lake prior to diking and draining, and, there has been no assessment of the function of the extensive wetlands that remain in the lake. The failure of the lake's investigators in the past 40 years to assess the potential significance and consequences of the removal of around 34,140 acres is the impetus of this paper. The objective of this paper is to present an alternative paradigm for understanding the effects of wetland loss on the quality of Upper Klamath Lake, and, present suggestions for reclaiming wetland functions lost to improve the quality of the lake.

## WETLAND LOSS AND GAIN AT UPPER KLAMATH LAKE

The comprehensive wetland classification system of the U. S. Fish and Wildlife Service (Cowardin *et al*. 1979) defines lakes, as lacustrine wetlands (one of five wetland systems), as having two components: a littoral and a limnetic area. As a suggestive rule, the lower limit of the shallow littoral area is two meters in depth. Since Upper Klamath Lake (UKL) surface water elevation has been fluctuating approximately 4 ft during the course of a water year since construction of the Link River Dam in 1921 (U. S. Bureau of Reclamation 2001), the potentially vegetated shallow area can be very wide in this shallow lake, and at certain times at UKL, very dry.

The location of littoral, jurisdictional wetland regulated by the Oregon Division of State Lands and the U. S. Army Corps of Engineers has not been sufficiently defined at UKL. However, the U. S. Fish and Wildlife Service wetland maps for the Klamath Basin, based on earlier, and in some cases black and white aerial photography, are good approximations of where wetland is located.

The current geographical information system (GIS) data in the Klamath Basin (e.g. the Bureau of Reclamation wetland GIS theme) is the digital form of the USFWS maps.

The estimates of where littoral wetlands used to be, but which have been isolated from lake through diking and draining, appear to be relatively accurate. These estimates are based on an analysis of soil types and elevation and are supported by aerial photographic analysis. Snyder and Morace (1997) provided a summary of the sequence of wetland loss and maps showing the location of wetlands openly associated with the lake and former wetland areas behind dikes. Earlier work which was focused on identifying these areas accurately include (Atkins 1970, U. S. Fish and Wildlife Service 1979, and Carlson 1993).

The Bureau of Reclamation in its 1997 estimate of what constitutes the area and volume of Upper Klamath Lake (UKL), which in this paper will include Agency Lake, has included wetlands at lake level which are seasonally inundated by fluctuating lake water levels as part of the lake area and volume (Basdekas 1997). Table 1 provides an overview of how the lake has changed in area through the isolation of 34,140 acres of marsh wetland from the lake through diking and draining.

**Table 1.** **The area of littoral marsh and limnetic open water of Upper Klamath Lake (including Agency Lake) before commencement of diking (~1889) and after diking, draining and UKL outlet dam (Link River).**

| **Condition of Lake** | **Lake Surface Elevation** | **Lake Area (Ac)** | | |
|---|---|---|---|---|
| **Before Diking** | **Minimum (BR datum, ft)** | **Littoral** | **Limnetic** | **Total** |
| | 4140.0 | 20,320 (30%) | 47,400 (70%) | 67,720 |
| **Before Diking** | **Maximum (BR datum, ft)** | **Littoral** | **Limnetic** | **Total** |
| | 4143.0 | 51,510 (46.2%) | 60,000 (53.8%) | 111,510 |
| **After Diking and Dam** | **Minimum (BR datum, ft)** | **Littoral** | **Limnetic** | **Total** |
| | 4136.0 | 0.0 (0.0%) | 55,800 (100%) | 55,800 |
| **After Diking and Dam** | **Maximum (BR datum, ft)** | **Littoral** | **Limnetic** | **Total** |
| | 4143.3 | 17,370 (22.4%) | 60,223 (77.6%) | 77,593 |

The littoral wetland area of the lake once comprised 51,510 acres (46.2%) of the total lake area of 111,510 acres at maximum pool surface elevation. The historical records of lake fluctuation prior to construction of the Link River Dam in 1921 document the lake fluctuating between a maximum of 4143.0 ft (U. S. Bureau of Reclamation datum [~2.3 ft above the USGS NGV datum]) and a minimum of 4140.0 ft. Following dam construction and after the last diking and draining in 1968 (Snyder and Morace 1997), the lake area at maximum pool elevation of 4143.5 ft had decreased to 77,590 acres, with littoral marsh area decreased to 17,370 acres (22.4% of the total lake area). In other words, the lake lost 30.4% of its area, and the associated lake volume associated with this area, through diking and draining. The in-lake wetland area was reduced by 66.3%. In addition, there was a reduction of littoral lake volume from 82,000 ac-ft to 28,000 ac-ft; a reduction of 65.9%. Further, the wetland area at minimum lake storage volume (4136.0 ft versus the pre-dike, pre-dam minimum of 4140.0 ft, had shrunk from 20, 320 acres to 0.0 acres (Basdekas 1997), which represents an additional seasonal loss of function. The lowering of the reef at the Link River Dam would allow more water to be withdrawn from the lake.

Three recent analyses of Upper Klamath Lake have excluded wetland areas and associated wetland littoral volumes from their analyses (Kann and Walker 1999; Walker 2001, and Phil Williams and Associates, Inc. 2001). These analyses, which attempt to draw conclusions from modeling of the limnetic zone of the lake about the performance of the whole lake system, ignore the complex contributions of the 17,370 acre littoral zone of Upper Klamath Lake, the marsh wetlands in the lake that were not isolated by diking and draining. As the limnologist R. Wetzel (1975) noted, the littoral zone "…contributes significantly to the productivity of lakes and the regulation of metabolism of the whole lake ecosystem." These analytical omissions are unfortunate.

## MARSH DISSOCIATION HYPOTHESIS: WETLAND ISOLATION AS A PRIMARY DETERMINANT OF LAKE WATER QUALITY CONDITIONS

**Hypothesis:**

The isolation of former wetlands from UKL by diking and draining has degraded the water quality of this lake primarily by the resultant deprivation of wetland functions.

**An Alternative Hypothesis**:

The acceleration of the eutrophic process in Upper Klamath Lake is attributed to the removal of upland and littoral wetlands in the system.

The discussion of the effects of the alteration of wetlands of the Klamath Basin above the lake has been addressed in news articles but has yet to be assessed systematically. This analysis would entail the evaluation of changes made in the extensive Wood River wetland area, the Upper Klamath Marsh wetlands on the upper end of the Williamson, the Sycan Marsh, and the headwater Sprague River wetlands. These alterations which would have affected receiving water quality and quantity, and ultimately the lake quality, will not be addressed in this paper.

An appropriate introductory analogy for the consequences of isolation of in-lake marshes from the lake by means of diking and draining would be the removal of an appreciable portion of the liver and kidney from a human. It appears to be commonly understood that the effect of wetland loss was subsequent agricultural discharge from the "reclaimed" 34,140 acres of farmed and ranched area and a resultant degraded lake water quality. This paper asserts an alternative explanation for degraded lake quality.

UKL is unique among lakes in Oregon and Washington in having such a high proportion of the lake area as wetland, primarily emergent marsh wetland area (Table 1). Considering the extensive research on the multifaceted capacity of wetlands to alter water quality that has been conducted and reported most prominently since 1978 (e.g. Good, Whigham and Simpson 1978; Hammer 1989; Moshiri 1993, SRI/Shapiro 1994; Kadlec and Knight 1996; U. S. Environmental Protection Agency 2000; Mitsch, Horne and Nairn 2000), it would seem reasonable to assume that the isolation of 34,140 ac of wetland from the lake would have affected lake quality.

Further, considering the extensive decomposition that occurs each year in marshes of the Klamath Basin, primarily during late fall and winter, and the resultant production of organic detritus, release of stored plant nutrients in above-ground biomass, and the production of dissolved organic carbon compounds (see Godshalk and Wetzel 1978), it would be no surprise if the loss of these decomposition products to the lake from the isolation of 34,140 ac of wetland had systemic consequences.

## ESTIMATES OF PRE-DIKING AND POST-DIKING WETLAND NUTRIENT RETENTION

The seasonality of wetland uptake or retention of nitrogen and phosphorus, the plant nutrients of primary interest to wetland treatment scientists, is well documented (e.g. Kadlec and Knight 1996, U. S. Environmental Protection Agency 2000, Mitsch, Horne and Nairn 2000). However, uptake of nitrogen and phosphorus in winter that appears associated with wetland detritus also occurs (Kadlec and Knight 1996). At Upper Klamath Lake nutrient uptake would be expected to occur most prominently during the period of increasing water temperature when marsh plant materials emerge and proliferate, May through early fall plant senescence in September.

There has been no investigation at Upper Klamath Lake of nutrient uptake by wetlands positioned at different hydraulic settings at the lake surface, and, through seasonal cycles of growth and decomposition. Only preliminary assessments have been made by Sartoris, Sisneros and Campbell (1993), Forbes (1997), Forbes, Sartoris and Sisneros (1998), and by Geiger, Caldwell and Hollen (2000). Lake bottom sediment has been characterized with respect to precipitation and entrainment, in relation to winds and currents (Laenen and LeTourneau 1996), but not wetlands as similar in-lake sources and sinks of nutrients.

There has also been no characterization of the types of UKL wetlands as defined by their hydroperiods and hydraulic settings. These factors would be expected to affect the rate of nutrient uptake. A closer inspection of presettlement or pre-diking wetlands at lake surface suggests the different roles and functions of these wetlands. At least three types of presettlement wetlands can be differentiated by their settings: 1) slow diffusing (Wocus Marsh); 2) rapid diffusing (Caledonia and Hanks Marsh); and 3) stream flow advective wetlands (Wood River Ranch, Williamson River Delta Preserve).

In the absence of basin studies addressing the function of marsh wetlands in the littoral zone under specific hydrologic conditions, it is still possible to provide estimates of annual nitrogen and phosphorus uptake to suggest the relative magnitude of influence on lake quality of wetlands that have been lost and of wetlands remaining in the lake. Measurements of nitrogen and phosphorus annual net retention rates are readily available in wetland treatment literature. The following average to low-end estimates were selected from recent literature (Table 2).

Based on these assumptions, isolating the wetlands through diking and draining would have meant a loss of nitrogen and phosphorus uptake capacity of 10,529 metric tons of total nitrogen and 152 metric tons of total phosphorus per year. The magnitude of these numbers is noteworthy in view of the estimated annual loads of nitrogen and phosphorus to the lake in Kann and Walker (1999) and Walker (2001), which ignore the marsh wetland component of the lake.

**Table 2.** **Nitrogen (N) and phosphorus (P) emergent wetland net retention rates (kg/ha/yr) and estimated quantities of nitrogen and phosphorus retained in pre-diking wetlands (51,510 ac/23,025 ha) and post-diking wetlands (17,370 ac/7,763 ha) at Upper Klamath Lake.**

| N and P Forms | Retention Rate (kg/ha/yr) | Pre-Diking (metric tons) | Post-Diking (metric tons) | Rate References |
|---|---|---|---|---|
| Ammonia-N | 576.7 | 13,279 | 4,477 | Kadlec and Knight 1996 |
| Nitrate-N | 401.5 | 9,244 | 3,117 | Kadlec and Knight 1996 |
| Total N | 689.9 | 15,885 | 5,356 | Kadlec and Knight 1996 |
| Total P | 10.0 | 230 | 78 | Mitsch, Horne and Nairn 2000 |

The 34,140 ac of former wetland areas behind the dikes have been loaded each year since diking and draining with nitrogen and phosphorus through irrigation withdrawal. Irrigation withdrawals have imposed an artificial spatial and temporal partitioning of water and nutrients. Irrigation has put the nitrogen and phosphorus to work in the growth of pasture grass, barley and row crops such as onions, potatoes and beets, but it has also used the water that would have otherwise stayed in the lake with less nitrogen and phosphorus from in-lake wetland nutrient uptake. Further, agricultural drainage pumped back to the lake, generally in late winter and early spring, has been another aspect of the artificial spatial and temporal partitioning of water. It is likely there has been a smaller load of nitrogen and phosphorus returning in the agricultural drain water to the lake than occurred through the marsh decomposition process in the pre-diking period.

These preliminary findings suggest that if loading from the basin would have remained constant through the period of diking, draining and dam construction, the loss of wetland and the associated loss of nutrient uptake capacity would have resulted in increasing amounts of phosphorus and nitrogen becoming available to plants within the undiked portions of the lake. It is likely that both logging and agricultural activities have increased the loading of nitrogen and phosphorus from the basin in the past 150 years, however, the isolation of wetlands is likely to have had the greatest effect on lake water quality and produced the accelerated lake eutrophication reflected in the sediment data of Eilers *et al*. (2001).

## WETLANDS AS SOURCES OF DECOMPOSITION PRODUCTS

Wetland scientists interested in the use of wetlands to treat wastewater in all months of the year, e.g. at Arcata, California (Gearheart 1992), have been particularly concerned about the winter, low temperature treatment capability when wetland plants are senescing and decomposing. As commonly noted in wetland treatment literature, wetlands are seasonally sources and sinks of nitrogen, phosphorus (e.g. Kadlec and Knight 1996). The characterization of Upper Klamath Lake marsh nutrient release as well as uptake during winter is of interest because these products could influence summertime lake concentrations, however, the release of dissolved organic materials may be more relevant to the growth dynamics of *Aphanizomenon*.

Estimates of the quantities of forms of nitrogen and phosphorus, major ions and trace elements contained in marsh plant materials released into Upper Klamath Lake through the cycle of senescence and decomposition cannot be made due to the lack of lake-specific information.

However, an estimate could be developed using literature values for the chemical composition of marsh plant species on the basis of assumptions about timing of decomposition processes during

typical temperature excursions of the lake. This effort is beyond the scope of this paper. It may be useful, however, to note that the net annual productivity of freshwater wetlands typical of basin wetlands generally exceeds that of the net productivity of typical Klamath Basin farm crops (Table 3).

**Table 3. Comparison of estimates of the net annual productivity (g/square meter dry weight) of various mixed and single species freshwater wetland assemblages with a variety of typical Klamath Basin farm crops.**

| Plant Materials | g/m2/yr | Estimate Source |
|---|---|---|
| **Freshwater Wetlands** | | |
| *Phalaris* JBEW 1992 | | |
| Roots | 1,207 | SRI/Shapiro 1994 |
| Shoots | 1,501 | |
| Prairie Glacial Marshes | | |
| Low above-ground estimate | 731 | de la Cruz 1978 |
| High above-ground estimate | 2,852 | |
| *Typha* below-ground estimate | | |
| Low estimate | 662 | Keefe 1972 |
| High estimate | 1,300 | |
| *Typha* above-ground estimate | | |
| Low estimate | 474 | Keefe 1972 |
| High estimate | 2,106 | |
| **Klamath Basin Farm Crops** | | |
| Onions | 1,121 | Rykbost 2001 |
| Potatoes (excluding above-ground) | 1,345 | Rykbost 2001 |
| Grain (Barley, Oats, Wheat) | 673 | Rykbost 2001 |
| Grain Straw | 448 | Rykbost 2001 |
| Alfalfa | 1,345 | Rykbost 2001 |

This comparison of net annual productivity suggests that the decomposition of marshes may produce more dissolved substances than the decomposition of typical farm crops, or residues of those crops. In contrast to wetland plant materials the biomass of which senesces and decomposes in place, many of the farm crops in Table 3 are removed from fields (e.g. onions, tubers of potatoes, grain, and above-ground alfalfa and straw). Thus, when fields are flooded in winter in former wetland areas around the lake to control rodents, there is less biomass per unit area to decompose than would have been present when these former wetland areas were in the lake. The extraction of crops from farm lands does entail subsequent fertilizer supplementation to compensate for biomass removal with its associated nitrogen, phosphorus, potassium and trace minerals. However, the addition of fertilizer is crop specific and also specific to the growth phase of the plant. Farmers will spend no more money on fertilizer than is necessary. Ranchers do not fertilize pasture lands.

This comparison of potential quantity of decomposition products suggests that the quality of pumped discharge from reclaimed wetlands may surprise some wetland managers. Where rainfall and leakage produce sufficient water to require spring pumped discharge to maintain reasonable water levels in the reclaimed farm or ranch land behind dikes, the quality of water discharged may be unexpectedly high in nitrogen and phosphorus and highly discolored. This is a reasonable explanation for the increase in nitrogen and phosphorus concentrations in pumped discharge from the Bureau of Land Management Wood River Ranch following conversion of 2,800 acres of land from ranching to wetland development (Geiger, *et al*. 2001). The seasonal loading from reclaimed wetland areas would be expected to be similar to the seasonal loading that occurs now from in-lake wetlands, and at a much greater amount from former more extensive wetland areas in the lake.

## DECOMPOSITION PRODUCTS AND CYANOBACTERIA GROWTH

The annual dominance of *Aphanizomenon flos-aquae*, a cyanobacteria, phytoplankton species, in UKL through the period of May through October is widely known. The prominence of this species, and the primary focus of past work on the planktonic algae of the open waters of the lake has diverted attention from other algae that are present in the wetland areas of the lake and during the times of the year when *Aphanizomenon* is not dominant, or even absent. Bureau of Reclamation funding has supported examination of limnetic samples, with the sole exception of the Pelican Bay site, and the speciation and volumetric estimation of the species found in this open water part of the lake. The potential influence of wetlands in the lake on the growth of *Aphanizomenon flos aquae* is suggested by the data on this species' biomass at the Klamath Tribes Pelican Bay station (in the vicinity of the Upper Klamath Lake NWR) compared with its biomass at other locations (mid-north and mid lake stations of the Klamath Tribes limnological monitoring program) (Kann 1999). Figure 1 shows the very significant reduction in *Aphanizomenon* biomass in the vicinity of the marsh at Pelican Bay compared with the other open lake stations.

This absence or reduction of *Aphanizomenon* just downstream, at or within marsh environments has been noted by those scientists who have spent time obtaining data on marsh character. Forbes (1997) noted the absence of *Aphanizomenon* except at the waters off the edge of Hanks Marsh, and Sartoris, Sisneros and Campbell (1993) noted the same in their report on characteristics of Upper Klamath Marsh National Wildlife Refuge. Perdue *et al*. (1981) noted the absence of *Aphanizomenon* in Upper Klamath Lake at a location heavily influenced by the Williamson River.

Forbes (1997) noted the work of Kim and Wetzel (1993) in assessing the effect of dissolved humic substances, one of the products of marsh plant decomposition, on the growth of various species of algae. Kim and Wetzel (1993) found that humic substances enhanced or suppressed algal growth. *Anabaena flos-aquae* was inhibited by 20 mg/l of *Typha* humic acids while the growth of the diatom *Nitzschia palea* was stimulated. *Microcystis aeruginosa* growth was inhibited by all, except very low (1 mg/l) concentrations of humic acids.

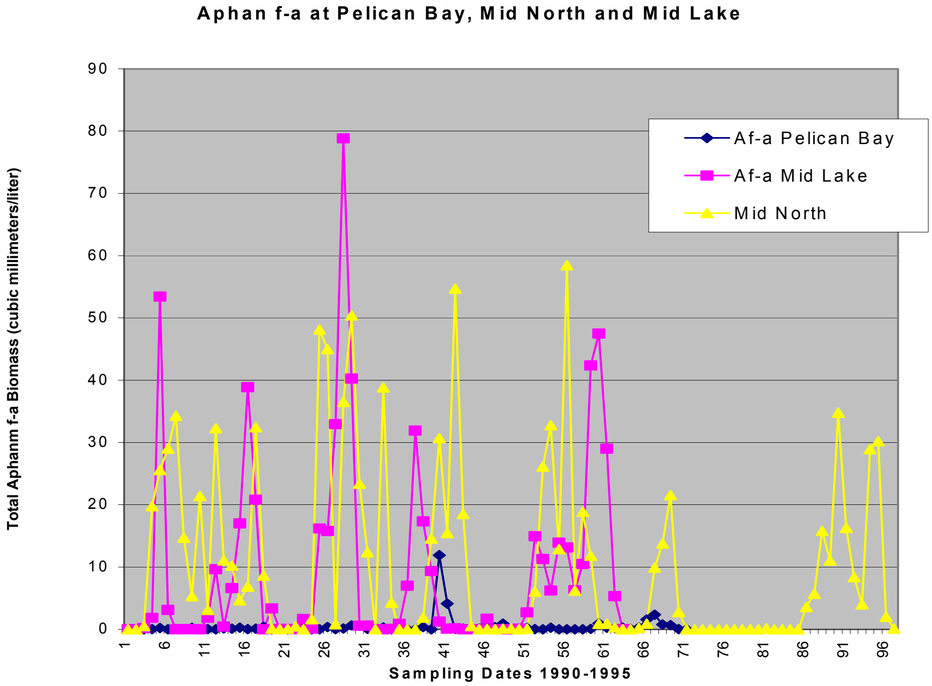


**Figure 1.** Seasonal occurrence of *Aphanizomenon flos-aquae* biomass at the Klamath Tribes-Bureau of Reclamation Pelican Bay monitoring station adjacent to Upper Klamath Lake NWR marsh as compared with its biomass at two open water stations in Upper Klamath Lake (Mid-Lake and Mid North). Numbers on the x axis are the numbers of sampling occasions from start of sampling in 1990 through 1995.

A preliminary literature review indicates that a wide variety of possible mechanisms have been proposed involving dissolved organic matter that may explain the effects observed in the vicinity of Upper Klamath Lake marshes on the growth of *Aphanizomenon*. An incomplete list of proposed mechanisms, in addition to the findings of Kim and Wetzel (1993) that humics inhibit alkaline phosphatase includes:

- The effect of dissolved organic material on light availability (Havens et al 1998);
- Various interactions among dissolved iron, dissolved organic matter and phosphorus (Jones *et al* 1993; Guildford *et al* 1987, Jackson and Hecky 1980);
- Various interactions between dissolved organic matter and nitrogen availability (Berman and Chava 1999; Devol *et al* 1984);
- Complexation of toxic metals by dissolved organic matter (Xue and Sigg 1999).

In 1962 at Oregon State University, C. Peek, with the assistance of H. Phinney, approached the puzzle of the reasons for *Aphanizomenon* dominance in Upper Klamath Lake with an evaluation of the potential growth promoting qualities of humic substances (Peek 1963). It would appear that an assessment of potential suppressing effects of dissolved organic carbon constituents, including dissolved humic substances, from the marshes of the lake, on *Aphanizomenon* from the lake would be a valuable contribution to an understanding of what the loss of wetlands from the lake has meant for lake quality.

It is not possible with the historical nutrient inflow or limnological data bases (Kann 1998, 1999), or even that of previous study data (e.g. Miller and Tash 1967, Klamath Consulting 1983), to differentiate water high or low in total and dissolved organic carbon or dissolved humic substances (DHS). The interpretation of light measurements (Secchi disk, PAR, etc.) must therefore be ambiguous in this stream and lake system where the seasonal brown color of water in Link River, and the Lower Klamath River is a signature feature.

There has been no systematic, seasonal monitoring of dissolved humic substances (DHS), or other organic decomposition products, including total organic carbon (TOC), dissolved organic carbon (DOC), tannins and lignins, or color in streams or in the lake. There has been only one station, the Pelican Bay station, out of twelve stations sampled in the lake since 1990 (Kann 1999) that would have been in the immediate vicinity of a large wetland. The Pelican Bay station was discontinued by the Klamath Tribes after 1995 (water quality; 1997 phytoplankton). The data from the Pelican Bay station was excluded from the data set used to estimate lake-wide means of forms of nitrogen and phosphorus in recent attempts to develop a water and nutrient budget for the lake and a total maximum daily load for total phosphorus (Kann and Walker 1999, Walker 2001).

Recent measurements of organic carbon constituents have been made by Shapiro and Associates, Inc. related to its recent work in assisting Running Y Ranch Resort reclaim 554 acres of wetland at Caledonia Marsh adjacent to Howard Bay (see Shapiro and Associates, Inc. 2001). Samples of water from a 94 acre reclaimed marsh test unit provided information on the dissolved organic carbon concentrations in a young marsh (first growing season 1998). Samples of water were also obtained from Howard Bay and from pumped winter field floodwater drainage discharge. Preliminary results are provided in Table 4.

Measurements in Howard Bay outside of the dike isolating Caledonia Marsh at Running Y have been low relative to the concentrations in the reclaimed Caledonia Marsh Test Unit (TU) and the winter flooding drainage discharge from the Geary Canal pumps. Water within the Test Unit wetland (94 acres) is distinctly brown and reduces light transparency significantly. The differences in DOC concentrations have varied in the Test Unit on days when the unit was sampled in two locations but concentrations are still elevated relative to the Bay. These differences were likely due to the dilution effects of adding Howard Bay water to compensate for evapotranspiration in the wetland. Since humic carbon can comprise over 50% of the dissolved organic carbon concentrations (Perdue *et al*. 1981), both wetlands in the lake, reclaimed wetlands behind the dikes, and winter flooded farm fields are large reservoirs of what may be a valuable cyanobacteria suppressant. The loss of in-lake wetlands, diffusing these humic compounds differently and at different times depending on hydrologic setting, would have resulted in lower lake concentrations of dissolved humic substances.

**Table 4.** **Dissolved organic carbon (DOC, mg/l) concentrations at sampling stations in Howard Bay, Geary Canal Wocus Marsh pumping station, and at the wetland reclamation unit (Test Unit of 94 acres) at Running Y Ranch Resort on Caledonia Marsh 1998-2001. All analyses were performed by Aquatic Research Inc., Seattle, Washington.**

| Date | Sampling Sites | DOC (mg/l) |
|---|---|---|
| **Howard Bay** | | |
| July 2, 1998 | Howard Bay-Dike | 8.97 |
| May 19, 1999 | Howard Bay-Dike | 6.61 |
| July 24, 1999 | Howard Bay-Dike | 11.90 |
| February 9, 2000 | Howard Bay-TS | 7.13 |
| May 3, 2000 | Howard Bay-HB30 | 6.06 |
| May 3, 2000 | Howard Bay-Dike | 6.14 |
| December 19, 2000 | Howard Bay-TS | 7.40 |
| December 19, 2000 | Howard Bay-140 | 7.25 |
| **Geary Canal** | | |
| February 9, 2000 | Geary Canal Pumps | 40.30 |
| May 3, 2000 | Geary Canal Pumps | 22.10 |
| January 31, 2000 | Geary Canal Pumps | 43.10 |
| January 31, 2000 | Geary Canal Pumps | 43.60 |
| **Caledonia Marsh** | | |
| July 2, 1998 | Caledonia Marsh TU | 43.10 |
| July 2, 1998 | Caledonia Marsh TU | 56.30 |
| May 19, 1999 | Caledonia Marsh TU | 93.40 |
| May 19, 1999 | Caledonia Marsh TU | 32.20 |
| July 24, 1999 | Caledonia Marsh TU | 67.60 |
| July 24, 1999 | Caledonia Marsh TU | 43.10 |
| February 9, 2000 | Caledonia Marsh TU | 42.20 |
| May 3, 2000 | Caledonia Marsh TU | 58.40 |
| January 31, 2001 | Caledonia Marsh TU | 53.50 |

## CONCLUSIONS AND RECOMMENDATIONS

### Conclusions

- Investigators of Upper Klamath Lake have decried wetland loss but ignored the significance and consequences of isolating large wetland areas from the lake through diking and draining and lake water surface management;
- Estimates of nitrogen and phosphorus retention by marsh littoral wetlands pre-diking and post-diking suggest the potential influence of the littoral zone of Upper Klamath Lake has been and is large;
- There is no integrated plan or schedule for reassociating behind-the-dike wetlands with the lake being developed or implemented by agencies, organizations and corporations responsible for wetland reclamation;
- The slow development of connections between the 17,553 acres of reclaimed wetlands behind dikes and Upper Klamath and Agency Lakes is supported by a single focus attempt

to reduce phosphorus discharges to the lakes, the TMDL process that will quantify the needed phosphorus reduction, and the misapprehension that eliminating agricultural use of these lands will in itself improve lake water quality;
- The role of marsh decomposition products from littoral wetlands and from wetlands in the lake basin has not been characterized, but preliminary findings suggest the potential influence of these products, particularly dissolved humic substances, on *Aphanizomenon* growth may be large.

**Recommendations**

- Link behind-dike reclaimed wetland areas to the lake by means of screened gravity flow from lake or tributary streams and return water to the lake via pumped return;
- Assess the performance of the three types of in-lake wetlands focusing on seasonal nutrient dynamics and decompositional processes and products, then develop a management plan for in-lake and behind-the-dike reclaimed wetlands that will closely mimic presettlement wetland uptake and dispersion;
- Develop TMDL (total minimum daily loads) of dissolved humic substances based on estimates from former concentrations when 51,510 acres of wetlands were in the lake and estimates from bioassays with *Aphanizomenon* and Upper Klamath Lake marsh decomposition products;
- Manage lake levels to optimize wetland functions related to water quality regulation;
- Increase production of humic substances from agricultural lands by increasing the amount of residual biomass, particularly barley, on field flooded for rodent control then drained;
- Manage late winter agricultural return flows to more closely mimic the pre-dike diffusion of decomposition products from different types of marsh;
- Include wetlands in the lake and those that are being reclaimed behind dikes in all modeling of lake quality.

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## PESTICIDE IMPACT ASSESSMENT IN TULE LAKE AND LOWER KLAMATH NATIONAL WILDLIFE REFUGES

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### ABSTRACT

This paper reviews a 3-year pesticide incident monitoring study conducted at Tule Lake and Lower Klamath National Wildlife Refuges. The objectives of this study were (1) to survey both refuges for dead or impaired wildlife, (2) to determine whether pesticide exposure is implicated in any death or impairment discovered, and (3) to investigate the source of any pesticide exposure detected. Endangered shortnose suckers (*Chasmistes brevirostris*) and Lost River suckers (*Deltistes luxatus*) inhabit Tule Lake and both refuges are key wintering areas for migratory waterfowl and bald eagles (*Haliaeetus leucocephalus*). Lands on the refuges are leased to growers under requirements of the Kuchel Act, which provides for leasing of up to 22,000 acres. Crops currently grown include potatoes, onions, sugarbeets, alfalfa, and grains. More than 45 different pesticides are allowed on the lease lands, including some extremely toxic insecticides, such as the organophosphates, disulfoton and chlorpyrifos, and pyrethroids, such as permethrin and cyfluthrin. These pesticides have been allowed by Region 1's Pesticide Use Proposal (PUP) Committee under a series of strict application methods, weather restrictions, and buffer zones.

### INTRODUCTION

Tule Lake and the adjacent Lower Klamath National Wildlife Refuges (TLNWR and LKNWR) serve as key spring/fall staging and overwintering areas for Pacific Flyway migratory waterfowl, with more than 89 million goose and duck use days recorded in the refuges in 1988. As many as

1000 bald eagles (the greatest concentration in the lower 48 states) also overwinter in the Klamath Basin, utilizing these refuges for food resources. The shortnose suckers (*Chasmistes brevirostris*) and the Lost River suckers (*Deltistes luxatus*), listed as endangered in 1988, inhabit Tule Lake (in TLNWR), habitat that is currently proposed critical habitat for the suckers. The refuges are located in northern California and southern Oregon in a region of intensive agriculture. Lands on the refuges are leased to growers under requirements of the Kuchel Act, which provides for leasing of up to 22,000 acres. Crops grown include potatoes, onions, sugarbeets, alfalfa, and grains. More than 45 different pesticides are allowed on the lease lands, including some extremely toxic insecticides, such as the organophosphates, disulfoton and chlorpyrifos, and pyrethroids, such as permethrin and cyfluthrin. These pesticides have been allowed by Region 1's Pesticide Use Proposal (PUP) Committee under a series of strict application methods, weather restrictions, and buffer zones. Early studies, before the institution of these restrictions on pesticide use through the PUP process, revealed a variety of ecosystem-wide impacts on TLNWR. For example, Boyer (1993), using TLNWR drainwater and FETAX bioassays with the African frog, demonstrated numerous deformities in amphibians. Boyer also found few frogs of any species on the refuge. Littleton (1993) showed a wide variety of deformities, high rates of parasitism, and extremely low fish diversity in refuge aquatic systems. She also noted a fish kill after application of acrolein to one canal. Similarly, *in situ* bioassays with invertebrates (*Daphnia, hyalella*) during the growing season disclosed very low rates of survival, often less than 20 percent, in many drainwaters (Bennett 1994). Studies of terrestrial birds have also revealed some bird mortalities (various National Wildlife Health Laboratory Mortality Reports). Sixty-eight percent (28 of 41) adult pheasants (*Phaisianus colchicus*) in and near potato fields sprayed with organophosphate pesticides at TLNWR during 1990 - 1992 showed brain AChE inhibition of 19-62% (Grove 1995). Similarly, 62 percent (33 of 53) of juvenile Savannah sparrows (*Passerculus sandwichensis*) had AChE inhibition of 21-92% (Grove 1995). Since the institution of PUPs on the refuge in 1994, systematic surveys or spot checks have only recently been conducted (1998-2000 field seasons) to determine PUP compliance or to assess bird and fish impacts following pesticide spraying. The objectives of this study were (1) to survey TLNWR and LKNWR for dead or impaired wildlife, (2) to determine whether pesticide exposure is implicated in any death or impairment discovered, and (3) to investigate the source of any pesticide exposure detected.

## METHODS

### Surveys

Wildlife impacts from pesticide use were monitored primarily through observational surveys. Each location surveyed was searched for evidence of impacts. Locations were chosen, depending on survey type, either at random or in response to information about recent pesticide use or exposure in the area. Surveys were of four general types: (1) Field surveys, (2) Aquatic surveys, (3) Driving surveys, and (4) Response surveys.

Field Surveys. For the purposes of this study, a field is defined as a single lease lot. Plantings that ran over lot boundaries were considered separate fields. All field surveys were conducted on foot at a pace of 30 meters per minute. Field surveys were either conducted within the perimeter of the field (in-field survey) or on the immediate border of the field (field perimeter survey).

*In-field surveys* were conducted by walking transects through fields with visual coverage of approximately 6 meters from either side of transect. The number of transects performed per field depended on the width of the single crop planting, the majority of which were onions. An average of four transects were performed per field, incorporating binocular surveys into each transect walked. Binocular surveys consisted of a visual assessment of the field from three points on the transect, the beginning, center and end points. The objective of infield surveys was to visually inspect 75% of the field area.

*Perimeter surveys* were conducted following applications of specific pesticides, before permissible reentry periods would allow in-field surveys, in specific crops where restricted use pesticides were used, or when in-field surveys became impractical due to crop height and density or due to potential damage to crop. Perimeter surveys were conducted by walking the entire perimeter of the field and visually inspecting ~3 meters infield and 6 meters outfield for evidence of pesticide use impacts to wildlife. Surveys identified as buffer zone surveys were perimeter surveys conducted within a buffer zone. A buffer zone is an area where pesticide application is prohibited to prevent possible contamination of an adjacent waterway.

<u>Aquatic Surveys</u>. For the purposes of this study, an aquatic survey was defined as a survey associated with a particular body of water rather than with a specific field. Aquatic surveys were conducted throughout the agricultural season with efforts intensified following applications of interest or mortality events. All aquatic surveys were conducted on foot at a pace of 30 meters per minute. Each aquatic survey was comprised of two aspects, a survey of the chosen water body and a survey of the adjacent area within 10 meters of the water body. Waterway surveys were conducted by walking the bank of a chosen body of water, scanning the water for evidence of impacts. Adjacent areas were then surveyed by walking the bank of the chosen body of water, scanning the vegetation within 6 meters of the water for evidence of impacts.

<u>Driving Surveys</u>. Driving surveys were conducted throughout the agricultural period, both in transit to other field survey locations and in response to observed and reported aerial spray or other agricultural activities. Driving surveys were not associated with any particular location and were not conducted over specific distances or for set lengths of time. All driving surveys were conducted from a vehicle moving at an average rate of 10 mph. Driving surveys were conducted by driving observer selected path within refuge boundaries, and scanning as much of the passing scenery as could be seen for evidence of impacts. Only pesticide spills (spill finds) or dead or impaired wildlife (casualty finds) were recorded during these surveys.

<u>Response Surveys</u>. Response surveys were those surveys conducted in response to a pesticide spill incident or to dead or impaired wildlife finds reported by sources outside the study. Conduct of the response surveys depended on what was reported but generally involved walking concentric circles extending around a reported wildlife mortality or spill and visually expecting the area for dead or impaired wildlife or cause of death. Spill finds or casualty finds were recorded in Field Notebooks and on Affected Wildlife Survey Data Forms.

**Find Documentation and Sampling**

A record was made of any evidence of possible pesticide impact found during surveys, and when feasible, samples were taken for further analysis. At a minimum, a written record was made of each find. Additional documentation could then include digital photographs, GPS coordinates, and water quality profiles. When sample collection was feasible, samples were collected via the most appropriate of the following methods:

Terrestrial Vertebrate Sampling. Terrestrial vertebrates, whether collected from land or water, were first examined for evidence of injury or disease by a nitrile-gloved technician. Each individual would then be weighed wet on an electronic 2000g scale, measured with a meter tape, and given a descriptive leg tag. The individual would then be placed in a plastic bag to be sealed with chain-of-custody or evidence tape, and descriptive information would be placed on the bag's exterior. Next, the sample was placed into a second plastic bag and sealed to prevent future contamination. The so processed specimen would then be immediately chilled to await either long-term storage or shipment to an analytical facility.

Aquatic Vertebrate Sampling. Aquatic vertebrates were collected using the same method as for terrestrial vertebrates, with one important exception. Each individual would be wrapped in aluminum foil before being placed in a plastic bag due to concern of sample contamination by plastics. On occasion, however, an aquatic vertebrate would be small enough to be placed directly into a pre-cleaned glass jar in which case it would not be wrapped with aluminum foil. If the sample was too small for individual testing it might be lumped into a glass jar with other individuals to form a single, larger sample.

Water Sampling. Water samples were typically collected from the area of a casualty find on water. All water samples were grab samples taken from the water's surface. Water for pesticide analysis was collected in a variety of container sizes, all pre-cleaned glass. Containers were filled completely, capped, sealed with signed and dated chain-of-custody tape, given a descriptive label, and sealed in a plastic bag also marked with descriptive information. Containers of 40 ml capacity were used to collect samples for volatile pesticide analysis._One or two drops of hydrochloric acid was added to preserve samples for volatile pesticide analysis.

Additional Sampling. On one occasion, eleven vegetation samples (~40 g each) were collected for pesticide residue analysis to evaluate compliance with buffer zone requirements and to determine if a drift might have been responsible for a wildlife mortality incident.

**Hydrolabs**

Whenever possible following discovery of a fish die-off, a hydrolab (Hydrolab Corp., Austin, TX) would be deployed for on-site analysis of water quality. Hydrolabs are self-contained water quality measurement and recording devices that monitor temperature, pH, conductivity, and dissolved oxygen of water at pre-set intervals. A typical hydrolab deployment during this study would be at a depth of three feet below the water's surface and last a minimum of two days and nights. Hydrolab data would be downloaded after the unit was recovered and reviewed for lethal water quality values.

**Testing Facilities**

Samples collected were typically sent for analysis to the most appropriate of the following testing facilities:

National Wildlife Health Center, Madison, WI. Analysis of terrestrial vertebrate specimen for botulism, cholinesterase depression, and/or general cause.

National Fish and Wildlife Forensic Laboratory, Ashland, OR. Analysis of terrestrial vertebrate specimens for cause of death and cholinesterase analyses.

Mississippi State Chemical Laboratory, Miss State, MS. Analysis of water and aquatic vertebrate samples for presence of pesticides.
California Animal Health and Food Safety Lab (CAHFS), University of California, Davis, CA. Pesticide residue analysis, brain cholinesterase and other standard biochemical analyses.

Patuxent Wildlife Research Center, Laurel, MD. Analysis of samples for presence of pesticides and cholinesterase analysis.

## RESULTS AND DISCUSSION

### Casualty Finds

Table 1 indicates number of surveys and casualty finds during the monitoring study. Casualty finds were categorized as either isolated casualties (*i.e.* a single casualty find that did not appear temporally or spatially related to other casualty finds) or part of a multiple casualty event (*e.g.* casualties related by a single event, such as an avian botulism die-off, large fish kill, *etc*.). Systematic field and aquatic surveys resulted in few casualty finds given search effort. Only 3 casualties were found in 179 field surveys during the three-year monitoring study. A total of 38 casualties were found during 226 aquatic surveys. The majority of casualties recovered were those associated with multiple casualty events from response or road surveys during the 1998 field season.

Table 1. Number of casualties found and numbers of surveys during 3-year pesticide monitoring study.

| | Survey | | | |
|---|---|---|---|---|
| | Field | Aquatic | Road[1] | Response[1] |
| 1998 | Surveys: 97<br>Isolated Casualties: 0<br>Multiple Casualties: 0 | Surveys: 74<br>Isolated Casualties: 9<br>Multiple Casualties: 0 | Isolated Casualties: 40<br>Multiple Casualties: 4971 | Isolated Casualties: 11<br>Multiple Casualties: 5000 |
| 1999 | Surveys: 20<br>Isolated Casualties: 1<br>Multiple Casualties: 0 | Surveys: 122<br>Isolated Casualties: 15<br>Multiple Casualties: 12 | Isolated Casualties: 25<br>Multiple Casualties: 0 | Isolated Casualties: 7<br>Multiple Casualties: 1060[2] |
| 2000 | Surveys: 62<br>Isolated Casualties: 2<br>Multiple Casualties: 0 | Surveys: 30<br>Isolated Casualties: 2<br>Multiple Casualties: 0 | Isolated Casualties: 3<br>Multiple Casualties: 0 | Isolated Casualties: 7<br>Multiple Casualties: 13 |
| Total | Surveys: 179<br>Isolated Casualties: 3<br>Multiple Casualties: 0 | Surveys: 226<br>Isolated Casualties: 26<br>Multiple Casualties: 12 | Isolated Casualties: 68<br>Multiple Casualties: 4971 | Isolated Casualties: 25<br>Multiple Casualties: 5573 |

[1]Number of surveys not documented
[2]Includes off-refuge fish kill of 500

### Cause of Mortalities

Though pesticide analysis for the 2000 field season is pending, field data and laboratory analysis from 1998 and 1999 indicate few pesticide-related casualties (Table 2). One northern pintail (*Anas* *acuta*) was found dead in Tule Lake during 1998 with significant inhibition of brain cholinesterase (32% below normal). Cholinesterase is an enzyme important in neurotransmission and its inhibition is a commonly used indicator of exposure to organophosphate and carbamate insecticides. Residue analysis did not confirm a specific pesticidal active ingredient. The inability to detect an organophosphate or carbamate insecticide may be attributable to the rapid dissipation rates typical of these compounds. During the 1999 field season, monitors responded to a fish kill on the Lost River approximately 2 miles upstream from Tule Lake National Wildlife Refuge. Twelve specimens, including Tui (*Gila bicolor*) and blue chubs (*Gila coerulea*), were collected of the approximately 500 dead fish observed. The aquatic herbicide acrolein had been applied to the general area the previous day. Acrolein is highly toxic to fish. Applications are legally used to kill aquatic vegetation in a closed system and commonly used by irrigation districts to eliminate vegetation hampering the flow of water through canals and drains. It is not allowed for use on the Refuge and this fish kill is not believed to be related to pesticide use on the refuge. However, the Lost River is the primary source of water for Tule Lake. The incident is included in this report because it is pertinent to the quality of water entering the Refuge.

Table 2. Mortalities found during casualty searches (1998-2000) and suspected source of mortality

| | Pesticide | Low $O^2$ | Predator | Disease | Vehicle Strike | Other | Unknown |
|---|---|---|---|---|---|---|---|
| Bird | 1 | 0 | 17 | 23 | 22 | 4 | 31 |
| Mammal | 0 | 0 | 7 | 0 | 6 | 1 | 8 |
| Fish | 500[1] | 10,523 | 2 | 0 | 0 | 0 | 4 |
| Herp | 0 | 0 | 0 | 0 | 3 | 12 | 2 |

[1]Off refuge

Multiple casualty events were of special interest as they were thought to be indicators of environmental health. Although pesticide exposure can cause sublethal effects that can contribute to higher rates of disease and predation, casualty finds in these categories were relatively low given the search effort and may indicate typical background mortality. Avian botulism was the primary disease related casualty observed (Table 3). The most common source of casualties were fish kills attributable to episodes of low dissolved oxygen. Fish kills resulting from fluctuations in oxygen levels associated with algal bloom and crash cycles are common throughout the Upper Klamath Basin waterways and likely the source of the majority of the fish kills observed. Fish kills attributed to low dissolved oxygen had less than 2 mg dissolved oxygen/L and analysis of water and/or fish tissue did not reveal detectable pesticide residues. Pesticide analysis is pending for the fish kill observed during 2000 which included both Lost River and shortnose suckers.

Table 3. Suspected cause of multiple casualty events.

| Date | Number Found | Species | Location | Suspected Cause |
|---|---|---|---|---|
| 08/06/98 | 150 | Fish | Tule Lake | Low dissolved oxygen |
| 08/09/98 | 1500 | Fish | Tule Lake | Low dissolved oxygen |
| 08/17/98 | 3000 | Fish | Tule Lake canal | Low dissolved oxygen |
| 08/24/98 | 21 | Duck | Tule Lake | Botulism |
| 09/01/98 | 300 | Fish | Tule Lake canal | Low dissolved oxygen |
| 09/08/98 | 5000 | Fish | Lower Klamath drain | Low dissolved oxygen |
| 05/20/99 | 12 | Frog | Tule Lake | Temperature |
| 07/20/99 | 500 | Fish | Lost River[1] | Pesticide (acrolein) |
| 09/02/99 | 48 | Fish | Lost River[1] | Low dissolved oxygen |
| 09/13/99 | 500 | Fish | Lower Klamath drain | Low dissolved oxygen |
| 05/05/00 | 13 | Fish | Tule Lake canal | Low dissolved oxygen[2] |

[1]Off refuge [2]Pesticide analysis pending

## CONCLUSION

Although pesticide residue analysis for 2000 is pending, there was limited evidence of pesticide related wildlife mortality during the monitoring study. On several instances, sampling efforts to evaluate potential involvement of pesticide exposure in mortality events could have been improved. Sampling was not always done immediately upon discovery of an incident potentially jeopardizing the validity of the sample. Study monitors often did not receive notice of intent to apply restricted use pesticide and therefore missed sampling opportunities with some of the higher risk applications. Additionally, this study was designed to assess direct acute mortality and not more subtle effects such as influence on avian reproduction. Fish kill events associated with episodes of low dissolved oxygen were the principal source of mortality observed during the study. Fish kill events associated with poor water quality (low dissolved oxygen, high temperatures, high concentrations of unionized ammonia) are relatively common both on the refuge and in upstream source waters. Management actions are needed to improve water quality both on and off refuge.

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# WATER QUALITY IMPACTS TO THE KLAMATH RIVER FROM THE KLAMATH STRAITS DRAIN

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## ABSTRACT

This study assessed the impact of the Klamath Straits Drain (KSD) on the Klamath River using water quality data collected in the KSD and the Klamath River by the Bureau of Reclamation in 1999 and 2000. The impacts of the KSD are limited by the fact that the outflow is usually small in proportion to the total river flow. The average monthly relative contribution of the KSD to the river during the irrigation season was 20% or less for the period 1990-2000. Temperature and turbidity in the KSD were higher than the river at times but no impact was observed downstream, possibly because of the much higher river flows. Dissolved oxygen concentrations in the river were not impacted by KSD outflow because of the extremely low dissolved oxygen concentrations in the river upstream of the KSD at Miller Island. Dissolved oxygen concentrations at Miller Island appeared to be related to river flows. Dissolved oxygen concentrations are saturated with respect to atmospheric oxygen until flow decrease to 1000-1200 cfs or less. The relationship suggests that higher river flows may be needed to maintain high dissolved oxygen concentrations. Ammonia concentrations seemed to be correlated with dissolved oxygen concentrations in the river and not as dependent on KSD outflow. Low dissolved oxygen corresponded with high ammonia concentrations, possibly due to release of ammonia from decomposition of organic matter. KSD outflow did contribute a significant percentage of the nitrate (25-75%) and soluble reactive P (25-50%) load in the river. In general, the higher river flows required for salmon may tend to limit the water quality impacts of the KSD outflow in the future.

## INTRODUCTION

The Klamath Straits Drain (KSD) conveys return flow from the Klamath Basin Irrigation Project to the Klamath River. The impacts of the KSD on the river have been questioned for a number of years. Water quality in the KSD and the river is very poor at times and is characterized by high temperatures, low dissolved oxygen, high pH, high turbidity, high un-ionized ammonia concentrations, and high nutrient concentrations. A number of schemes to mitigate the impacts of the KSD have been proposed and many involve the Lower Klamath National Wildlife Refuge (NWR). These include diverting the return flow to wetlands on the Lower Klamath NWR or routing the return flow through treatment wetlands constructed on the refuge. But there has never been a thorough examination of the water quality impacts of the KSD on the river and this needs to be done before potential solutions can be evaluated. The purpose of this study is to evaluate the water quality impacts of the KSD on the Klamath River.

## METHODS AND RESULTS

In 1999 and 2000, the Bureau of Reclamation collected water quality samples along the Klamath Straits Drain and the Klamath River. Samples were collected every two weeks from Mar-Nov 1999 and May-Nov 2000. Three sampling sites were examined for this study: pump F&FF at the outflow of the KSD, the Klamath River at Miller Island (upstream of the KSD outflow), and the Klamath River at Keno Bridge (downstream of the KSD outflow). Measurements included temperature, dissolved oxygen, pH, electrical conductivity, and concentrations of nitrate, ammonia, total Kjeldahl nitrogen, soluble reactive phosphorus, and total phosphorus. Flows for all three sites are reported by the Bureau of Reclamation.

**Flows**

The average monthly percent contribution of the KSD to the Klamath River during the irrigation season was calculated as a percent of the total river flow just downstream of the KSD outflow for the period 1990-2000 (Figure 1). For the period, the KSD contribution to the total river flow averaged about 20% for Apr-Jul, about 10% for Aug and Sep, and < 5% in Oct. In general, the percent contribution has decreased over the ten year period, in part because of higher river flow requirements and in part because the latter half of the decade has been wetter, requiring more releases from Upper Klamath Lake to the river. Figure 2 shows the Klamath River flow above the KSD outflow and the KSD outflow for Mar-Nov 1999. From Mar-May of 1999, the KSD outflow made up only a small proportion (average 7% for the period) of the total Klamath River flow. For the remaining months, KSD outflow represented a greater percentage of the total river flow but monthly averages never exceeded 30%. 1999 was an above average year in terms of snowpack and precipitation. KSD outflow is a combination of return flow from Tule Lake, outflow from Lower Klamath NWR (return flow, drainage from seasonal units, seepage, unused diversions), and return flow from the agricultural lands downstream of Lower Klamath NWR (Figure 3). In Sep and Oct, very little water flows from Lower Klamath NWR because of the seasonal flooding requirements. Almost all of the KSD outflow at this time of year is from irrigation lands downstream of the refuge.

**Temperature and Turbidity**

Results for temperatures in 1999 and 2000 indicate that temperature was slightly higher (1-3EC) at the KSD outlet compared with the two river sites in the spring and early summer of both years but lower (1-2EC) in Oct and Nov. Figure 4 shows temperatures at all three sites for 1999. Temperatures were similar in 2000. River temperatures did not vary upstream and downstream of the KSD outflow. Turbidity was higher in the KSD outflow as compared to the river in early spring in 1999 but there did not seem to be a measurable impact at Keno Bridge (Fig. 5). This may be because of the relatively small contribution of flow at that time of year.

**Dissolved Oxygen**

Dissolved oxygen saturation percentages for 1999 and 2000 are presented in Figure 6. In both years, dissolved oxygen concentrations at all three sites were close to saturation in spring and early summer. In June of both years, concentrations at all three sites decreased dramatically. The decrease does not seem to be related to conditions in Upper Klamath Lake. In 1999, saturation percentages at the outlet of Upper Klamath Lake (A Canal) declined later in the summer and did not decrease nearly as much as those at Miller Island (Fig. 7), suggesting that the low dissolved oxygen at Miller Island is a result of conditions in the river.

The low oxygen levels at Miller Island are most likely a result of sediment oxygen demand in the river. A draft report by the Oregon Department of Environmental Quality stated that Lake Euwana and the Klamath River below Link River Dam had an extremely high sediment oxygen demand that was unprecedented anywhere in Oregon. This may be due to a combination of releases from Upper Klamath Lake, which are almost certainly high in organic matter, and the extensive accumulation of bark and woody debris on the channel bottom from past log storage practices in the river.

There is a relationship between dissolved oxygen and flow in the river at Miller Island. Figure 8 shows this relationship for 1998, 1999, and 2000. Generally, waters were close to or at 100% saturation with respect to atmospheric oxygen at flows above 1200 cfs. As flows decreased below 1200 cfs, waters become depleted in dissolved oxygen. The relationship suggests, but does not prove, that higher river flows are needed to maintain dissolved oxygen levels. The relationship may be due to temperature or oxygen mixing. It may be that the lower flow slows the transport of atmospheric oxygen into the water column to the point that the sediment oxygen demand can not be met. No such relationship between flow and dissolved oxygen was apparent in the KSD for 1999. It has been suggested that one way to improve dissolved oxygen in the KSD is increase flows by circulating Klamath River water through the KSD via the Ady Canal and Unit 2. The lack of a relationship between flow and dissolved oxygen suggests that increasing flows in the KSD may not improve water quality, at least in terms of dissolved oxygen.

**Nutrient Loading**

Figure 9 shows the instantaneous percent contribution of the KSD to the Klamath River for nitrate, ammonia, soluble reactive P, and flow in 1999 and 2000. Flow is included in the graphs for comparison. The fraction of ammonia loading from the KSD is quite high early in the season in 1999, but this is only because there were very low or non-detectable concentrations of ammonia in the river at that time. Later in the summer, as dissolved oxygen concentrations decreased, there was an increase in ammonia concentrations and the ammonia loading from the KSD went down proportionately. Nitrate loading from the KSD was a significant percentage (25-75%) of the total river load in both 1999 and 2000. Nitrate concentrations in the KSD were very low at the outflow from Lower Klamath NWR but increased at pump F&FF (KSD outflow to the river) as a result of return flow from agricultural lands downstream of the refuge. Soluble reactive P loading from the KSD was a significant percentage (25-50%) of the total river load in both 1999 and 2000.

## CONCLUSIONS

The flow from the KSD to the Klamath River during the irrigation season represents a small percentage of the total river flow (20% or less on a monthly basis). This is especially true with higher river flow requirements for Coho salmon. Temperature and turbidity in the Klamath River did not appear to be affected by KSD outflow in 1999 or 2000. Dissolved oxygen concentrations in the KSD were low but the river concentrations at Miller Island upstream of the KSD outflow were even lower. Dissolved oxygen concentrations in the river were related to river flows at Miller Island; higher flows corresponded to higher dissolved oxygen concentrations (100% saturation) and flows less than 1000-1200 cfs corresponded with low dissolved oxygen concentrations (< 100% saturation). Ammonia concentrations in the river were most closely related to dissolved oxygen concentrations in the river rather than KSD loading. The outflow from the KSD did contribute a significant percentage of the nitrate (25-75%) and soluble reactive P (25-50%) load in the river in 1999 and 2000.

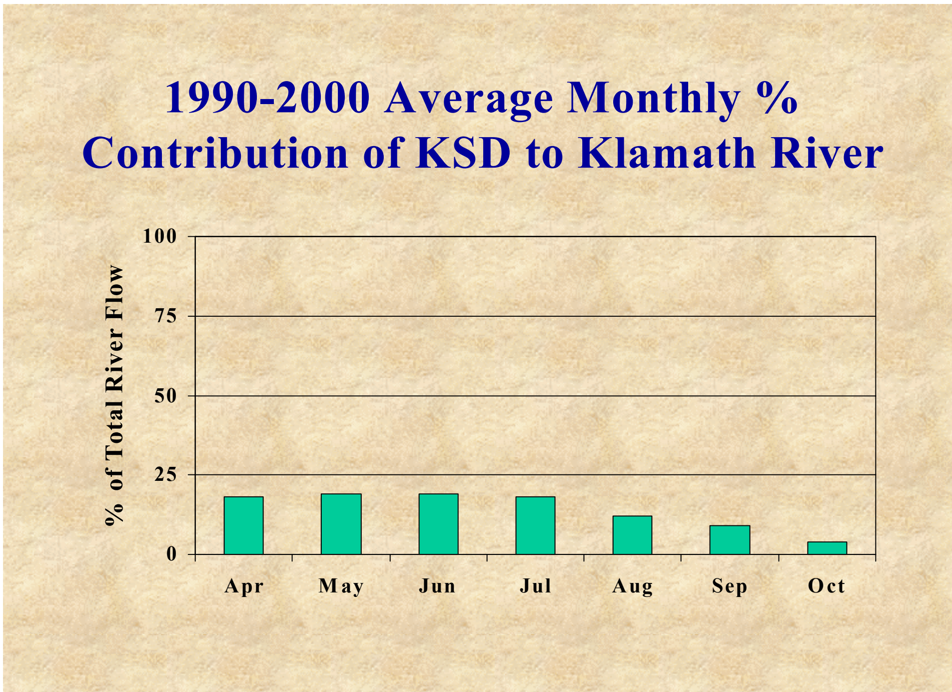



**Figure 1**. Average Monthly Percent Contribution of the Klamath Straits Drain to the Klamath River

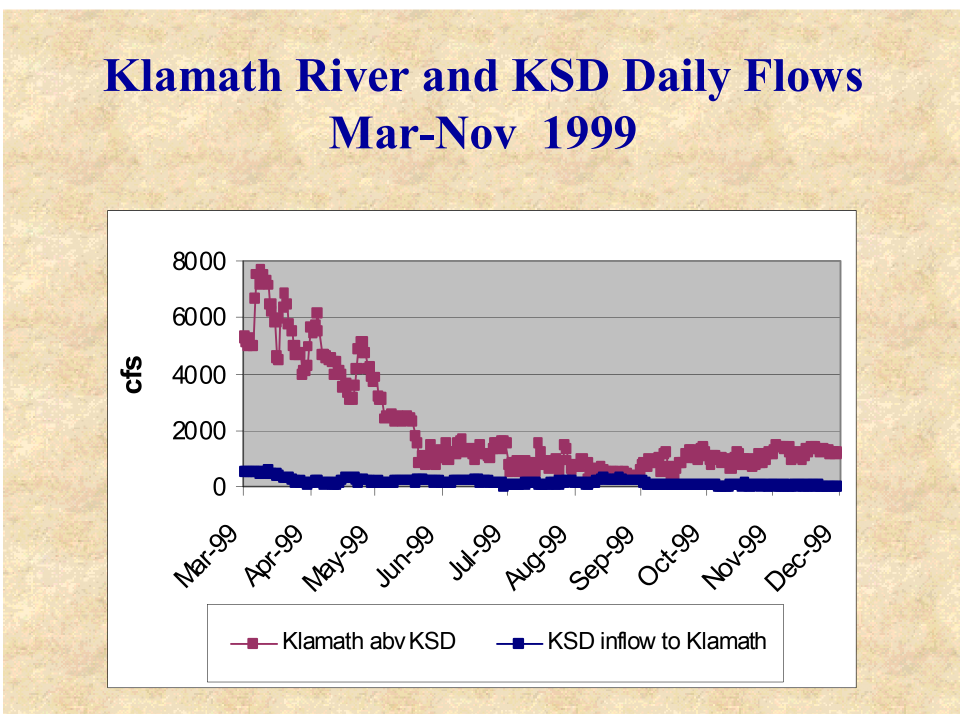



**Figure 2.** Daily flows in the Klamath Straits Drain and in the Klamath River above the Klamath Straits Drain

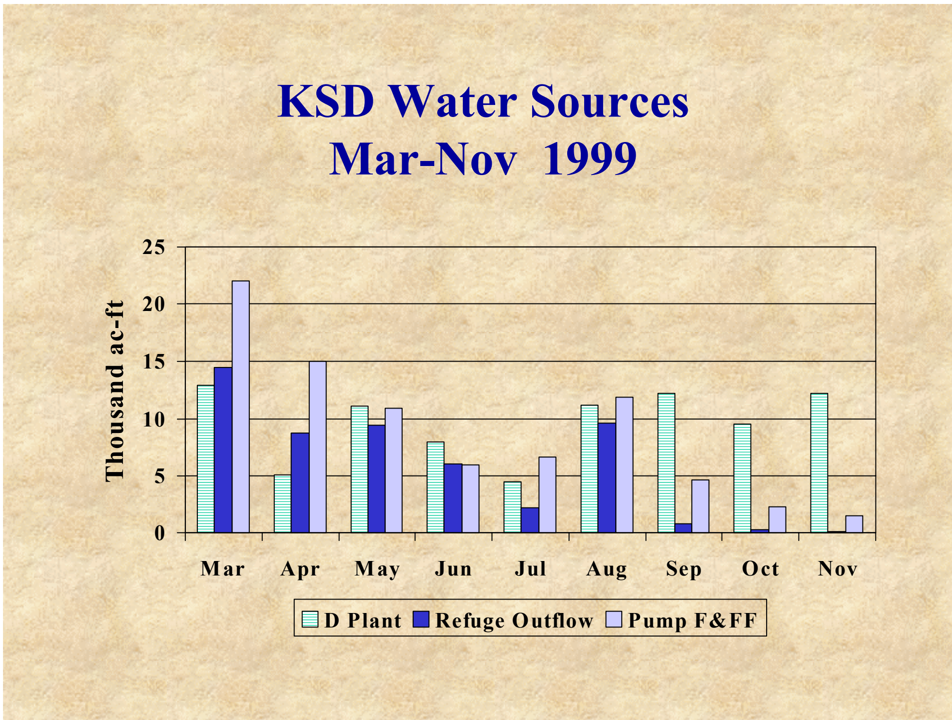



**Figure 3**. Sources of water for the Klamath Straits Drain

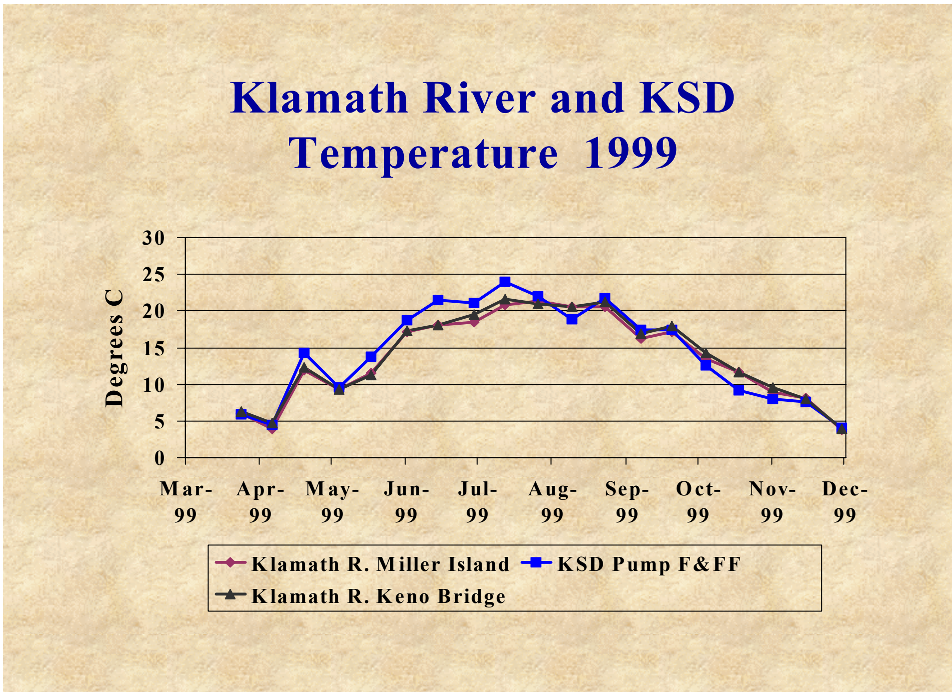



**Figure 4** Water temperatures at the Klamath Straits Drain outflow and upstream (Miller Island) and downstream (Keno Bridge) in the Klamath River in 1999.

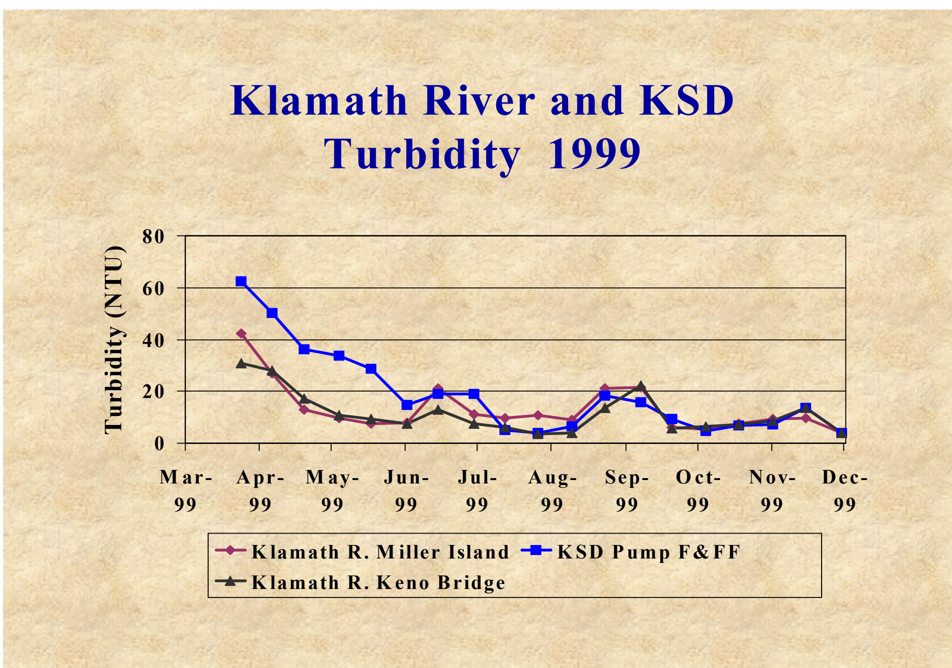
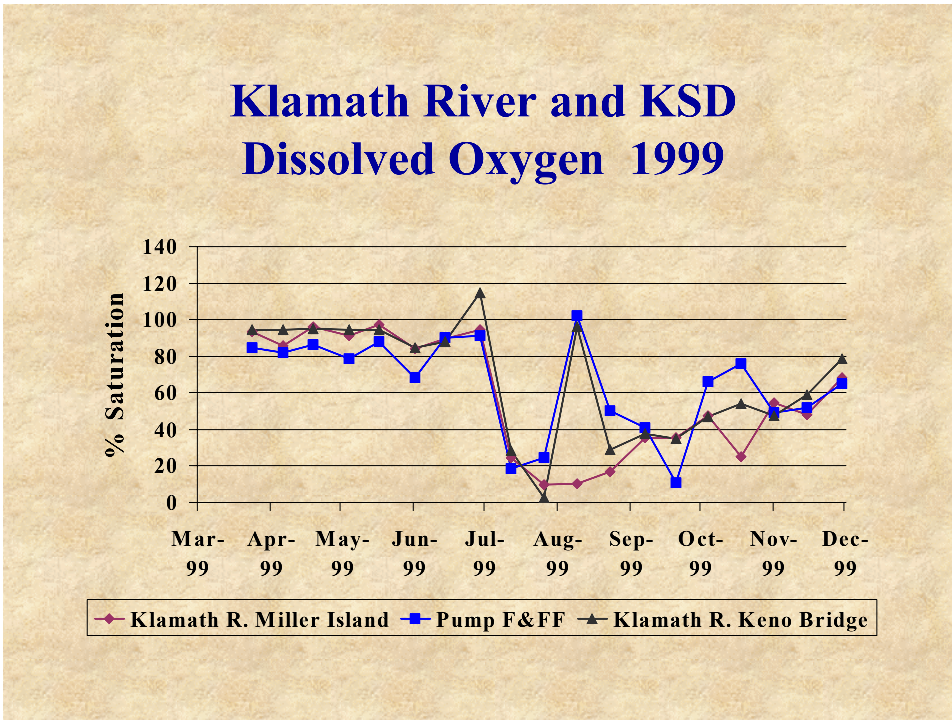



**Figure 5**. Turbidity at the Klamath Straits Drain outflow and upstream (Miller Island) and downstream (Keno Bridge) on the Klamath River



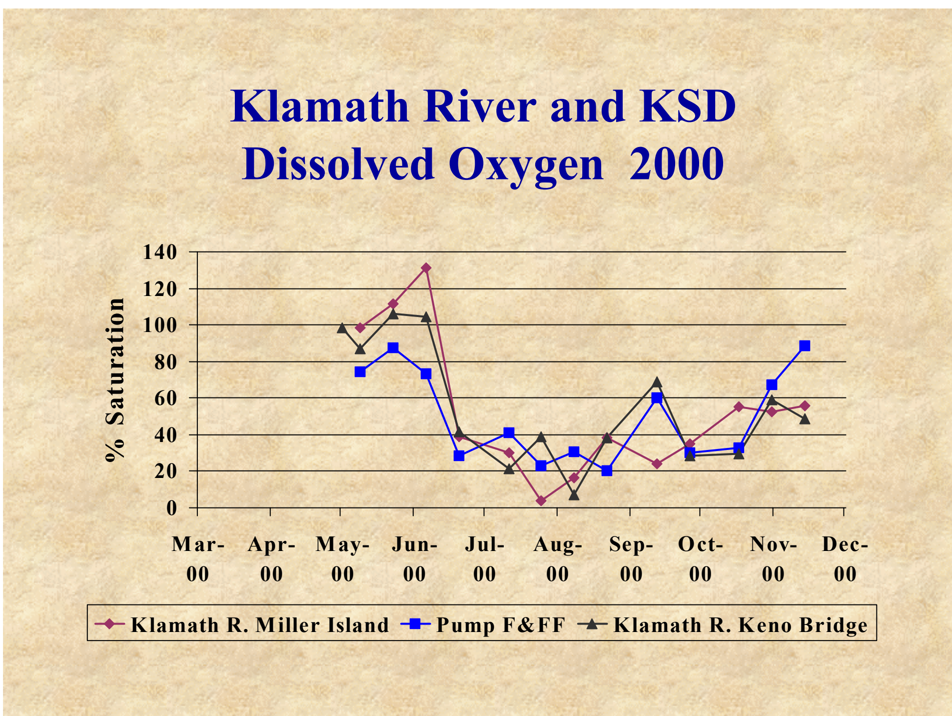




**Figure 6.** Dissolved oxygen percent saturation at the Klamath Straits Drain outflow and upstream (Miller Island) and downstream (Keno Bridge) on the Klamath River for 1999 and 2000.

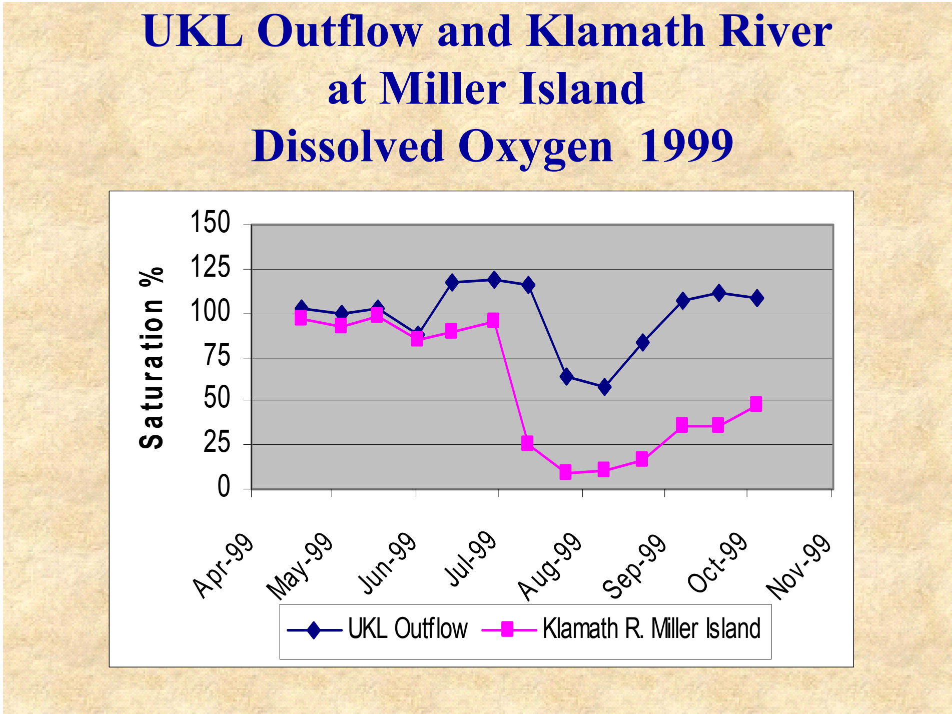



**Figure 7.** Comparison of dissolved oxygen saturation percentages at the outlet of Upper Klamath Lake and downstream in the Klamath River at Miller Island.

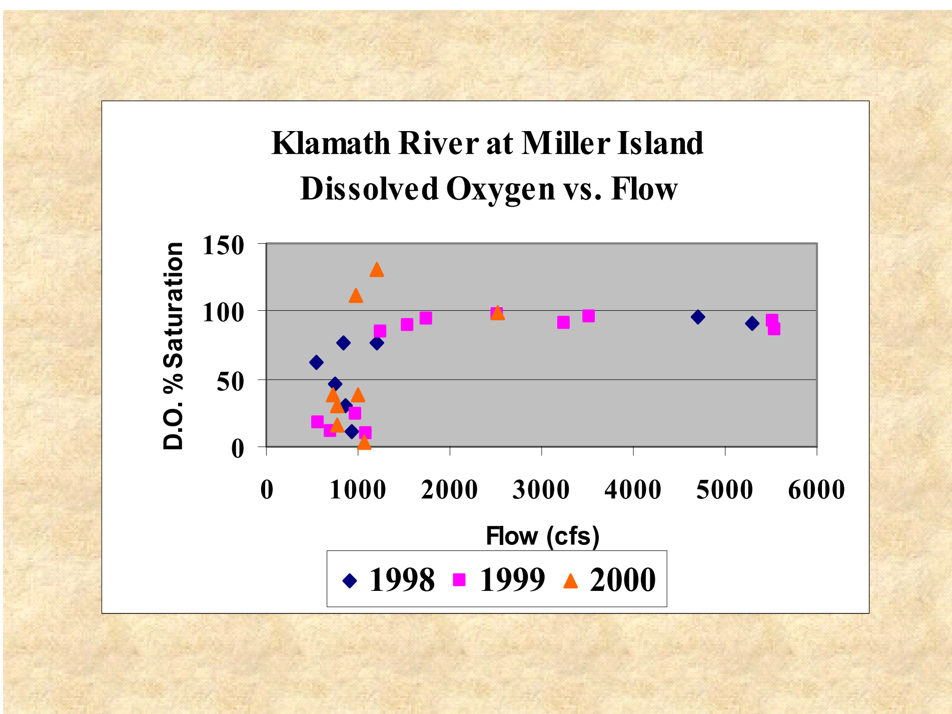
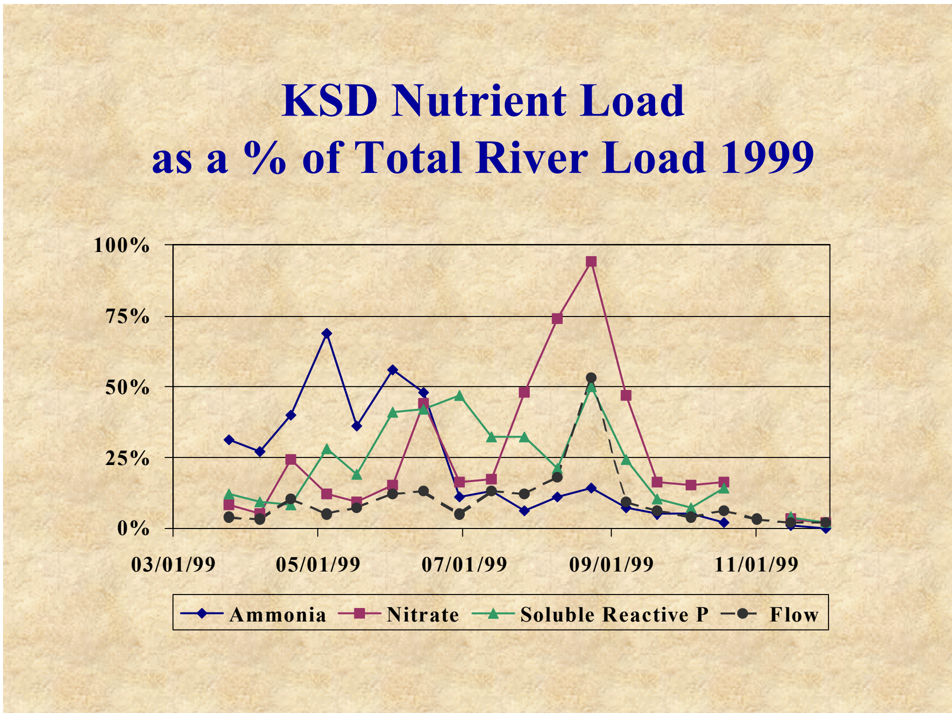



**Figure 8.** Relationship between Klamath River flow at Miller Island and dissolved oxygen.



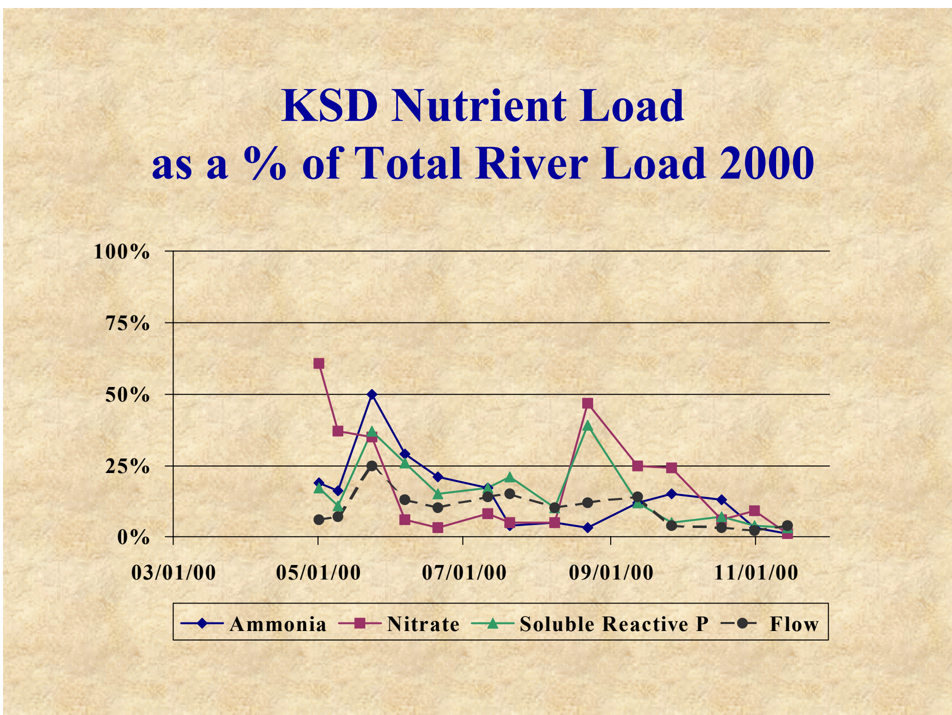




**Figure 9.** Relative contribution of the Klamath Straits Drain to the River for nitrate, ammonia, soluble reactive P, and flow.

## REFUGE WETLANDS: DO THEY DEGRADE OR IMPROVE WATER QUALITY IN THE KLAMATH BASIN?

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Nonpoint source pollution from a variety of land management practices is believed to be responsible for water quality problems in the Klamath Basin. One area of particular interest is the Lower Klamath National Wildlife Refuge. To evaluate water quality impacts from this area, I have examined physical and chemical data and developed water and nutrient budgets for the years 1999 and 2000. Results indicated both detrimental impacts (decreased dissolved oxygen concentrations) as well as favorable impacts (lower turbidity and pH) from the refuge. Surprisingly, elevated water temperatures from wetlands did not seem to be an issue. Nutrient dynamics on the refuge revealed a very interesting picture. While outflow concentrations were often higher than inflow concentrations, evaluation of chemical loads (flows* concentrations) indicated significant nutrient removal by the refuge. Nitrate and ammonia removal was very high. TKN, TP, and SRP removal was lower but still appreciable. Monitoring of several individual wetlands corroborated the findings for the refuge as a whole and shed light on possible removal mechanisms. In terms of N and P, water quality is improved as it passes through the refuge. The findings demonstrate the importance of assessing chemical loads as well as concentrations when evaluating water quality impacts.

## NUTRIENT LOADING IN THE KLAMATH BASIN

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### ABSTRACT

Implementation of the Federal Clean Water Act and Oregon Senate Bill 1010 is proceeding under 2 simultaneous processes in Oregon. The Oregon Department of Environmental Quality (DEQ) is responsible for developing Total Maximum Daily Load (TMDL) allocations for water-quality limited water bodies. The Oregon Department of Agriculture is developing Management Area Plans to guide management of private agricultural lands to meet Clean Water Act objectives. Both processes seek input from local advisory committees comprised of landowners and other stakeholders, and technical review committees.

Klamath Lake and Klamath River have been designated water-quality impaired for several parameters including nutrients. Previous research has attempted to determine the extent of agriculture's contributions to nutrient enrichment of surface waters in the Upper Klamath Basin.

From 1998 through 2000, the Klamath Experiment Station (KES) has investigated nutrient loading from drainage of agricultural lands adjacent to Klamath Lake, natural background sources including major springs and several artesian wells, and loading to the Klamath Irrigation Project (KIP) from diversions out of Klamath Lake and Klamath River. Findings indicate contributions from agricultural lands adjacent to Klamath Lake have been overestimated, and the KIP is probably a net sink for nutrients diverted out of Klamath Lake and Klamath River. Data to support these assertions are presented.

## INTRODUCTION

Most of the surface waters in the Klamath Basin are included in the DEQ 303D list as water-quality limited. While the only criterion for listing of many streams is temperature, based on a preliminary standard of $64^0$F, Klamath Lake and Klamath River are listed for chlorophyll a, dissolved oxygen, un-ionized ammonia, and pH. The DEQ is working toward development of TMDL allocations for Klamath River and Klamath Headwater regions. During the Klamath River TMDL planning process, discharge from the KIP at the Straits Drain was identified as a source of contaminants requiring assignment of TMDLs. Agricultural activities within KIP are widely thought to be a major source of nutrient loading to discharge waters. However, multiple water sources and diversion pathways, the influence of 2 wildlife refuges within KIP, and other inputs complicate assessment of this complex system.

Klamath and Agency lakes (referred to as Klamath Lake), the main source of water supply for KIP, is in advanced stages of eutrophication. The 80,000-acre lake has an average depth of only 8 feet. High phosphorus (P) content in the lake supports massive blue-green algae (*Aphanizomenon flos-aquae*) blooms in summer months. The die-off of algae blooms creates conditions toxic to resident fish, including pH near 10.0, dissolved oxygen levels less than 2.0 mg/l, and un-ionized ammonia concentrations near 1.0 ppm. Fish kills associated with poor water quality in 1995, 1996, and 1997 depleted stocks of shortnose suckers (*Chasmistes brevirostris*) and Lost River suckers (*Deltistes luxatus*), listed as endangered under the Endangered Species Act. Conditions favorable for algae blooms existed before the region was settled; early explorers documented foul water conditions in Klamath Lake in the 1840s.

Nutrient loads in Klamath Lake and its tributaries have been monitored and documented (Kann and Walker, 1999, Snyder and Morace, 1997, Campbell and Ehinger, 1993, Campbell et al, 1993, Sartoris and Sisneros, 1993, and Miller and Tash, 1967). United States Geological Survey (USGS) studies of drainage from agricultural lands adjacent to Klamath Lake implicated these lands as major sources of P loading (Snyder and Morace, 1997 and Miller and Tash, 1967). Findings from these and other studies have been used to support acquisition of private lands adjacent to the lake and conversion to wetlands. Three major parcels totaling over 15,000 acres have been purchased to date with public funds. About 1/2 of the property is intended for additional water storage and the remainder for conversion to wetlands, which are projected to serve as filters to remove nutrients in drainage waters from upland agricultural lands and provide refugial habitat for juvenile suckers.

Studies by the USGS of drainage waters from agricultural lands failed to consider nutrient loading in water diverted onto these properties. Over 7,000 acres adjacent to southern portions of Klamath Lake are irrigated with water diverted from Klamath Lake in late fall and early winter. A long-term study of water quality in Klamath Lake identified high nutrient content in Howard Bay, the source of irrigation water for over 6,000 acres of these agricultural lands (Kann and Walker, 1999). Nutrient loading to KIP from the major diversions out of Klamath Lake and Klamath River was not documented prior to 1999. KES initiated a water-quality monitoring study in 1998 to further define nutrient loading from natural and agricultural sources.

## OBJECTIVES

1. Determine total phosphorus (TP) and total Kjeldahl nitrogen (TKN) concentration in natural background sources including major springs and artesian wells;
2. Determine nutrient content of irrigation water applied to and drainage water from agricultural properties adjacent to Klamath Lake;
3. Determine nutrient loading to the KIP at A Canal, North Canal, and ADY Canal diversions.

## METHODS

Most water samples were collected as grab samples, refrigerated immediately, and delivered to the Oregon State University Department of Crop and Soil Science Central Analytical Laboratory within 24 hours, or frozen for batch delivery at a later date. Duplicate samples were frequently taken for quality control purposes. On 3 occasions in 1999, 24-sample sets were collected with an ISCO automatic sampler at the A Canal headworks over 48-hour periods. Frozen samples were kept frozen until analyzed. All samples were analyzed for unfiltered TP and TKN using Kjeldahl digestion procedures and appropriate control samples.

Sampling sites included several springs that are the source of tributaries to Klamath Lake. These include the headwaters of Spring Creek, Wood River, Crystal Creek, and Fort Creek. Artesian wells sampled are reported to represent at least 3 different aquifers in the Fort Klamath Valley. Diked and drained agricultural land adjacent to Klamath Lake was monitored over 2 years to determine nutrient concentrations in water applied onto these properties and drainage from them into Klamath Lake. During 1999 and 2000, the diversions from Klamath Lake and Klamath River at headworks for the A, North, and ADY canals were sampled on an approximate 10- to 14-day schedule from May through October. Nutrient loading to KIP was calculated using flow data at the diversions reported by the Bureau of Reclamation’s (BOR) Klamath Project Office.

## RESULTS

Most of the samples collected were analyzed for TP and TKN. However, P is the limiting nutrient for blue-green algae and phosphorus drives the algae bloom cycle. Subsequent die-off of algae blooms contributes to water quality problems related to pH, dissolved oxygen, and un-ionized ammonia. Blue-green algae fix nitrogen; during summer months, Klamath Lake is a nitrogen factory with algae driving the process. Phosphorus concentrations of 0.02 to 0.09 ppm are considered adequate to support blue-green algae present in the lake (Chu, 1943).

Springs are the source for several tributaries feeding Klamath Lake. Spring Creek contributes much of the flow in the Williamson River in late summer. Wood River, and Fort Creek are important sources of inflow. Each of the springs feeding these streams was found to have TP concentrations at levels not limiting to blue-green algae (Table 1).

**Table 1. Nutrient concentrations in artesian wells and springs in the Upper Klamath Basin, Oregon.**

| Springs | Sample date | Total phos-phorus | Total Kjeldahl nitrogen | Wells | Sample date | Total phos-phorus | Total Kjeldahl nitrogen |
|---|---|---|---|---|---|---|---|
| | | --- ppm --- | | | | --- ppm --- | |
| Annie Creek Spring | 09/03/99 | 0.03 | < 0.2 | Sevenmile | 08/18/98 | 0.09 | -- |
| | 09/03/99 | 0.04 | < 0.2 | | 09/30/98 | 0.10 | 0.2 |
| Crystal Creek Spring | 08/11/98 | 0.11 | -- | A. McAuliffe Ranch | 08/18/98 | 0.09 | -- |
| | 07/28/99 | 0.07 | < 0.2 | | 09/30/98 | 0.11 | 0.1 |
| Mares Egg Spring | 09/30/98 | 0.07 | 0.2 | Fort Klamath | 09/30/98 | 0.31 | 0.3 |
| | | | | Telephone Company | 09/03/99 | 0.31 | < 0.2 |
| Blue Spring | 09/30/98 | 0.06 | 0.1 | Horseshoe Resort | 09/30/98 | 0.69 | 0.5 |
| | | | | | 09/03/99 | 0.71 | 0.5 |
| Kimball Park Spring | 09/30/98 | 0.07 | 0.1 | Church House | 09/30/98 | 0.75 | 0.5 |
| (Wood River Source) | 09/03/99 | 0.06 | < 0.2 | | 09/03/99 | 0.73 | 0.6 |
| Fort Creek Spring | 09/30/99 | 0.09 | 0.1 | Porter Residence | 08/18/98 | 0.79 | -- |
| | 09/03/99 | 0.06 | < 0.2 | | 09/30/98 | 0.75 | 0.5 |
| | | | | | 09/03/99 | 0.76 | 0.5 |
| Spring Creek Spring | 09/30/98 | 0.08 | 0.1 | W. McAuliffe | 08/18/98 | 1.20 | -- |
| | 09/03/99 | 0.09 | < 0.2 | Residence | 09/30/98 | 1.13 | 1.3 |
| | 09/03/99 | 0.09 | < 0.2 | | | | |
| Barkley Spring | 11/04/98 | 0.08 | < 0.2 | McNeary Residence | 09/30/98 | 1.56 | 1.9 |
| Malone Spring | 07/28/99 | 0.06 | 0.4 | Wood River Ranch | 11/04/98 | 2.58 | 9.1 |
| | | | | Northwest | 12/30/98 | 1.86 | 8.7 |
| Odessa Spring | 09/30/98 | 0.04 | 0.19 | | 04/06/99 | 2.77 | 6.0 |
| | | | | | 03/15/00 | 2.28 | 8.5 |
| Harriman Spring | 09/30/98 | 0.04 | 0.20 | | | | |
| | | | | Wood River Ranch | 11/04/98 | 5.87 | 5.8 |
| Threemile Creek | 09/30/98 | 0.02 | 0.19 | Corral | 12/30/98 | 6.10 | 5.8 |
| Spring | | | | | 04/06/99 | 5.90 | 7.3 |
| | | | | | 03/15/00 | 3.23 | 5.7 |

Over 1,500 artesian wells reportedly have been developed in the Fort Klamath Valley. Over 800 of these are still in use or are not capped (L. Porter, personal communication). Local residents suggested that at least 3 aquifers are represented by the wells sampled in this study. The Sevenmile and A. McAuliffe wells are reportedly from a 460-foot deep aquifer located in the western side of the valley (Table 1). Six wells sampled were located within 5 miles of Fort Klamath in the center of the valley. Well drilling data indicates these are all from a 230-foot deep aquifer. Two wells on the Wood River Ranch property are of unknown depth. The very high nutrient contents in these and a 3rd well on the property sampled in a previous study (Snyder and Morace, 1997) suggest a different aquifer may be involved. The water volume discharged by artesian wells is minimal and nutrient loading from this source is probably not significant in the overall picture. However, springs adjacent to and within the lake are estimated to be the source of about 17 percent of the inflow to Klamath Lake and 25 percent of P loading (Miller and Tash, 1967).

Snyder and Morace (1997) monitored drainage discharge from several properties in 1993-95, including Running Y Ranch properties (Wocus Marsh and East Caledonia Marsh) near Howard Bay and the Wood River Ranch property at the north end of Agency Lake. The KES study sampled Running Y Ranch drains as well as the inflow to the properties during 1998 through 2000. The West Caledonia Marsh property was also sampled by KES in 1999 and 2000. Wood River Ranch drains and inlets were sampled by KES in 1999 and 2000. Nutrient concentration data from these studies are presented in Table 2.

**Table 2. Concentration of total phosphorus (TP) and total Kjeldahl nitrogen (TKN) in inflow and drainage water of Wocus Marsh, East Caledonia Marsh, West Caledonia Marsh, and Wood River Ranch in the Klamath Basin as measured by Snyder and Morace (1993-1995) and KES (1998-2000).**

| Site | Study | No. sample dates | No. samples | Inflow TP | Inflow TKN | Drainage TP | Drainage TKN |
|---|---|---|---|---|---|---|---|
| | | | | ppm | | | |
| Wocus Marsh | | | | | | | |
| | 1993-1995 | 9 | 9 | -- | -- | 0.21 | 4.2 |
| | 1998-2000 | 19 | 29 | 0.13 | 2.8 | -- | -- |
| | 1998-2000 | 24 | 41 | -- | -- | 0.18 | 3.8 |
| East Caledonia Marsh | | | | | | | |
| | 1993-1995 | 3 | 3 | -- | -- | 0.24 | 4.2 |
| | 1998-2000 | 10 | 16 | 0.06 | 1.1 | -- | -- |
| | 1998-2000 | 16 | 27 | -- | -- | 0.24 | 3.7 |
| West Caledonia Marsh | | | | | | | |
| | 1998-2000 | 5 | 9 | 0.06 | 1.3 | -- | -- |
| | 1998-2000 | 9 | 18 | -- | -- | 0.17 | 2.6 |
| Wood River Ranch – Sevenmile Canal | | | | | | | |
| | 1993-1995 | 6 | 6 | -- | -- | 0.93 | 3.3 |
| | 1999-2000 | 11 | 22 | -- | -- | 0.49 | 3.0 |
| Wood River Ranch – Wood River | | | | | | | |
| | 1993-1995 | 6 | 6 | -- | -- | 0.98 | 2.7 |
| | 1999-2000 | 5 | 10 | -- | -- | 0.86 | 3.5 |
| Wood River Ranch – Inflow 1999-2000 | | | | | | | |
| | Fall | 11 | 22 | 0.12 | 0.7 | -- | -- |
| | Spring | 15 | 30 | 0.21 | 1.8 | -- | -- |

The KIP provides water to about 220,000 acres, including Tulelake and Lower Klamath national wildlife refuges. Major points of diversion to the project include the A Canal at the south end of Klamath Lake and the North and ADY canals that divert water out of the Klamath River about 8 and 10 miles downstream from Klamath Lake, respectively. During 1999 and 2000, the KES study monitored these diversions on about 2-week intervals from May through October. Mean TP and TKN values for each sample date are shown in Table 3. On most dates, means are for duplicate samples. Means for July 9, July 27, and August 31, 1999 include 24 samples from an ISCO automated sampler and grab samples taken at the beginning of the sampling period. Using flow volumes provided by the BOR, nutrient loading was calculated for each diversion for time-periods midway between sampling dates.

Total nutrient loading to the KIP from Klamath Lake and Klamath River diversions is estimated at approximately 170,000 lb P and 2 million lb N in 1999 and 180,000 lb P and 2 million lb N in 2000 (Figures 1-4).

**DISCUSSION**

Natural sources of P in springs feeding tributaries and in artesian wells are sufficient to support blue-green algae blooms. Miller and Tash (1967) suggested nutrients contained in the top inch of lake sediments would sustain algae production if all external loading were eliminated for decades. Kann and Walker (1999) estimated internal loading from lake sediments account for 61 percent of P loading. The eutrophic condition of Klamath Lake prior to the arrival of settlers attests to the effects of natural nutrient sources, absent anthropogenic contributions.

Nutrient loading in Klamath Lake is unquestionably enhanced by the drainage of irrigation water from agricultural properties adjacent to the lake. Prior to reclamation, all of these properties were either permanent or seasonal wetlands. Following construction of dikes and drainage systems, the properties were managed for pastures and/or crop production. Soils are high in organic matter content and native fertility; therefore pastures and hay crops on these lands are generally not fertilized. Natural processes associated with mineralization of these soils release nutrients subject to transport in drainage water.

Drainage water from agricultural land adjacent to Klamath Lake was estimated to account for 26.5 percent of external P loading and 20 percent of N loading by Miller and Tash (1967). Estimates did not account for nutrient loading to these properties from water applied to the properties. Several properties at the southern end of Klamath Lake are irrigated with water diverted from Klamath Lake in late fall and early winter. After allowing for infiltration and recharging of the soil profile, water is pumped off in the spring to prepare fields for planting. KES data indicate water diverted onto Wocus Marsh in 1998 and 1999 had TP and TKN concentrations 72 and 74 percent as high as concentrations in drainage water, respectively. The intake and discharge points for this property are about 500 feet apart, resulting in recirculation of much of the water diverted onto the property. Nutrient concentrations in discharge water were similar in KES and USGS studies (Table 2). Mass loading cannot be calculated, as there is no means to measure the inflow volume of irrigation water diverted from Klamath Lake. However, the purpose for irrigating is to recharge the soil profile, and inflow volume undoubtedly exceeds drainage discharge.

**Table 3. Nutrient concentrations of unfiltered samples collected at A, North, and ADY diversion canals during 1999 and 2000 and analyzed for total phosphorus (TP) and total Kjeldahl nitrogen (TKN), Klamath Falls, Oregon.**

| Sample | A Canal | | North Canal | | ADY Canal | |
|---|---|---|---|---|---|---|
| date | TP | TKN | TP | TKN | TP | TKN |
| | - - - - - - - - - - - - - - - - - - - - - - - - - - | | | -ppm - - - - - - - - - - - - - - - - - - - - - - - - - | | |
| | | | 1999 | | | |
| 05/13 | 0.050 | 0.55 | 0.100 | 0.65 | 0.145 | 0.90 |
| 05/25 | 0.065 | 0.55 | 0.125 | 0.70 | 0.110 | 0.70 |
| 06/09 | 0.070 | 0.60 | 0.150 | 0.90 | 0.100 | 0.60 |
| 06/21 | 0.100 | 1.25 | 0.105 | 1.05 | 0.145 | 1.55 |
| 07/01 | 0.140 | 2.30 | 0.160 | 2.60 | 0.180 | 2.40 |
| 07/09 | 0.270 | 4.60 | 0.180 | 2.30 | 0.300 | 4.20 |
| 07/27 | 0.340 | 3.20 | 0.150 | 1.70 | 0.140 | 1.90 |
| 08/06 | 0.210 | 2.00 | 0.185 | 1.95 | 0.195 | 1.55 |
| 08/19 | 0.305 | 3.75 | 0.290 | 1.80 | 0.150 | 1.15 |
| 08/31 | 0.210 | 1.90 | 0.310 | 3.30 | 0.275 | 2.85 |
| 09/13 | 0.230 | 2.60 | 0.235 | 2.85 | 0.565 | 6.30 |
| 09/23 | 0.245 | 3.00 | 0.260 | 2.05 | 0.225 | 2.10 |
| 10/04 | 0.150 | 2.80 | 0.140 | 1.65 | 0.155 | 1.95 |
| Mean | 0.183 | 2.24 | 0.184 | 1.81 | 0.207 | 2.17 |
| | | | 2000 | | | |
| 05/01 | 0.050 | 0.50 | 0.100 | 0.65 | 0.100 | 0.70 |
| 05/16 | 0.070 | 0.65 | 0.165 | 0.85 | 0.095 | 0.65 |
| 06/02 | 0.105 | 1.30 | 0.150 | 1.20 | 0.135 | 1.05 |
| 06/21 | 0.175 | 2.90 | 0.210 | 1.55 | 0.255 | 3.05 |
| 06/28 | 0.180 | 2.75 | 0.225 | 1.85 | 0.260 | 2.25 |
| 07/07 | 0.335 | 4.00 | 0.265 | 2.30 | 0.340 | 2.05 |
| 07/19 | 0.225 | 2.70 | 0.275 | 2.45 | 0.250 | 2.25 |
| 07/27 | 0.270 | 2.75 | 0.325 | 3.05 | 0.345 | 2.70 |
| 08/07 | 0.250 | 2.90 | 0.345 | 3.60 | 0.325 | 3.55 |
| 08/17 | 0.185 | 2.00 | 0.210 | 2.70 | 0.245 | 2.90 |
| 09/03 | 0.195 | 2.35 | 0.225 | 2.05 | 0.225 | 2.65 |
| 09/08 | 0.250 | 2.85 | 0.240 | 1.50 | 0.285 | 1.80 |
| 09/15 | 0.370 | 3.80 | 0.330 | 1.90 | 0.350 | 2.15 |
| 09/26 | 0.225 | 2.60 | 0.275 | 1.35 | 0.295 | 1.55 |
| 10/12 | 0.190 | 2.25 | 0.190 | 2.10 | 0.165 | 1.80 |
| Mean | 0.205 | 2.42 | 0.235 | 1.94 | 0.245 | 2.07 |

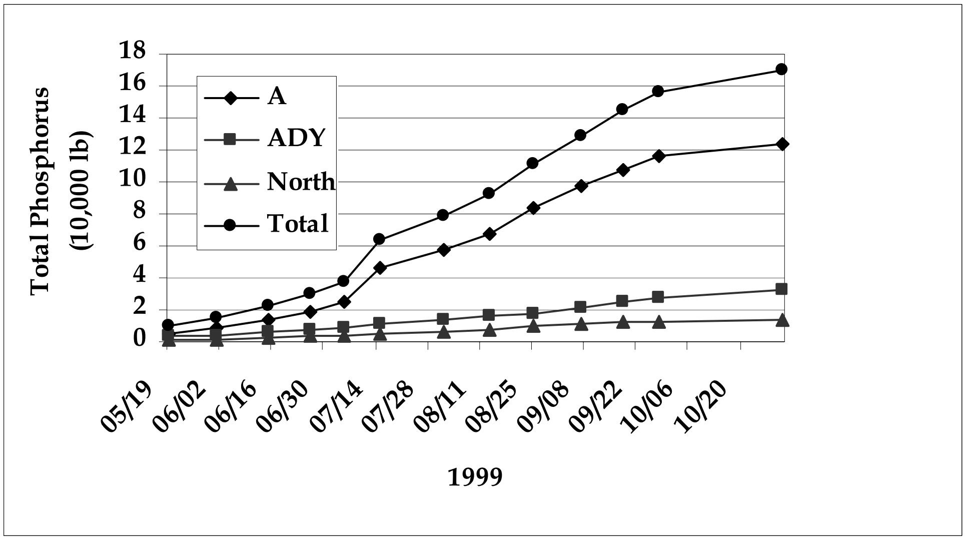


Figure 1. Total phosphorus loading in the KIP from the A, North, and ADY canals in 1999.

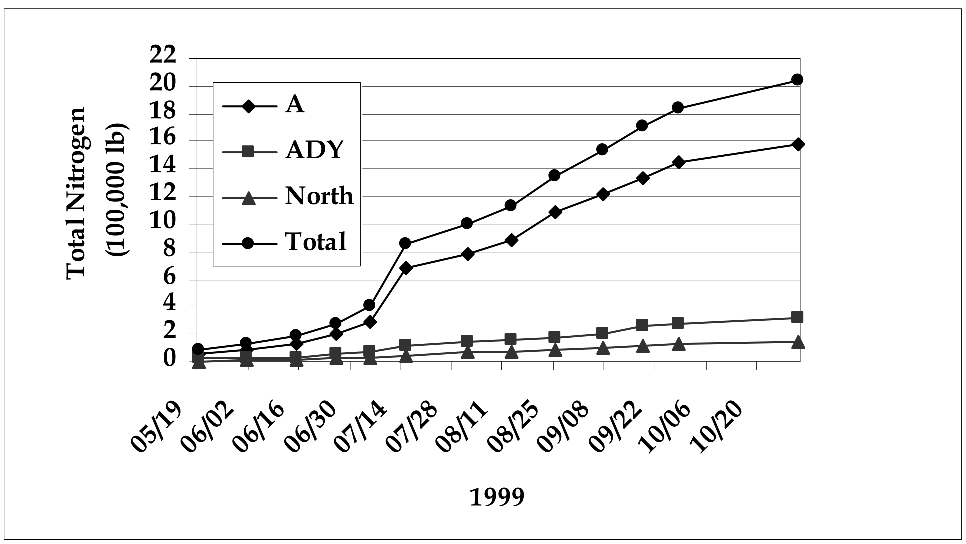


Figure 2. Total Kjeldahl nitrogen loading in the KIP from the A, North, and ADY canals in 1999.

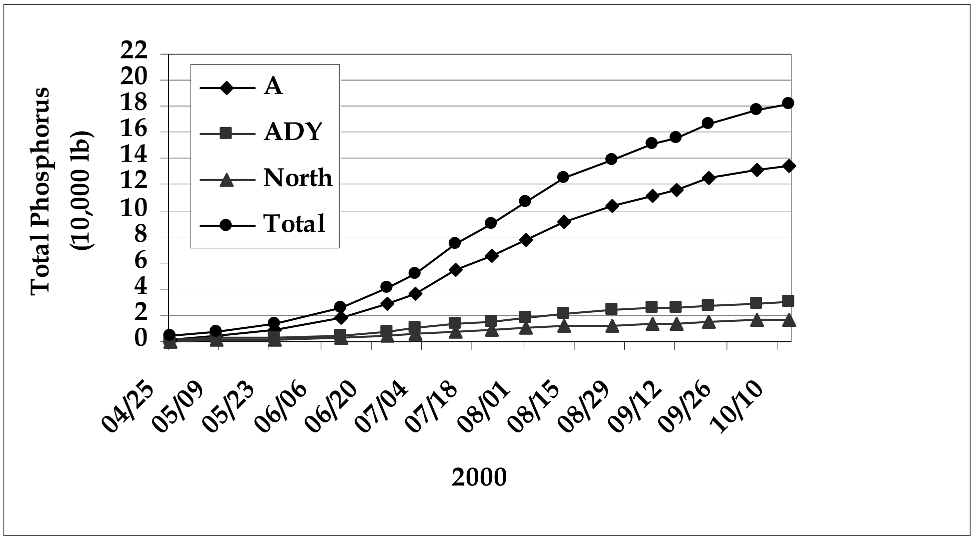


Figure 3. Total phosphorus loading in the KIP from the A, North, and ADY canals in 2000.

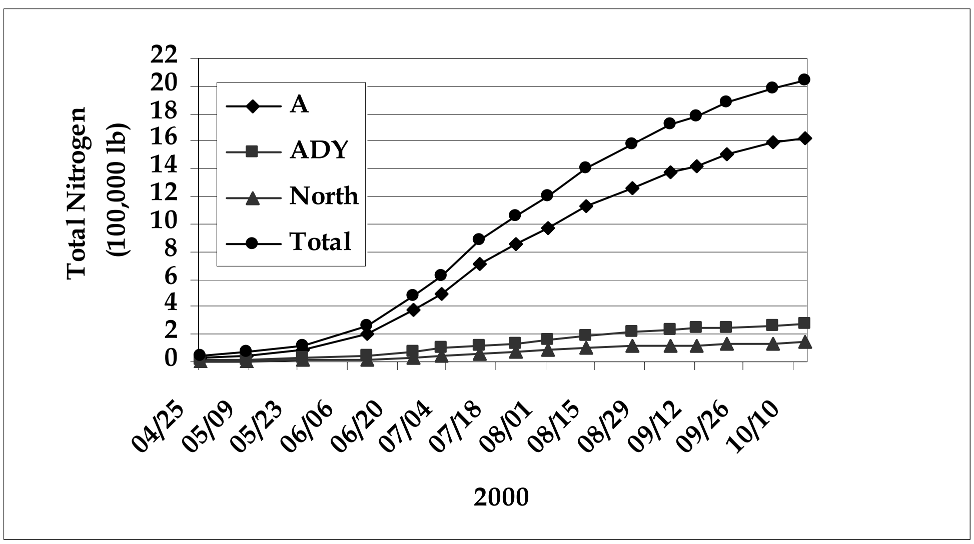


Figure 4. Total Kjeldahl nitrogen loading in the KIP from the A, North, and ADY canals in 2000.

Nutrient concentrations in inflowing Caledonia Marsh irrigation water were less than in Wocus Marsh (Table 2). Inflowing TP concentrations were 25 and 35 percent of concentrations in drainage from east and west sections, respectively, while TKN concentrations were 30 and 50 percent, respectively. Intake and discharge points are far apart for both sections with virtually no opportunity for recirculation of drainage water.

The Wocus and Caledonia Marsh properties are actively used for agriculture. Wocus Marsh is predominantly pasture with less than 25 percent used for grain and row crop production. Caledonia Marsh is primarily used for spring grain production, with less than 20 percent used for row crops, including onions and potatoes. These properties were drained and developed for agricultural production in the 1890s (Wocus) and 1910s (Caledonia) (Snyder and Morace, 1997). The situation at the Wood River Ranch is quite different. This property was drained and developed between 1940 and 1957, was used exclusively as pasture for cattle production until 1995, and since 1996 is undergoing restoration to seasonal wetlands.

The Wood River Ranch property receives diversion water from the Sevenmile Canal and tail water from irrigated upstream properties at the north boundary, and discharges drainage at the mouths of the Wood River and Sevenmile Canal. Snyder and Morace (1997) determined high P content in drainage water from both discharge points on this property (Table 2). Cattle were removed from the property following transfer of ownership to Federal agencies in 1995. KES data from discharge sampling 4 and 5 years later indicate high P loading continued after cattle were removed from the property. TP concentrations in drainage water were 53 and 88 percent of values observed by Snyder and Morace (1997) for Sevenmile and Wood River pumping station, respectively (Table 2). TP concentrations in water diverted onto this property for wetlands varied depending on the time of diversion. Water diverted in April and May in 1999 and 2000 averaged 0.21 ppm TP, while water diverted in September and October averaged 0.12 ppm TP (Table 2). All drainage samples were obtained in March and April. Interestingly, water diverted onto the Wood River Ranch is at least partially drainage water from pastures upstream from this property. While the long-term objective of converting the Wood River Ranch to wetlands is to provide scrubbing or filtering of nutrients, evidence to date indicates significant enhancement of nutrient content in water passing through this property.

An extensive data set developed from 1991 to 1998 by Kann and Walker (1999) documents lake-wide mean nutrient concentrations in Klamath Lake at up to nine continuously monitored sites on approximately 2-week intervals through spring, summer, and fall months (Table 4). Less frequent monitoring was conducted through the winter. TP concentrations cited vary from lows of 0.04 or 0.05 ppm in winter months to 0.30 ppm or more in the summer. Kann and Walker (1999) also presented data for the Fremont Bridge site (not shown here), which is within 1,000 feet of the intake for the A Canal diversion at the south end of Klamath Lake. Concentrations at this site ranged from 0.03 to 0.49 ppm TP and from 0.17 to 5.87 ppm total nitrogen (TN). The nutrient concentration in A Canal diversions out of Klamath Lake can be expected to be about the same as values observed at Fremont Bridge for May through October.

In 1999, A Canal samples ranged from 0.05 ppm TP in May to 0.34 ppm TP in late July. TKN concentrations ranged from 0.5 ppm in May to a high of 4.6 ppm in early July. In 2000, ranges were from 0.04 to 0.38 ppm TP and 0.5 to 4.3 ppm TKN. Using flow data from the BOR, total nutrient loading to the A Canal in 1999 was estimated at about 124,000 lb P and 1,578,000 lb N in the total water diversion for the season of 277,000 acre-feet (Figures 1 and 2). This represents a season-long mean concentration of 0.166 ppm TP and 2.11 ppm TKN. Slightly higher loading was estimated for 2000 (Figures 3 and 4), with mean nutrient concentrations of 0.184 ppm TP and 2.23 ppm TKN. Total 2000 loading was 134,700 lb P and 1,626,000 lb TKN in a total water diversion of 271,000 acre-feet.

**Table 4. Lake-wide mean concentrations of total phosphorus (TP), total nitrogen (TN), and ammonia nitrogen, ($NH_3$-N) by month for Upper Klamath/Agency Lake, 1991-1998. (Data from Appendix I, Kann and Walker, 1999.)**

| Month | No. samples | Total phosphorus (TP) | Total nitrogen (TN) | Ammonia nitrogen ($NH_3$-N) |
|---|---|---|---|---|
| | | - - - - - - - - - - - - | ppm | - - - - - - - - - - - - |
| January | 6 | 0.09 | 1.42 | 0.48 |
| February | 22 | 0.07 | 0.95 | 0.08 |
| March | 40 | 0.05 | 0.60 | 0.08 |
| April | 84 | 0.06 | 0.72 | 0.04 |
| May | 105 | 0.06 | 0.67 | 0.05 |
| June | 142 | 0.12 | 1.67 | 0.14 |
| July | 149 | 0.22 | 2.25 | 0.35 |
| August | 146 | 0.19 | 2.03 | 0.21 |
| September | 127 | 0.19 | 1.88 | 0.27 |
| October | 118 | 0.14 | 1.73 | 0.23 |
| November | 34 | 0.09 | 1.21 | 0.26 |
| December | 1 | 0.09 | 2.42 | 0.84 |

Several opportunities for changes in nutrient status occur between the outlet from Klamath Lake and Klamath River diversions to North and ADY canals. These include storm drain discharges, discharge from a water treatment plant, influence of a lumber mill with log decks in the river, decomposition of submerged wood debris, and effects from marshes and waterfowl habitat along the river. The 1999 diversion into the North Canal totaled about 30,000 acre-feet with nutrient loading estimated at 14,000 lb TP and 140,000 lb TKN. Mean nutrient concentrations were 0.175 ppm TP and 1.72 ppm TKN.

The ADY Canal diversion totaled about 61,000 acre-feet. Nutrient loading was estimated at 32,000 lb TP and 322,000 lb TKN, with mean concentrations of 0.195 ppm TP and 1.95 ppm TKN. There appeared to be a slight increase in P content below the outlet to Klamath Lake while N concentration was higher in the A Canal than in either diversion from Klamath River.

Results of the 2000 monitoring for KIP diversions were similar to 1999 findings (Figures 3 and 4). Mean nutrient concentrations were 0.222 ppm TP and 1.82 ppm TKN for the North Canal and 0.220 ppm TP and 1.93 ppm TKN for the ADY Canal. High nutrient peaks occurred in early July in both years.

Personnel from the University of California, Davis have monitored numerous sites in the California portion of the KIP, as well as the discharge to the Klamath River at the Straits Drain. Estimates from this study indicate an annual P discharge at the Straits Drain of approximately

100,000 lb P (S. Kaffka, personal communication). With no consideration for loading from the Lost River, municipal sources, or 2 national wildlife refuges within the KIP, the P discharge appears to represent approximately 60 percent of P diverted to the KIP from Klamath Lake and Klamath River.

## CONCLUSIONS

In all cases where comparisons were possible, nutrient concentrations observed in water samples collected during the KES study are in general agreement with data reported in previous studies. This is true for samples from springs with relatively low nutrient concentrations, and for artesian wells that had high P concentrations. No evidence suggests errors in sample analyses or indicates major changes in nutrient status of water sources over the years covered by various studies.

Natural background sources feeding tributaries to Klamath Lake are enriched with P at their source. While drainage water from agricultural properties adjacent to Klamath Lake do contribute nutrients to the lake, some of these properties are irrigated with Klamath Lake water that is high in nutrients at the point of diversion. Previous studies that have not accounted for this have overestimated contributions from drainage of agricultural lands to nutrient loading of the lake.

Approximately 75 percent of water supplied to the KIP is diverted from Klamath Lake or Klamath River via the A Canal, North Canal, or ADY Canal. Estimates from sampling of these diversions in 1999 and 2000 indicate nutrient loading to KIP of approximately 180,000 lb P and 2 million lb N annually. Preliminary data from a University of California, Davis study estimates nutrient loading to the Klamath River from the outlet for the KIP at the Straits Drain of approximately 100,000 lb P. With no consideration for loading from other sources, the KIP appears to provide a net sink for nutrients diverted out of Klamath Lake. The nutrient contributions from 2 national wildlife refuges and 2 municipalities located within KIP are not well documented. However, drainage water from the majority of agricultural lands within KIP passes through and is retained in the refuges for extended periods during summer months. Some enrichment from natural processes and resident waterfowl in the refuges is likely.

Comparing P concentrations between the A Canal and diversions out of the Klamath River at North and ADY canals indicates some P enrichment occurs within the Klamath River above the Straits Drain. No attempt has been made in this study to determine the source of this loading.

In assigning TMDL allocations for the Straits Drain, it is imperative that nutrients discharged to the Klamath River at this point are not considered wholly or in large part an agricultural contribution. High nutrient inputs to the KIP from Klamath Lake and Klamath River must be recognized as background sources beyond the control of agricultural interests.

## ACKNOWLEDGEMENTS

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## SOIL AND WATER QUALITY CHANGES DURING A WETLAND-CROPLAND ROTATION IN THE TULELAKE WILDLIFE REFUGE (POSTER)

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Wetland/cropland rotation is being proposed as a strategy to improve wetland habitat and soil quality in the Tule Lake NWR. We examined the impacts of rotation from cereal / row farming into wetland on marsh vegetation development, soil fertility and water quality. Desirable moist soil vegetation was established in 1-3 years in previously farmed sites. Undesirable weedy species were eliminated by the second year of seasonal flooding. Total soil N changed little after 3 years in seasonal / permanent wetlands, but Olsen-P increased by 70% in most sites. Wetlands generally maintained good water quality, although sporadic spikes in nitrate-N, ammonium-N and orthophosphate-P occurred throughout the year. Dissolved oxygen measured mid-morning generally fell to less than 7 mg / L around May and was low for much of the summer. The implications of these results for management of the refuge will be discussed.

## NITROGEN AND PHOSPHORUS LOSSES FROM DRAINED WETLANDS ADJACENT TO UPPER KLAMATH LAKE, OREGON

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Upper Klamath Lake likely is naturally eutrophic, though effluent pumped from drained wetlands may contribute to increased eutrophication. Most wetlands surrounding Upper Klamath Lake have been drained for crop cultivation and grazing. Lowering the water table in the wetlands allows air and oxygenated water to move through the subsurface and facilitate aerobic decomposition of the peat soils. Nutrients, nitrogen and phosphorus, are then liberated, leach into adjacent ditches, and are subsequently pumped to the lake or its tributaries, or are lost through other pathways. Potential nutrient loading to Upper Klamath Lake from drained wetlands was estimated by determining the pre-drainage and present-day nutrient masses of organic soils within the drained wetlands to calculate the loss in nutrient mass. For all the drained wetlands sampled, the estimated cumulative nitrogen and phosphorus loss since drainage totaled 250,000 tons and 4,300 tons, respectively, about 30% and 22% of the respective pre-drainage masses of those nutrients in the soils. The estimated nutrient input to the lake from sampled drained wetlands is a maximum value, as not all the nutrients released by the soils are discharged to the lake. The results of this study could be useful in determining which drained wetlands may provide the greatest benefits with regard to reducing nutrient loads to the lake if restored.

## NORTHERN PROVINCE TMDL IMPLEMENTATION STRATEGY FOR FOREST SERVICE LANDS

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The initiation of the TMDL process in Northern California necessitated that the Forest Service engage in TMDL development and implementation. Most watersheds within the Six Rivers, Klamath, Shasta-Trinity and Mendocino National Forests are affected by the TMDL process. The shear extent of Forest Service lands involved in the TMDL process clearly illustrated a need to develop a consistent and stream lined implementation strategy that could be included in all future TMDL Implementation Plans. Components of the Northern Province TMDL Implementation Strategy include: 1/ identifying and implementing existing Forest Service programs that meet TMDL goals; 2/ setting watershed restoration priorities on a Basin/Province Scale; 3/ establishing criteria that define practical completion of restoration efforts; 4/ completion of Road Analyses; and 5/ reporting of annual restoration and monitoring accomplishments. The initiation of the TMDL process has provided an incentive for the Forest Service to focus and articulate its watershed restoration program and thereby provide a much needed dialogue and feedback mechanism with regulatory agencies and interested publics.

## TMDLS IN THE UPPER KLAMATH BASIN

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Oregon Department of Environmental Quality is currently completing Draft TMDLs for the Upper Klamath, Sprague and Williason River Subbasins. The primarily TMDL for the 303(d) listed tributaries to Upper Klamath lake is temperature. The TMDLs for Upper Klamath Lake are related to the hypereutrophic status of Upper Klamath Lake and associated exceedances of water quality standards for pH and dissolved oxygen. A TMDL for nutrients was developed for phosphorous as the primary limiting nutrient to growth of the dominant algae. Temperature TMDL development was based on GIS analysis of stream morphology, flow, riparian vegetation and FLIR data sets from selected stream segments within the 3,380 mi2 study area. Phosphorous TMDL for Upper Klamath and Agency Lakes was developed through analysis of extensive water quality and flow data collected from Water Years 1992 to 1998. An empirical model was developed to determine the loading capacity of the lakes for phosphorous. The modeling effort indicated that significant improvements will occur from educing the anthropogenic load of phosphorous to the lakes. Included in the Draft TMDL document will be a Water Quality Management Plan (WQMP) describing implementation of the TMDLs under an adaptive management strategy. Contributors to the WQMP include agriculture, forestry, municipalities, county and federal agencies .

## THE NORTH COAST REGIONAL BOARD'S APPROACH TO TMDLS

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The Klamath River basin in California is listed as impaired for low dissolved oxygen (mainstem and Shasta), nutrients and temperature (all), and sediment (Scott). The Regional Board is working under a consent decree schedule that mandates USEPA adoption of the Klamath basin TMDLs in 2004 and 2005. We will discuss current Basin Plan standards for listed pollutants and the schedule for completing the various Klamath basin TMDLs. We also will discuss the approaches we have used to look at sediment and temperature TMDLs and how these may apply to the Klamath. Finally, we will touch on the implementation framework developed for the Garcia River sediment TMDL, which may serve as a model for other watersheds.

## CAN SCIENCE SAVE THE KLAMATH RIVER WITH TMDLS?

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The Klamath River was once the southern "anchor" of the elaborate Pacific Northwest Salmon culture, which some anthropologists say was the only non-agricultural society of "prehistoric" times to amass the kind of surplus wealth reflected in the art and architecture it enabled. According to Heizer and Elsasser (1980), it was not uncommon for the houses of Yurok people of the lower Klamath to river contain as much as a ton of salmon hanging from the rafters in the fall and winter. One estimate says that California Indians caught and consumed as much as 15,000,000 tons of salmon each year.

Today, the runs of salmonids that were coming and going from the Klamath River during most of the months of the year have been largely replaced by a run of fall chinook salmon dominated by fish from hatcheries associated with dams.

Did science conspire to re-plumb the Klamath Basin, drain its marshes and turn its falling water into cheap electricity? Is the Klamath fated to be an agricultural sewer? Will the science of TMDLs restore the Klamath River's former wonder and biological glory? Or will the answer to be found elsewhere? Politics perhaps?

## TMDLS AND TRIBES

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Tribes are in a unique position with respect to the TMDL process in the following ways:

- Tribes as regulators through self-governance
- Tribes as land managers subject to regulation
- Federal government trust responsibility of Tribal resources
- Government-to-government consultation requirements
- State and Tribal jurisdiction within TMDL
- Historic lack of adequate federal support to Tribes in developing standards and regulatory capacity

Tribes will be impacted by the development and implementation of TMDLs in the following ways:

- Economic development
- Tribal regulatory capacity burden
- TMDL as a tool to improve water quality conditions where Tribe's have not assumed jurisdiction through consultation

What Tribes are doing in TMDL watersheds:

- Hoopa Valley Tribe – Assessment, monitoring and modeling efforts
- Point Arena Manchester – Consultation issues, Garcia River TMDL
- Tribal management plans – Forestry, Roads, Grazing
- Yurok Watershed Restoration, Fisheries & Environmental Program – Assessment, implementation & monitoring (sounds like a TMDL?)

# PART 2: SALMONIDS, SUCKERS, AND FISHERIES MANAGEMENT

## SALMONID USE AND PHYSICAL CHARACTERISTICS OF THERMAL REFUGIAL AREAS ON THE MAINSTEM KLAMATH RIVER FROM IRON GATE DAM TO WEITCHPEC, CA

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The Klamath River mainstem, home to the Yurok Tribe, and once home to millions of chinook, coho, steelhead, lamprey, and sturgeon, has a serious water quality problem. High water temperatures, well into the range thought to be deleterious to salmonids regularly occur, during the summer, and fish retreat to areas of cool water at tributary confluences. Salmonid use of major and minor thermal refugial areas from Iron Gate Dam to Weitchpec (approximately 150 river miles) was investigated during the summer of 1998 using visual observation techniques. The maximum number of salmonids at any single refugial area was approximately 4000 fish, while other refugial areas held no fish at all. During some weeks in the summer, refugial areas in total hosted over 10,000 juvenile and adult salmonids. Twenty-four-hour observations at Indian Creek revealed that juvenile salmonids left the refugial areas near dawn, presumably to feed, with fish abundance and densities within the refugial area rebounding a few hours after daybreak. There was no relationship between the Klamath River mainstem-refugial area temperature difference and total number of salmonids, and there was only a weak relationship between aerial extent of refugial area size and observed fish numbers. Physical parameters of refugial areas including aerial extent, cool water inflow volume and temperature, as well as depths and velocities. Data collected in this study shows the importance of these areas to the pre-dam Klamath River aquatic ecosystem, and the consequences that loss of access to key thermal refugial areas above Iron Gate Dam has had.

## RESPONSE OF A RESIDENT BULL TROUT POPULATION TO NINE YEARS OF BROOK TROUT REMOVAL, CRATER LAKE NATIONAL PARK, OREGON

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Native bull trout (*Salvelinus confluentus*) were threatened with a high risk of extinction from hybridization and competition with introduced brook trout (*S. fontinalis*) in Sun Creek, Oregon. A bull trout restoration plan was written, peer reviewed, and implemented. The goals of the plan were to restore the remnant population of bull trout to historic numbers and distribution in Sun Creek, remove brook trout, and prevent re-invasion of non-native fish. Barriers were constructed to prevent

re-invasion of non-native fish in 1992. Before stream-wide brook trout eradication was attempted, bull trout abundance was increased and refugial populations were established to reduce the risk of local extinction during the restoration project. Brook trout were eradicated using a combination of techniques including electrofishing, snorkel diving, trap nets, and the fish toxin antimycin. Bull trout have increased in abundance from approximately 200 individuals in 1992 to nearly 800 in 2000, and have increased in stream distribution from approximately 2 kilometers to 14 kilometers.

## DISEASE AND ELEVATED WATER TEMPERATURE IN THE KLAMATH RIVER BASIN

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The California – Nevada Fish Health Center has performed 16 field and laboratory projects on the health and physiology of juvenile salmonids in the Klamath and Trinity Rivers since 1991. Early work centered on pathogen surveys of both natural and hatchery out-migrants while the last 4 years focused on controlled studies regarding the effects of elevated temperature on smolt health. Columnaris and ceratomyxosis are the most common and significant diseases observed in sick fish during the spring and summer months. Both diseases are accelerated with elevated water temperatures and the associated shift of the host: parasite balance. Juvenile chinook show both impaired immune defenses and smolt development in response to elevated water temperature. The health and temperature relationship is complex and is influenced by factors such as previous acclimation, energy reserves, duration and extent of temperature increase, and individual fish variation. Data and observations from controlled temperature studies with juvenile chinook will be discussed as well as objectives of future investigation.

## MODELING MICROHABITAT FOR FALL CHINOOK LIFE STAGES IN THE KLAMATH RIVER (IRON GATE DAM TO THE SCOTT RIVER)

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The commonly applied, yet frequently debated, Physical Habitat Simulation System (PHABSIM) was used to conduct a microhabitat study on the Klamath River from Iron Gate Dam to the confluence of the Scott River. However, instead of the common application of developing a microhabitat time series, the purpose of this study is to provide the necessary microhabitat versus

flow relationships for the mesohabitat computational units within a salmon production model named SALMOD. SALMOD emphasizes how the spatial and temporal variability of micro and macro habitat limits fish production. The study design, extent of data, error analyses, validation, and microhabitat versus flow for mesohabitat types are presented.

## PINNIPED PREDATION ON FALL-RUN CHINOOK

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The Yurok Tribal Fisheries Program conducted a pilot study to assess the impacts of pinniped predation upon fall-run chinook in the Lower Klamath River during 1997, and expanded their efforts with a more statistically rigorous study design during 1998 and 1999. Statistical analysis of the 1998 and 1999 data will be completed by the spring of 2001. Results from the 1997 study indicate that approximately 10,105 adult salmonids (chinook, coho and steelhead) and grilse chinook were consumed, however methods used during the pilot study were not suitable for determination of a confidence interval. Fall-run chinook was the primary prey species, with 8,809 estimated predation impacts, equivalent to 8.8% of the estimated 1997 fall chinook run. California sea lions *(Zalophus californianus)* were the primary pinniped predator, accounting for 87% of impacts on salmonids. The majority of predation events (21.5%) occurred near the confluence with the ocean. Pacific harbor seal scats were collected between April 1998 and November 1999. Adult salmonid remains were identified in over 15% of scats collected between August and mid-November, and were almost non-existent in scats collected during other time periods. Night observations conducted in 1999 indicated minimal pinniped predation in the estuary during darkness.

## SPRING CHINOOK SALMON
## (POSTER)

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Poster depicts the status and potential actions needed to recover the Spring Chinook Salmon in the Salmon River which have been identified by the United States Forest Service as being at-risk of extinction.

**REGIONAL ESTIMATION OF JUVENILE COHO *(ONCORHYNCHUS KISUTCH)* ABUNDANCE IN TRIBUTARIES TO THE LOWER KLAMATH RIVER, CA 2000**

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The Yurok Tribal Fisheries Program in conjunction with The Forest Science Project at Humboldt State University conducted surveys to quantify the abundance of age 0+ coho salmon in anadromous accessible tributaries to the lower Klamath River during late summer, 2000.

Additional objectives included the initiation of a long-term baseline data set with which to gage the relative status trend of lower Klamath River basin coho populations, and the refinement and development of the "regional estimate" methodology, which will in turn, benefit future projects utilizing this technique in other basins (such as the Klamath/Trinity River Basins).

Field sampling utilized the modified Hankin-Reeves Protocol (Hankin 1999; Hankin and Reeves 1988). The eventual formulation of overall regional coho abundance will utilize the Overton/McDonald sampling design methodology (Overton and McDonald 1998). Estimators for total number of fish and variance of the total fish estimate will be generated based on the assumption that data were collected from a sample of stream segments that had an equiprobable inclusion probability.

Juvenile coho were found in very low densities in 7 out of 20 reaches surveyed in 2000. Data analysis and the formulation of the regional population estimate are currently ongoing.

**RESIDENCE TIME OF JUVENILE CHINOOK SALMON IN THE KLAMATH RIVER ESTUARY**

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A juvenile chinook salmon length of residence study in the Klamath River estuary was conducted during the summers of 1997, 1998 and 1999 to determine if the estuary is important rearing habitat for young-of-the-year (YOY) chinook salmon. Annual mean estuarine residence times of recaptured YOY chinook salmon were 8.7, 12.0 and 16.2 days in 1997, 1998 and 1999, respectively, and their individual residence times ranged from 1 to 56 days. In all three years of this study project marked YOY chinook salmon released during the second half of sampling seasons had longer mean residence times than fish marked and released during the first half of the season. The mean residence time for fish marked in the first and second half of the sampling season was 6.4 and 10.0 days respectively in 1997; 6.5 and 13.4 days respectively in 1998; and 12.9 and 17.5 days respectively in 1999. It appears a higher portion of YOY chinook salmon rear in the Klamath River estuary in the late summer, and rear there for a longer period of time, compared to fish that emigrate during the time of peak catches in late June and early July. Since these late summer emigrants are composed of a higher portion of natural origin fish than during peak emigration, the Klamath River estuary may be more important to natural origin than hatchery origin YOY chinook salmon.

## ENDANGERED SPECIES ACT CONSULTATION ON THE EFFECTS OF KLAMATH PROJECT OPERATIONS ON THE ENDANGERED LOST RIVER AND SHORTNOSE SUCKER

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After the listing of the Lost River and shortnose suckers as endangered under the Endangered Species Act in 1988, the Bureau of Reclamation engaged in numerous Section 7 consultations with the U.S. Fish and Wildlife Service. These consultations on the effects of the Klamath Project on endangered suckers led to several biological opinions from the Service. The reasonable and prudent measures in these opinions have substantially affected Reclamation's operations. Water allocation priorities have changed, numerous studies have been conducted to assess factors affecting sucker populations, ecosystem restoration programs have been implemented, legislation has been created to resolve watershed problems and water supply, and Reclamation has gained greater authority to collaborate with other entities in resolving resource issues throughout the Klamath Basin.

## HABITAT UTILIZATION AND FORAGING SUCCESS OF LARVAL LOST RIVER SUCKERS *(DELTISTES LUXATUS)* AND SHORTNOSE SUCKERS *(CHASMISTES BREVIROSTRIS)* IN THE WILLIAMSON RIVER AND UPPER KLAMATH LAKE

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Little is known about the larval life histories of Lost River and shortnose suckers, two endangered species endemic to the Klamath Basin. Adult suckers spawn in the lower Williamson and Sprague Rivers and in springs along the eastern shore of Upper Klamath Lake. Larval suckers are typically found in the river-lake system between mid-April and mid-July. Sampling was conducted at multiple locations within the river and lake, April through August 1998 – 2000, to assess patterns of habitat utilization and foraging success. Within each location, sample effort was

stratified by habitat type delineated by vegetation characteristics (woody, non-woody, and no vegetation). We report a series of on-going analyses, including: 1) comparison of river and lake captured larvae, 2) distribution of larvae among habitat types, 3) distribution of larvae among different species of non-woody vegetation, 4) day and night habitat patterns, and 5) larvae foraging success. In general, larval suckers are much more abundant in non-woody vegetation than in all other habitat types. Additionally, there is no evidence of habitat change during the larval stage.

## THE COMPLEX TAXONOMY AND GENETICS OF KLAMATH BASIN LAMPREYS AND SUCKERS

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Numerous colleagues have collaborated over the past several years to better understand the taxonomy and genetics of Klamath Basin fishes, especially lampreys and suckers. Our work on morphology and genetics of lampreys showed that the Miller Lake lamprey, *Lampetra minima*, believed eradicated in 1958 and extinct, survives in upper tributaries of the historical Williamson drainage. The species, the smallest known parasitic lamprey, was believed to be endemic to Miller Lake. Its current disjunct distribution includes Miller Creek, and upper sections of the Williamson and Sycan rivers. It appears most similar to *L. lethophaga*, but is smaller (68-138 mm TL vs. 115-170 mm TL), has a larger disc length, larger eye, and is found at higher average elevations (1721m vs. 1471m). Analysis of mitochondrial DNA sequences of the cytochrome b gene did not help resolve identifications but did show interesting patterns. All Klamath Basin lamprey shared a unique transition and each species had at least two haplotypes. Miller Lake lamprey had three haplotypes and all shared a similar transversion, but both *L. similis* and *L. tridentata* also shared those haplotypes so they were not unique or diagnostic. The genetic data examined to date may be evidence of ancestral polymorphisyms or introgression and suggests that all four species evolved in place or freely exchange some genes.

Our work on morphology and genetics of Klamath and Rogue River suckers showed that the three genera and four species were remarkably similar in all features measured. However, four species could be recognized, each with two or more recognizable geographic forms. The most easily recognizable form was *Rogue C. rimiculus*, which differed from *Klamath Basin C. rimiculus* in most features examined. *Deltistes luxatus* and *Ch. brevirostris* from Lost River and Upper Klamath subbasins differed in meristic features with higher values in Lost River subbasin. *Catostomus snyderi* had morphometric and meristic differences between Upper Williamson, Sprague and Lost River subbasins and some individuals from the Upper Williamson had rare genes. Genetic diversity was exceptional with 179 genotypes in 237 fish. Even among *Upper Williamson C. snyderi* there were 13 genotypes in 18 fish. The most common genotype was found in 31 fish, representing three species and distributed throughout Klamath Basin.

The lowest genetic diversity was found *C. rimiculus*, those in the Rogue had four unique genotypes in 24 fish, and those in the Klamath River had five unique genotypes in 18 fish. No genetic data could distinguish *Ch. brevirostris* and C. snyderi. Hybridization rates may be high though the rate between *Ch. brevirostris* and *C. snyderi* is unknown. Again, genetic data examined to date suggests ancestral polymorphisyms or introgression. We suggest that Klamath Basin suckers have a curious combination of assortative mating and natural hybridization. They may be part of a syngameon, a complex of species that freely exchanges some genetic information. Such a system may be facilitated by their high fecundity which may reduce selection against wasting gametes and by their tetraploid genome which may allow incorporation of novel alleles.

## POPULATION GENETICS OF KLAMATH BASIN SUCKERS

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The Klamath River Basin in Oregon is home to four species of suckers: the Shortnose, Lost River, Klamath largescale, and Klamath smallscale suckers. Past overexploitation and the large-scale alteration of the Klamath River ecosystem caused the rapid decline of the Shortnose and Lost River suckers and led to their 1988 listing as endangered. Federal, state, and academic groups are conducting research to understand the biology of these species and their habitat requirements in order to manage them for recovery. The Shortnose-Lost River Sucker Recovery Plan requires a genetic evaluation of these species throughout their range. Several different laboratories are using independent strategies to find genetic markers to resolve questions regarding reproductive isolation, classification, systematic relationships, and extent of hybridization among Klamath Basin suckers. An understanding of which populations are functionally independent will enhance the success of management plans designed for the recovery of these species. Our previous work involved the development of species-specific loci to investigate putative interspecific hybridization. We have developed a suite of microsatellite markers for Klamath Basin suckers and are using them to determine the population structure of these four species throughout the Klamath basin. Herein we present data from fifteen microsatellite loci for Klamath Basin suckers.

## RECOVERY PLANNING FOR WEST COAST SALMONIDS

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Over the past several decades, populations of salmon and steelhead throughout the West Coast have declined to dangerously low levels. Since 1991, the National Marine Fisheries Service (NMFS) has completed status reviews for all Pacific anadromous salmonids and has identified more than 50 Evolutionarily Significant Units (ESU) of which 26 ESUs have now been listed as

endangered or threatened species under the Federal Endangered Species Act (ESA). If this pattern is to be reversed, it is critical that comprehensive, focused recovery efforts take place throughout the region. The NMFS is committed to this effort, and has developed an approach in planning for West Coast salmon and steelhead recovery.

The ESA and NMFS' recovery planning guidelines require that, in addition to evaluating the current status of the listed population or species, recovery plans must (1) assess the factors affecting the species, (2) identify recovery (delisting) goals, (3) identify the entire suite of actions necessary to achieve these goals, and (4) estimate the cost and time required to carry out those actions. Evaluating the species' current status, as well as elements (1) and (2), are largely a technical exercise with policy input, while elements (3) and (4) are largely policy exercises with technical input. The NMFS will address elements (1) and (2) by forming geographically-based Technical Recovery Teams (TRTs), in coordination with existing science teams and ongoing conservation planning efforts. For elements (3) and (4), NMFS intends to work with state, Federal, local, regional, tribal, and private entities to craft a recovery planning process suited to each planning area.

**OPERATING KLAMATH-TRINITY SALMON HATCHERIES AS IF RESTORATION OF WILD FISH MATTERED.**

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It is essential that hatchery practices are compatible with restoration of wild populations. At Trinity River Hatchery, two important hatchery practices have already been adopted for chinook salmon: (1) all fish are released "on-site", at the hatchery, and (2) a constant fraction (25%) of all race and release types receive adipose clips and coded wire tags. These two practices minimize straying of hatchery fish into natural spawning areas and allow accurate estimation of the proportion of hatchery fish among returning spawners. Other desirable practices include the following: (3) Minimize June releases of fingerlings and shift toward eventual exclusive release of yearlings during October, thereby minimizing potential competition between wild smolts and hatchery releases. (4) Both hatcheries should consider downward revision of their total production so as to be more consistent with the target harvest rates in today's tightly controlled fisheries. Current production levels are excessive relative to demand. (5) Klamath-Trinity system hatcheries should resist the temptation to mark all hatchery fish so as to maximize recreational fishing opportunities. Such strategies may create unreasonable long-term expectations for sport fisheries and may result in large but difficult-to-estimate non-catch (hook and release) mortality on wild fish. (6) Finally, in future we should use system hatcheries more as tools for learning about the basic life histories of chinook.

## THE NEW CHALLENGE FOR KLAMATH-TRINITY HATCHERIES, CONSERVING WILD SALMON AND STEELHEAD POPULATIONS WHILE AUGMENTING RUNS TO SUPPORT FISHERIES

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Artificial propagation and production hatcheries, have been a prominent feature of fisheries enhancement efforts for Pacific salmon for several decades. Runs in the Klamath and Trinity Rivers have been augmented as part of mitigation for dams and also on a small scale as part of restoration. Recently, the role of artificial propagation has shifted so that it allows, or at least does not confound, the conservation of natural salmon populations primarily because of concerns under the Endangered Species Act (ESA). This talk will outline sound conservation hatchery practices for large and small scale hatcheries and discuss how well hatcheries within the Klamath-Trinity Basin have performed with regard to conservation practices. It will also touch on the success of small-scale rearing programs in the basin over the last 20 years. Issues to be discussed include maintenance of genetic and ecological diversity, levels of planting, broodstock handling and fitness of the founding population. The talk will also touch on other areas of California and the progress made on hatchery reform since implementation of ESA. A suggestion for how optimal planting levels in the Klamath-Trinity could be discerned will be offered.

## EVOLUTION OF MANAGEMENT FOR KLAMATH LAKE REDBAND TROUT

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The Upper Klamath Basin redband trout fishery consistently produces redband trout which exceed 10 pounds in weight and is among the finest trout fisheries in the United States. The redband trout of the Upper Klamath Basin, have evolved through time, to become adapted to the often harsh environmental conditions found in Upper Klamath and Agency lakes. The trout have also developed behavioral and life-history characteristics which enable them to utilize the highly eutrophic waters of the Klamath Basin. The management of Klamath Lake redband trout has evolved from the early 1920s when large numbers of exotic rainbow trout were stocked in an attempt to supplement consumptive recreational fisheries; to the 1990s, when management no longer relies on trout stocking to supplement trout fisheries, depends on natural production, habitat protection and enhancement, and conservative angling regulations to provide for trophy redband trout fisheries. This evolution in trout management was the result of evaluation of hatchery trout stocking programs, information on stock specific disease resistance, life-history investigations, genetic analysis, and changes in Oregon Department of Fish and Wildlife trout management policies which

emphasize the importance native fish. It is important that managers continue to pursue new information critical to sound biological management, and incorporate this information into workable management plans.

## CALIFORNIA COMMERCIAL SALMON FISHERIES: THE KLAMATH ROLE IN MANAGEMENT SUCCESS

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The lower Klamath Basin tribal rights became one of the primary determinants of commercial salmon season structures in California from the late 1980s to the present, along with the state's limited entry program and the Pacific Fishery Management Council fishery management plans. The success of seasons established to accomplish tribal/non-tribal allocation and conservation goals depended on the response of the commercial fleet. In this paper I show that to achieve the desired impacts on the salmon runs, many factors were essential. Declining revenue potential affected the fleet size leaving so few vessels that the effect of variability in run sizes and fishing effort was minimized. As the price per pound dropped and endangered species listings further reduced fishing opportunities, vessel owners faced limited choices: to remain active, exit from the fishery or move to other areas. I analyzed the fleet's varied responses over time and show the pronounced impact on successful achievement of management objectives.

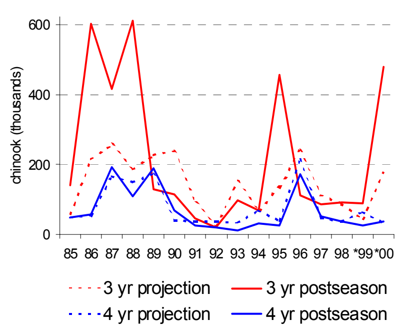
**Paper presented in reduced sized images of PowerPoint slides below. To view full sized slides using Microsoft PowerPoint (.ppt file), click here. To view full sized slides using Adobe Acrobat Reader (.pdf file), click here.**

## The Klamath Role

Commercial salmon harvest management

How variable are the runs?
What influences the runs?

Estimated abundance of ocean chinook




* Indicates preliminary data
Data source: PFMC Preseason Report I, 2001

# Statewide Changes:

## What influences the fleet?

- The abundance of salmon
- The management structures
- The landings: revenue and lbs

What are the regional differences?

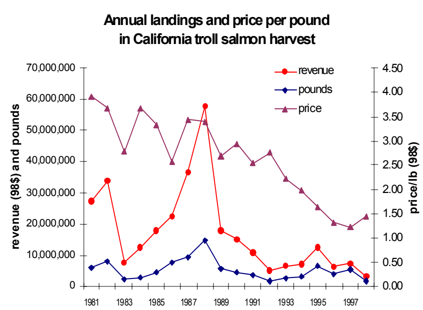
- vessel numbers, and sources
- exit and movement

What predicts whether vessels leave?

Where do vessels go?

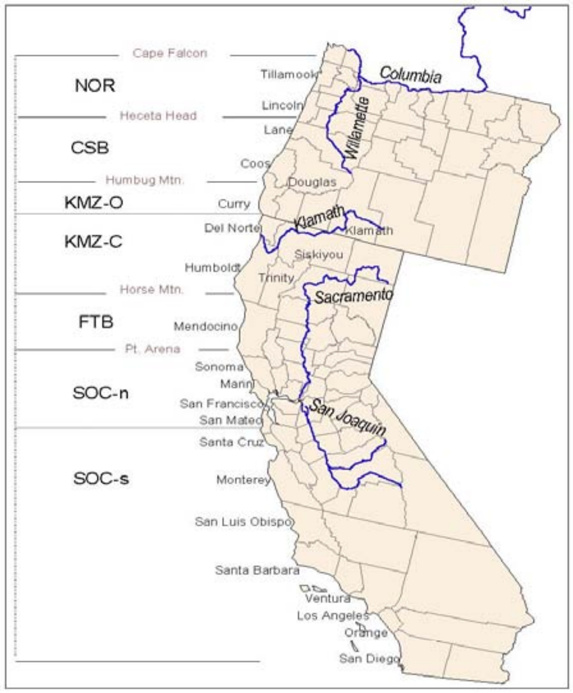
How are the harvest levels?

How is price/pound changing?



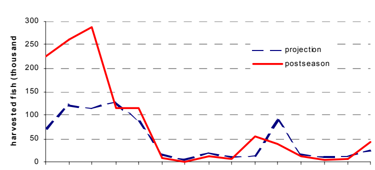

Source of data: PacFin database of vessel landings, 1981-88

Regional management units: CA and OR

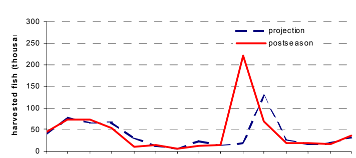



# How have the Klamath ocean and river harvest varied?

**Ocean chinook harvest:**
**projection and postseason estimate**




**River chinook harvest:**
**projection and postseason estimate**

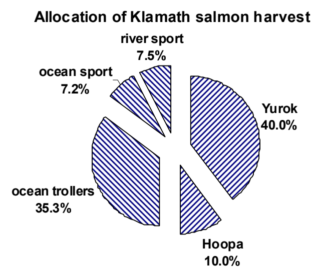



* Indicates preliminary data
Data source: PFMC Preseason Report I, 2001

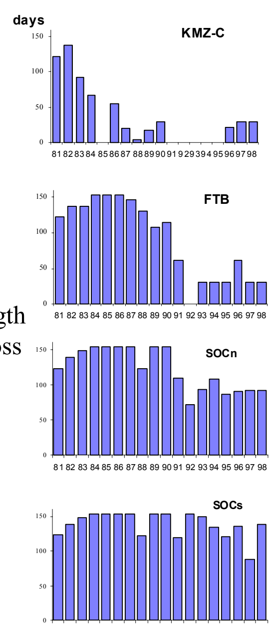
# What are the constraints and goals of management?

**Pacific Fishery Management Council must meet goals of**

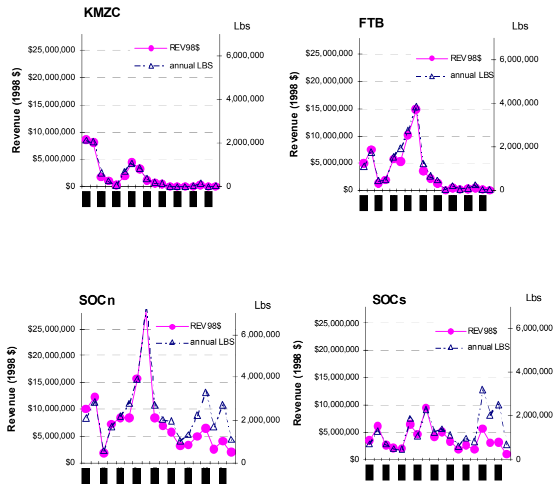
- **Allocation: distribution among groups**
- **Conservation: preventing overfishing**
- **MSY or optimal yield**
- **Variability: "complement rather than oppose"**




How has season length varied across regions?



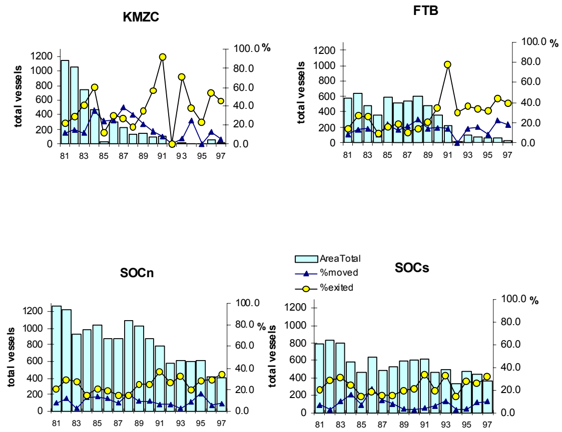
## Do the landing patterns follow the seasons and run sizes?



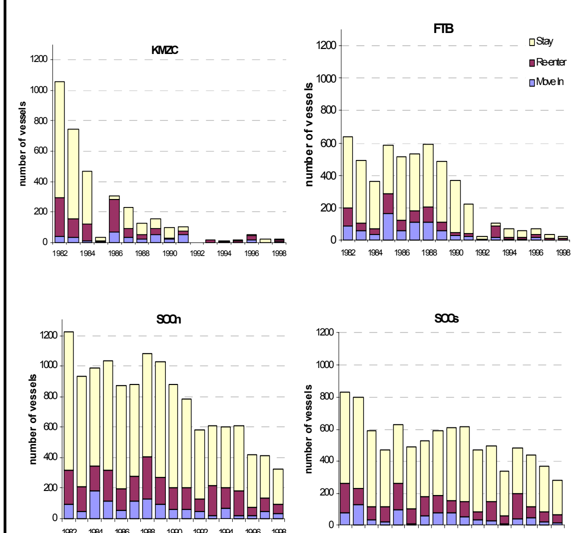

## I use vessels as the unit of analysis

Source:
http://www.salmon.room.net/salmonstory/salmonstory.htm
Florin High School, Sacramento, California

How have vessel participation, movement and exit rates been affected?




How have vessel sources varied?

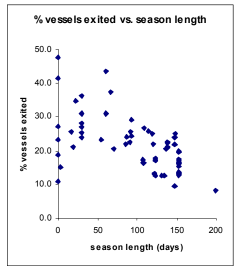


## Why do vessels leave?

Which variables are the best predictors?

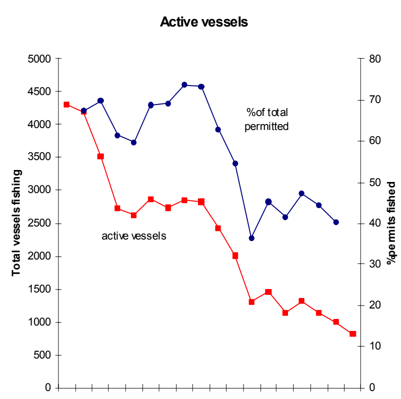
Area fished, Pounds landed

Logistic regression results compare:
year, season days,
revenue, pounds and,
price/vessel

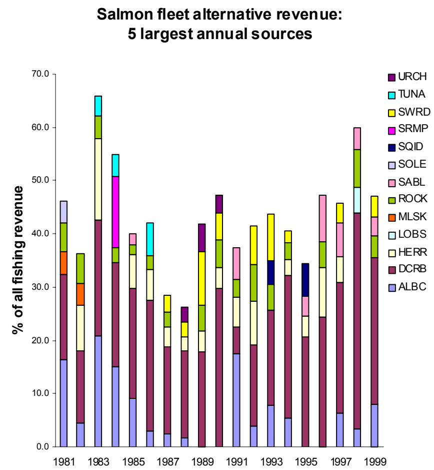



As season length is reduced
% vessels exiting increases.

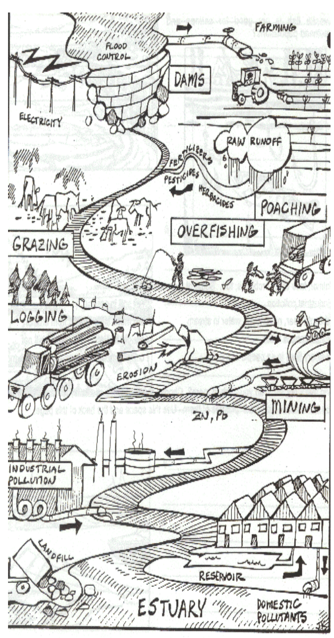
## Alternative vessel fates: Unfished salmon permits



## Where are other opportunities to fish?




Data source: David Tomberlin, NMFS
Analysis of PacFIN database




Source: http://www.salmon.room.net/salmonstory/salmonstory.htm, Florin High School

Source: http://eesc.orst.edu/salmon/

## COORDINATION OF HATCHERY MANAGEMENT PRACTICES WITH ENDANGERED SPECIES ACT COMPLIANCE

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One year ago, the California Department of Fish and Game (DFG) and National Marine Fisheries Service (NMFS) began a joint review of California's anadromous fish hatcheries. The review was initiated primarily in response to the listing of California salmon and steelhead populations under the federal Endangered Species Act (ESA) and the resulting requirement that the effects of hatchery operations on listed species be evaluated and, if necessary, authorized under the ESA. Hatchery Management Genetic Plans (HGMP) offer hatcheries a new application process whereby limited "take" of Federally-listed species covered under Section 4(d) of the ESA may be permitted within the hatchery management activities. The purpose of the HGMP is to provide a single source of hatchery information for comprehensive planning by federal, state, and tribal managers, and for permitting needs under the ESA. The best scientific and commercial information available should be provided in the HGMP to help determine if hatchery programs are likely to meet their goals and ESA obligations. The HGMP will include thorough descriptions of each hatchery operation, the facilities used, the methods employed to propagate and release fish, and measures of performance.

# PART 3: WILDLIFE CONSERVATION CONCERNS

## BEAR VALLEY NATIONAL WILDLIFE REFUGE BALD EAGLE HABITAT IMPROVEMENT PROJECT-AN UPDATE

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Bear Valley National Wildlife Refuge was established to preserve an important winter communal roost for bald eagles within the Klamath Basin. However, past high-grade logging activities, and fire exclusion have led to excessive fuel loadings and overstocked stand densities, thus placing roost habitat at risk of catastrophic wildfire and forest health problems. In 1996, the Final Environmental Assessment for the Bald Eagle Habitat Improvement Project was approved with the preferred alternative calling for the utilization of five commercial timber sales over a 10-15 year period to thin present timber stands to a desired stocking level. In order to assess the impact of forest thinning on eagle use of the refuge, we established monitoring plots in which roost trees were located by the presence of regurgitated castings and data was collected on roost tree characteristics. The goal of the first sale was to evaluate the effects of two silvicultural prescriptions on eagle use while preserving all roost trees and favoring large ponderosa pine and Douglas firs. The first sale of 250 acres was begun in 1998 and completed in 1999. In 2000 the effects of the sale on eagle use were analyzed and will be presented here.

## CHANGING PATTERNS OF WATERFOWL USE ON KLAMATH BASIN REFUGES DURING AUTUMN AND SPRING MIGRATION 1950-2000

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The Klamath Basin refuge complex is situated along a major corridor for migratory birds in the Pacific Flyway and contains five National Wildlife refuges of importance to waterfowl. Tule Lake and Lower Klamath are among the most important waterfowl refuges in North America. We used aerial survey estimates to assess changes in waterfowl use patterns from 1950-2000. From the 1950s through the early 1970s autumn peak populations on each of Tule Lake and Lower Klamath often exceeded one million, composed largely of Northern Pintail. Waterfowl numbers decreased on refuges from the 1960s through the 1980s mostly due to decreases in Pintail and arctic geese. Tule Lake daily waterfowl populations in autumn steadily decreased, exceeding Lower Klamath only until the mid 1970s when Lower Klamath stabilized then increased. Arctic geese preferred Tule Lake in the early decades but populations on both refuges were comparable in the 1990s. Lower Klamath daily population counts have increased in recent years, particularly for Mallard and Green-winged Teal and during spring migration. Apparent changes in migration arrival dates and overwintering of some species have been noted. Factors that may explain changes in waterfowl use patterns will be discussed.

## AVIAN BOTULISM RISK MODEL AND ADAPTIVE MANAGEMENT OF WETLAND ENVIRONMENTAL CONDITIONS TO REDUCE AVIAN BOTULISM MORTALITIES

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Based on recent studies conducted at the National Wildlife Health Center a strong relationship was found between several water quality parameters and the risk of avian botulism epizootics. A model based on this relationship provides potential for adaptive management of wetland environmental conditions to reduce avian botulism mortality. At the Klamath Basin National Wildlife Refuge, ten wetlands were selected based on botulism history, the length of time flooded, and current management practices. Within each wetland ten randomly selected water-sampling sites were designated and data collected bi-weekly. The risk model was used to compare actual epizootics, water quality data, and mortality on study sites to those predicted by the model. Using this approach, we evaluated how wetland management influences botulism epizootics and which management practices may reduce the occurrence of avian botulism. Results from the study are used to guide improved wetland management practices that reduce the risk of botulism epizootics and to assess the impacts of water shortages on avian botulism.

## BALD EAGLES *(HALIAEETUS LEUCOCEPHALUS)* NESTING IN THE OREGON PORTION OF THE KLAMATH BASIN

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We monitored Bald Eagles nesting in Oregon from 1978 to 2000. The number of occupied sites in Oregon increased from 56 in 1978 to 371 in 2000. During that time, statewide distribution changed from 4 fairly distinct sub-populations, to a single, relatively continuous population, with 5 densely populated areas. The Klamath Basin was a stronghold for Bald Eagles throughout the study. The first bald Eagle nest surveys were conducted by Weyerhaeuser Company and Winema National Forest in the early 1970s. The Oregon portion of the Klamath Basin had 23 (41% of Oregon, n = 56) occupied nest sites in 1978, and 103 (28% of Oregon, n = 371) in 2000. For 1971-2000, 91% of nest sites were occupied (n = 1662), nesting success was 62% (n = 1441), and there were 0.98 young raised/occupied site (n = 1441). Population growth was slower than for the state (5% vs. 7%), possibly because some habitat has been filled. At least one area at Upper Klamath Lake apparently reached carrying capacity, because for 1978-1997 the population as stable, and nesting success and productivity were lower than for the other breeding areas around the lake.

## COMPREHENSIVE BIRD MONITORING IN THE KLAMATH RIVER REGION A JOINT EFFORT OF THE KLAMATH BIRD OBSERVATORY AND VARIOUS COOPERATORS

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The Klamath Demographic Monitoring Network is a regional, cooperative, interactive group of people and organizations that monitor birds. The group is coordinated by the non-profit organizations, the Klamath Bird Observatory and Humboldt Bay Bird Observatory, in cooperation with many cooperators. The Network, which focuses on the entire watersheds of the Klamath River, is the first regional network of bird monitoring stations in North America. It is comprised of many cooperators operating constant-effort mist-netting stations in the Klamath Province (Figure 1). The network also coordinates and compiles the results of censuses taken throughout the entire year, and focusing on the breeding season. Stations are located throughout the Klamath and Siskiyou mountains.

The Network's primary purpose is to identify and investigate factors that affect bird populations through implementation of high quality scientific studies in monitoring and inventorying populations. Through this effort, we are able to provide information for federal, state, and local land managers to better protect and enhance bird populations and their habitats in the Klamath Province. The objectives of the Network are to: (1)promote the use of standard methods for bird monitoring; (2)provide a regional data center for data storage; (3)facilitate communication between cooperators to help ensure even coverage, both in time and space; (4)provide materials, such as identification keys, nets, and bands for stations with modest resources; (5)organize training and workshops in monitoring methods, and compile and analyze Network data to produce results of studies for scientific outlets, for land managers, and the public; and (6)integrate bird monitoring and conservation activities with national and regional bird conservation programs and initiatives, as well as various land management programs.

Begun 7 years ago, the impetus of the Network was to implement regional monitoring objectives of the volunteer organization, Partners in Flight, the nationwide, interactive landbird conservation, monitoring, education, and research organization.

## CONSTANT EFFORT MIST-NETTING

Over 55 mist-netting stations have provided information about the productivity and survivorship of bird populations. Mist nets also provide important information about bird distribution during late summer dispersal and migration seasons when bird censusing is less effective.

For example, Willow Flycatchers are fairly common breeders in the very upper portions of the Basin, but are rare breeders throughout the lower reaches. A marked shift takes place during dispersal and migration, as riparian habitats along the entire course of the Klamath River become extremely important for this sensitive species (Figure 2).

## POINT COUNT BREEDING BIRD CENSUS DATABASE

The results from over 7,000 census stations have been accumulated, providing information about bird distribution, habitat relationships, and long-term population trends. As examples, Green-tailed Towhees breed in the pine, juniper and shrub habitats that are common in the upper reaches of the Klamath Basin, and Swainson's Thrushes breed in the moister mixed-conifer habitats towards the west (Figure 3). Coupling the census data with multi-faceted GIS data layers has allowed in depth assessment of the relative effects of vegetation types, geology, and fire history.

## PARTNERS

The Klamath Bird Observatory, and its coastal partner, the Humboldt Bay Bird Observatory, have played a pivotal role in the implementation of the Network. Between the two operations, more than one-third of the Network's birds are banded each year, both residents, migrants, and winter visitors. The main organizer of the Network has been the Bird Monitoring Group of the U.S. Forest Service's Redwood Sciences Laboratory. Here, staff members facilitate communication and data processing. The Network's database is housed here. The inland Partner, the Klamath Bird Observatory, is assuming a larger and larger role in the data analysis and communication.

The essence of the Network is the many cooperators, including private individuals, non-profit research organizations like the Bird Observatories, timber companies, public utilities, university professors, state and national park personnel, U.S. Forest Service, and Bureau of Land Management personnel. We are always seeking new cooperators, both for mist-netting and census stations. Additional Klamath Demographic Monitoring Network partners include: Bureau of Reclamation, U.S. Fish and Wildlife Service, private industry and local land owners

For more information about the Klamath Bird Observatory, the Klamath Demographic Monitoring Network, and our efforts in the Klamath Basin please contact John Alexander (541-201-0866; jda@KlamathBird.org) or C. John Ralph (707-825-2992; cjr2@humboldt.edu), write us at Klamath Bird Observatory, PO Box 758 Ashland, OR 97520 of visit our web page at www.KlamathBird.org.

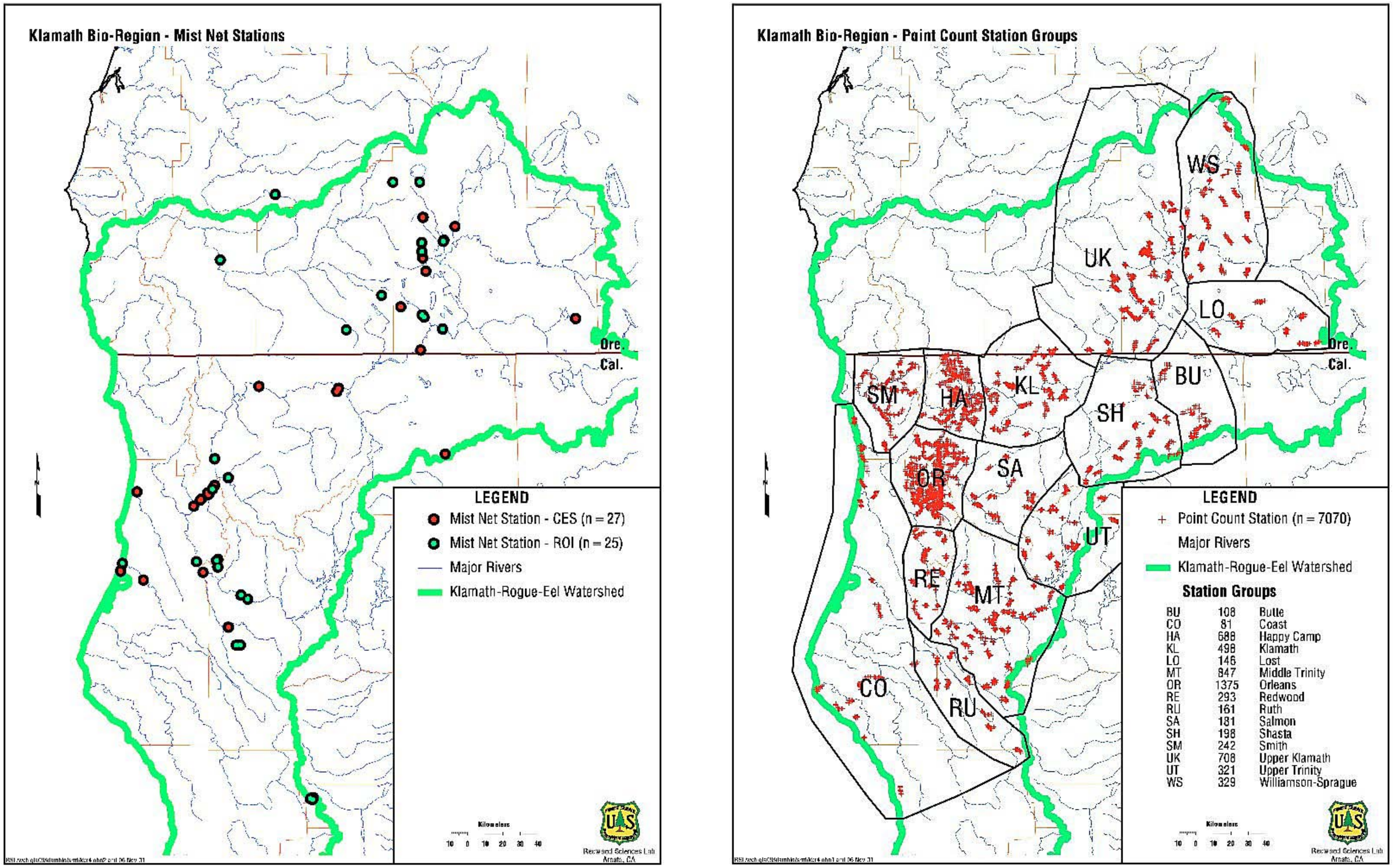


Figure 1. Distribution of Klamath Demographic Monitoring

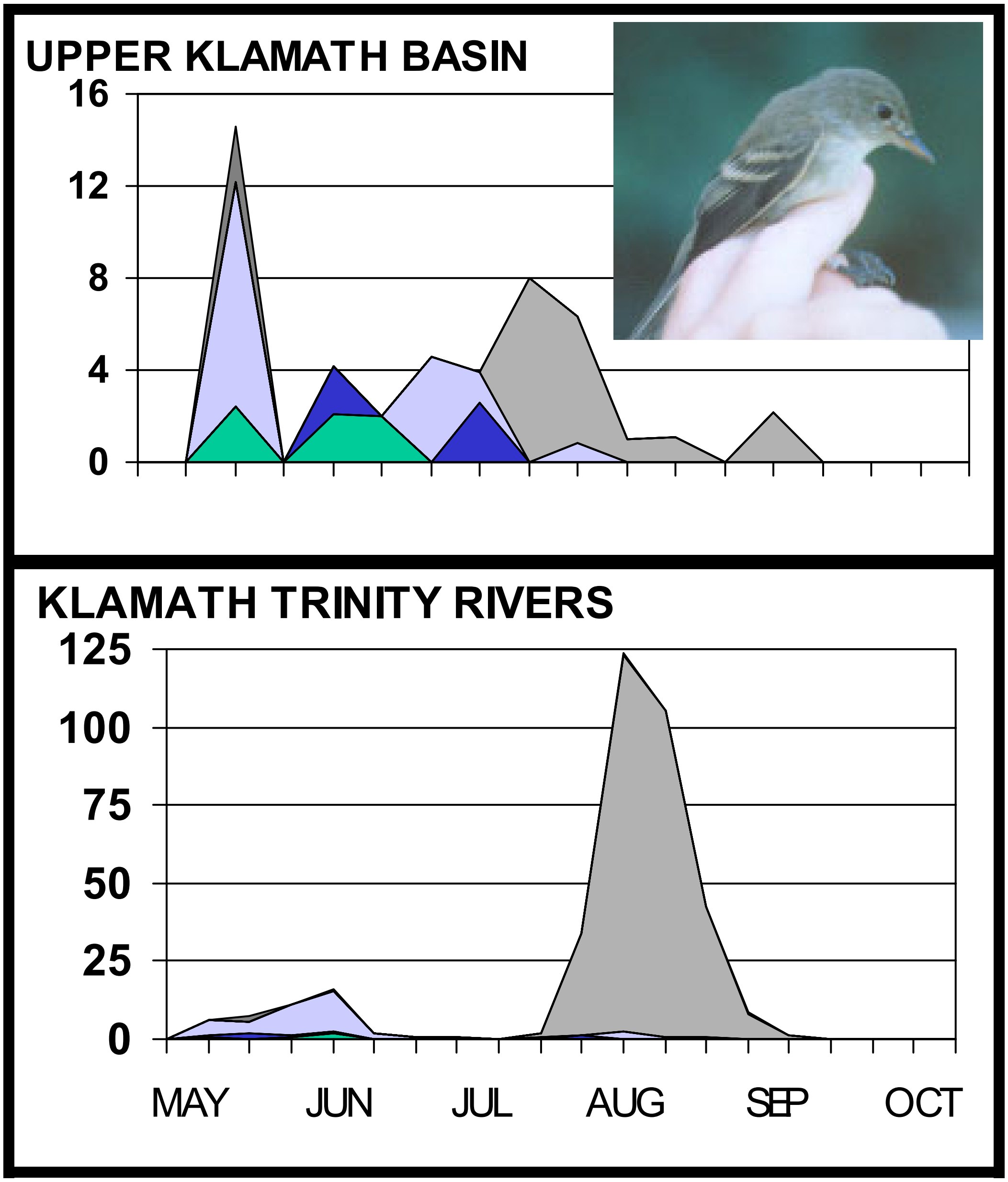


Figure 2. Willow flycatcher capture rates at stations in the Klamath Watershed during the breeding (May-June), dispersal (July - August), and migration (September-October) seasons.

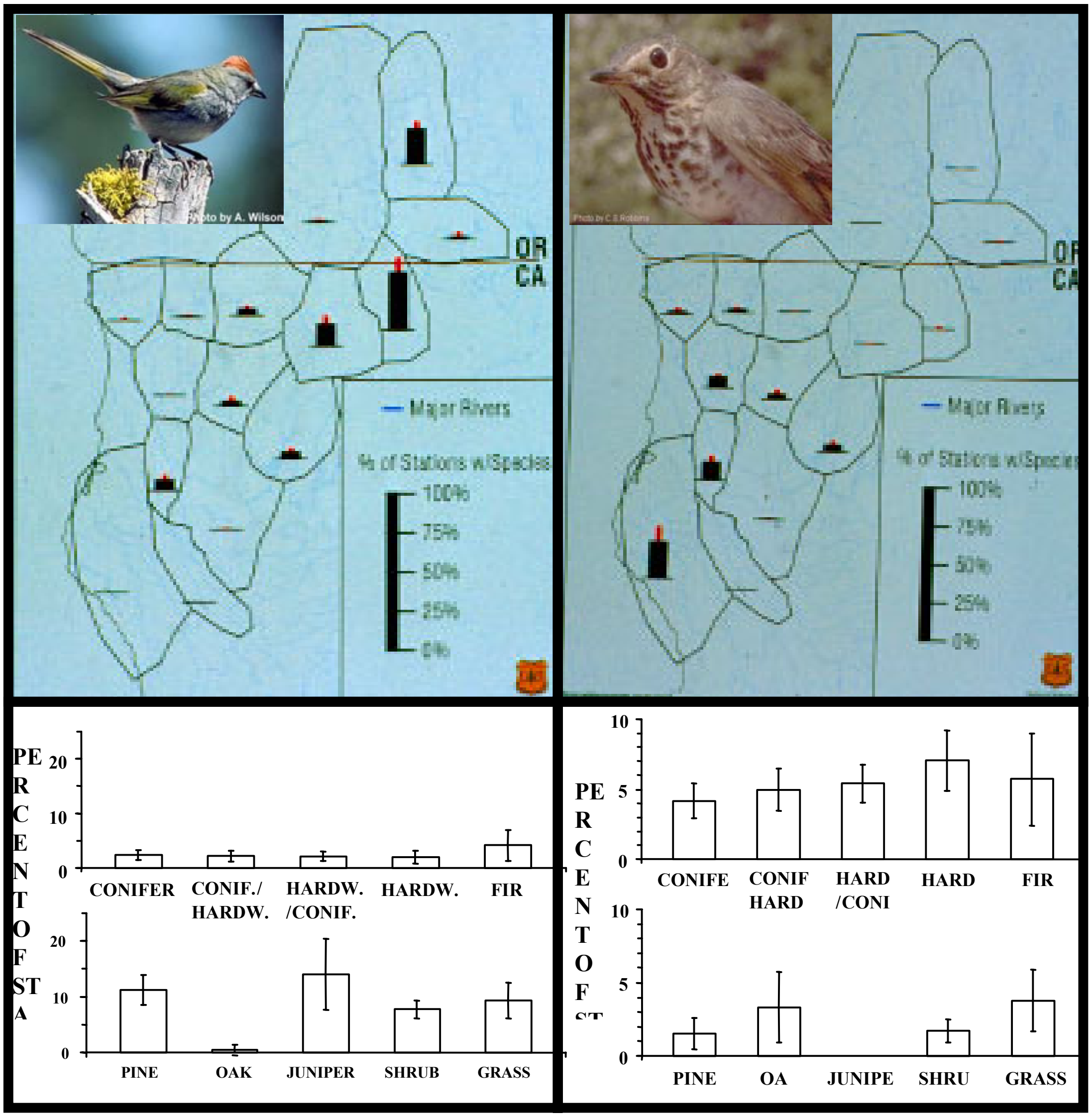


Figure 3. Geographic distribution and habitat relationships of green-tailed towhee and Swainson's thrush in the Klamath Watershed.

**A PLAN FOR CONSERVING RIPARIAN BIRDS IN CALIFORNIA. (POSTER)**

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In the Riparian Bird Conservation Plan (RBCP), we address conservation needs of 14 bird species that are strongly associated with California's riparian habitats. The needs of each species are summarized in conservation oriented species accounts and from ongoing monitoring efforts in riparian areas throughout the state. Census data from over 1300 stations, supplemented with demographic information using standardized mist nets and nest searching from a subset of locations were used to investigate current breeding distribution, habitat relationships, species richness and responses to vegetation and habitat features. Management and restoration recommendations based on the biological needs of these species can guide future conservation efforts in the Klamath and other bioregions of California. For example, managing for a diverse and vigorous understory and herbaceous layer in riparian and adjacent habitats has been shown to increase nest success for some songbirds. These results, along with results from research and monitoring throughout the state, are summarized in this RBCP "adaptive conservation plan" (available at www. prbo.org) that provides multi-species recommendations that can guide conservation efforts such as restoration and acquisition to benefit the maximum number of species.

**BREEDING ECOLOGY OF WHITE-FACED IBIS IN THE UPPER KLAMATH BASIN OF CALIFORNIA**

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The White-faced Ibis (*Plegadis chihi*) is a California State and U.S. Fish and Wildlife Service species of special management concern. We studied Ibis breeding ecology from May through July 1995 on Lower Klamath National Wildlife Refuge (NWR) in the upper Klamath Basin of California. A total of 2029 pairs nested in three colonies exclusively in early-successional hardstem bulrush (*Scirpus acutus*). Apparent and Mayfield estimates of nest success were some of the highest reported anywhere in the literature for White-faced Ibis. Consequently, Lower Klamath may maintain preferred White-faced Ibis breeding habitats in years of otherwise poor habitat conditions across the Intermountain West.

### A COMPARISON OF ABUNDANCE, ASSEMBLAGE, AND NOCTURNAL ACTIVITY OF AMPHIBIANS IN OLD GROWTH AND SECOND GROWTH REDWOOD FOREST CREEKS IN HUMBOLDT COUNTY, CALIFORNIA

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This study compares amphibian abundance in old growth and second growth redwood forests to consider the long-term recovery of amphibian populations following timber harvest. The study was conducted in two blocks (about 100 miles apart) with three matched pairs of creeks per block. The second growth forests (treatment, n=6) range from 30 to 70 years old; the old growth forests (control, n=6) contain 80% or more unharvested trees in the drainage area above the study sites. Pre-harvest data on amphibian populations were not available for the treatment creeks. Instead, the authors use a matched pairs study design, making the assumption that adjacent tributaries with similar pre-harvest topography and flora should harbor similar fauna. Several environmental factors (air and water temperature, relative humidity, and ambient light) were measured throughout the sampling period. Amphibian sampling by nocturnal visual encounter survey occurred in three seasons. Repeated measures of fixed reaches were conducted in random order to control for temporal variation in abundance and activity. Preliminary results indicate amphibian diversity and abundance are greater in the old growth creeks.

**BIOGEOGRAPHY, ENDEMISM, AND ECOLOGY OF AN ANCIENT LAKE MOLLUSK FAUNA: UPPER KLAMATH LAKE DRAINAGE, SOUTH-CENTRAL OREGON**

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**ABSTRACT**

A 1995-2000 Upper Klamath Lake drainage [UKL] freshwater mollusk survey covered Sycan and Klamath marshes and the remainder of the Oregon UKL, including the Williamson, Sprague, Lost, Sycan, and Klamath drainages above Keno. Recent survey of adjacent areas (Rogue-Umpqua, upper Klamath, Deschutes, upper Sacramento-Pit, part of the Interior Oregon Basins) places the UKL in a regional context. We report here on a total of *ca*. 400 UKL sites. The UKL has 70+ freshwater mollusks. Biogeographic relationships are Western, with a strong Great Basin influence; > 22 species (likely including undescribed genera) are strict endemics, mostly spring-restricted hydrobiids. Some are closely associated with the modern Lake; others fall within the borders of its Miocene predecessor(s). Adjoining areas (west, south) have high hydrobiid endemism/species richness; Interior Oregon so far has low endemic diversity/richness. None shares many hydrobiids with the UKL. Miocene-Pliocene block faulting and Miocene-Recent volcanism (including formation of Crater Lake) may have had major impacts upon mollusks. However, some persist unchanged from the Miocene ("Yonna" Formation). Pleistocene lake expansion may have had little effect. Mt. Mazama's last eruption caused persistent diversity impoverishment over the UKL's northern third; but in Sycan Marsh perhaps created habitats for taxa rare or absent elsewhere in the drainage.

**INTRODUCTION**

The extraordinary diversity and endemism characteristic of a handful of ancient (> 100,000 year continuity: Gorthner, 1994, Rossiter & Kawanabe in Rossiter & Kawanabe, 2000) lakes worldwide have long been the object of intense interest by zoologists (*e.g*., Brooks, 1950, Martens *et al*., 1994, Rossiter & Kawanabe, 2000). While widely distributed, surviving ancient lakes are not evenly so. North America possesses a rich assemblage of extant late Pleistocene (Wisconsinan), extinct Pleistocene (Smith & Street-Perrott, 1983) and extinct mostly Miocene-Pliocene lakes (Feth, 1964, Taylor, 1985), principally in the western U. S. But until recently, it has been assumed that no U. S. lake with a truly long history (> 1,000,000 year span) or diversity comparable to that of Lake Baikal, Lake Biwa, Lake Ohrid, or Lake Tanganyika survived into the present. Such ancient lakes have long been recognized for the unusual evolutionary phenomena they commonly display, perhaps most notably their tendency to harbor large endemic species swarms in various animal groups, including fish, mollusks, and other invertebrates (many are reviewed in Rossiter & Kawanabe, 2000).

We recently conducted a detailed survey of the Upper Klamath Lake drainage in south central Oregon (Figure 1). This 18,000 km$^2$ drainage presently contains all or remnants of three large lakes, Upper Klamath Lake, Lower Klamath Lake, and Tule Lake, as well as several river systems

(Williamson-Sprague-Sycan; Lost; head of the Klamath). Current information indicates that this drainage has contained one or more lake basins since at least the Miocene. We argue that the Upper Klamath Lake drainage (UKL hereafter) is an ancient lake basin. Large freshwater mollusk endemic radiations have occurred in this basin and persist to the present; and there is fossil evidence of continuity of freshwater habitats and lineages from at least the Late Miocene to the present. This drainage and Upper Klamath Lake itself thus constitute the best remaining U. S. example of an ancient lake. Detection of these facts has been delayed by the current hypereutrophic condition of Upper Klamath Lake itself and failure of malacologists to survey either the Lake or the rest of the drainage in any detail. The UKL has had a complicated geologic history, and it is likely that this history has contributed to the area's current mollusk biodiversity. In such cases, survey must include all of the drainage and investigation of past history and faunas in order to assemble an accurate picture of current diversity and mechanisms of its formation. In the UKL, endemism is now most concentrated in spring habitats scattered through the basin, with only a portion directly associated with the current lake itself. Such habitats probably have served as refugia for endemics during past low water events, such as have typified the UKL since the close of the Pleistocene.

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**METHODS**

An extensive freshwater mollusk survey in the Oregon portion (Figure 1) of the UKL (total area: 18,000 km$^2$) between 1995 and 2000 was sponsored by several Oregon State and Federal entities. The nature of the sponsorship meant that the California portion of the Basin, about 2,000 km$^2$, was not surveyed in any detail. From 1995 to 1998 we accumulated some 252 sites in that portion of the drainage basin south of areas heavily affected by the ca. 6980 YBP explosion of Mount Mazama (boundary on map). More recently we surveyed most of this area, adding over 150 freshwater sites, especially in the Klamath Marsh and Sycan Marsh areas. We also surveyed portions of the Oregon Interior Basins physiographic Province (Franklin & Dyrness, 1988) immediately to the east (especially Fremont National Forest: Figure 1). Detailed accounts of our collecting methods, preservation protocols, site locations and descriptions, and faunal lists are available in a series of reports (Frest & Johannes, 1995a, 1996, 1998a, 2000b). Short descriptions of this project or certain of its results have been previously published (Frest & Johannes, 1998b-c, 1999a). Mollusk faunas of the UKL were analyzable in a regional context due to the availability of recent reports on some adjacent drainages. Especially important are the Upper Sacramento system, California (Frest & Johannes 1995b, 1997), the Rogue and Umpqua systems, Oregon (Frest & Johannes, 1999b, 2000a) and part of the Oregon Interior Basins (Frest & Johannes, 2000b). We report here on 400+ UKL freshwater sites.

**SURVEY AREA**

The UKL occupies some 18,000 km$^2$, mostly in south central Oregon (Figure 1). It is bordered on the west by the Cascade Range (Rogue and Umpqua drainages); on the north by the Deschutes River system; and on the south by the Sacramento system (upper Sacramento and Pit river drainages). To the east lie various small interior basins, including Summer Lake, Lake Abert, and Goose Lake. It is generally considered a part of the Oregon Interior Basins physiographic Province, but has some unique properties that differentiate it from much of interior Oregon, often considered a part of the Great Basin (Grayson, 1993). Where Miocene-Pliocene block faulting typifies the Oregon Interior Basins, most interior drainages are small in extent and their lakes limited in size. The UKL is a large basin that derives considerable groundwater from the adjoining Cascade Range.

Unlike most Interior basins, the UKL currently drains to the Pacific (Klamath River via the Link River). This connection may be recent, perhaps originating in the late Pleistocene, when pluvial Lake Modoc drained through the ridge located near Keno (Dicken, 1980). Fault timing is similar to the rest of the Interior Basins; but the UKL is typified by numerous rather closely-spaced northwest-southeast trending faults. Volcanism has been episodic but frequent since the Late Miocene in parts of the area and continued into the Holocene, with the explosion of Mount Mazama and creation of Crater Lake the latest major event. The area remains seismically active and has common hot springs. Earthquakes are common.

The date of drainage origin is uncertain. The oldest known lake beds are those of the "Yonna" Formation (Newcomb, 1958; currently under revision: Sherrod & Pickthorn, 1992), which near its type area dates to 5.5-5.6 MYBP, at least in part Late Miocene, rather than Pliocene, as previously interpreted (Newcomb, 1958; Taylor, 1966). There are few other units with fossil mollusks known in the basin (Taylor, 1966). In particular, there are no extensive Pleistocene shorelines or associated deposits, as with Lake Bonneville and many other western U. S. pluvial lakes. There is thus a possibility that Lake Modoc, while quite large (Dicken, 1980) had a relatively short life span. The Miocene lake is presently unnamed. At the time of extensive European settlement, there were three large lakes in the basin: Upper Klamath Lake (including Agency Lake), Lower Klamath Lake, and Tule Lake. The latter two are now essentially agricultural sumps and Agency Lake dried recently. The UKL also has extensive marshes, including Klamath Marsh and Sycan Marsh. River systems (Lost; Williamson, Sprague, and Sycan) may be of rather recent origin. Much of the area between the NW-SE ridges is a series of flat valleys that are clearly former lake beds (*e.g.*, Yonna Valley, Poe Valley, Swan Lake Valley, Langell Valley, Spring Lake Valley).

The UKL is a regulated system with extensive irrigation, with canals and other modifications dating to the early 1900s. Upper Klamath Lake itself is regulated, in part by a dam in its drainage outlet, the so-called Link River, located at the south end. A striking UKL feature is the extensive and numerous springs, large and small, associated with faults located especially at the base of the rocky ridges. Nasmodes and limnocrenes are common and some very large cold springs occur here, *e. g.* those along the lower Williamson River. Submerged and partly emergent springs also occur in Upper Klamath Lake itself and in each of the major rivers. But most follow the standard western U.S. pattern of occurrence, in the headwaters of small tributaries. In this relatively arid area, springs and groundwater discharge are extremely important in supplying and supplementing the surface water system. As a result, they are subject to heavy exploitation for human domestic and livestock usage as well as crop watering. Much of the original wetland area has been reclaimed for farming, and irrigation is extensive. Both grazing and crop lands now occupy most of the old lake beds and areas peripheral to the surviving lakes.

Interior Oregon lakes mostly are pluvial and Pleistocene in age. This is in accord with much of the western U.S. Great Basin, which has over 100 named Pleistocene lakes (Smith & Street-Perrott, 1983, Taylor, 1985). Many Late Pleistocene lakes are now dry, alkaline, or are thought to have completely desiccated in the Holocene Altithermal episode. A few lakes are thought to be Miocene or Pliocene or even older in origin. Many "Blancan" (Pliocene) and Pleistocene lake freshwater mollusk faunas were reviewed by Taylor (1966, 1985). Restudy now indicates that some are Miocene (Repenning et al., 1995). One such Miocene or Pliocene lake is the extinct Butte Valley Lake, immediately southwest of the UKL, with a mollusk fauna (Hanna, 1963) having little in common with the "Yonna" fossils or modern UKL. Strong local endemism may be typical of the western U. S. lakes in this age group. Most older lakes are now extinct or have lost much of their fossil fauna, while often retaining a few endemics. The UKL may be unique in that a larger proportion of the ancient lake fauna still survives. This is due to its unusual geographic position and history. Exterior drainage is likely to prevent or slow the process of alkali accumulation that typifies many pluvial lakes, *e.g*. Oregon's Borax Lake, California's Mono Lake, Utah's Great Salt Lake. Proximity of the Cascade Range, which is also believed to have originated or greatly accelerated its development in the Miocene (Alt & Hyndman, 1995), meant that a voluminous source of both seasonal meltwater and cold groundwater became available for drainage into the system. While accompanying volcanism, landslides, debris slides, ash falls, etc., may have been detrimental to parts of the drainage, no single catastrophic event seems to have affected the whole UKL for more than a geologic instant. Hence, the UKL may have had an unusually long period of time to accumulate species and the evolutionary stimulation of new or shifting habitats simultaneously.

**RESULTS**

Presently the UKL has *ca*. 70 native freshwater mollusk taxa, *ca*. 50 gastropods (Figure 2). The lower UKL has 69 natives. Klamath and Sycan marshes add perhaps 3. There are 22 strict and 7 regional endemics (1-3 others not yet completely evaluated). This is an unusually diverse malacofauna regionally. The neighboring Rogue-Umpqua has as many as 81 taxa: but includes two major and several minor river drainages (Frest & Johannes, 2000a). The much larger Upper Sacramento system has 58 taxa (Frest & Johannes, 1995b, 1997). Upper Klamath River drainage sites collectively manage 40 taxa while Interior Oregon has about 30 (Frest & Johannes, 2000b). Note that the latter two figures are similar to that for the depauperate northern portion of the UKL (28 taxa). Site number rankings approximate the commonly-seen species curve (Rosenzweig, 1995), but the "tail" is unusually attenuate (Figure 2). The fauna is biogeographically complex. Most taxa are Washingtonian but several Great Basin forms not usually present this far north (*Helisoma (Carinifex) newberryi*, *Pyrgulopsis intermedia s. l*., and *Pisidium ultramontanum*) occur here. Taylor (1985) cited these taxa as characteristic of the northern and western Great Basin periphery "fishhook pattern". Possible recent Oregonian migrants ( *e. g., Juga* sp. and *Fluminicola* n. sp. 1) may swell diversity slightly. However, the coastal drainage connection is recent (Late Pleistocene: Dicken, 1980) and such considerations inadequately explain the UKL's extraordinary diversity. Interpretation of the drainage as a surviving ancient lake system is more plausible, even though Upper Klamath Lake itself is currently hypereutrophic (warm temperatures, limited clarity, high alkalinity and cation concentrations, rather low dissolved $O_2$: Johnson et al., 1985)

Ancient lake mollusk faunas share some features (Brooks, 1950, Boss, 1978, Davis, 1979, Taylor, 1988, Michel, 1994). Certain higher taxa (freshwater cerithioideans, hydrobioideans, planorbid pulmonates) are over-represented while at lower taxonomic levels (genus and lower) each radiation is unique. UKL radiations are in hydrobiids (*Fluminicola s. l*., *Lyogyrus s. l*.) and planorbid pulmonates (*Vorticifex*). One group is typically dominant (here, *Fluminicola*), as a result of ecology, history, or both. In the UKL, *Fluminicola* primarily occupies spring-influenced habitats (Table 3) but complex endemism patterns (Frest & Johannes, 1998a) suggest an involved basinal history for it. Ancient lakes occur in tectonically complex, active settings. This is certainly true for the UKL, with several dated episodes of active faulting and volcanism (Sherrod & Pickthorn, 1992), plus more unique events (Cascade Range rise on the drainage's west border, formation of Crater Lake) as further factors. Ancient lake endemics often display unusual morphology. Local examples are *Pyrgulopsis archimedis* and *Lyogyrus* n. sp. 3. Lakes with such faunas often display

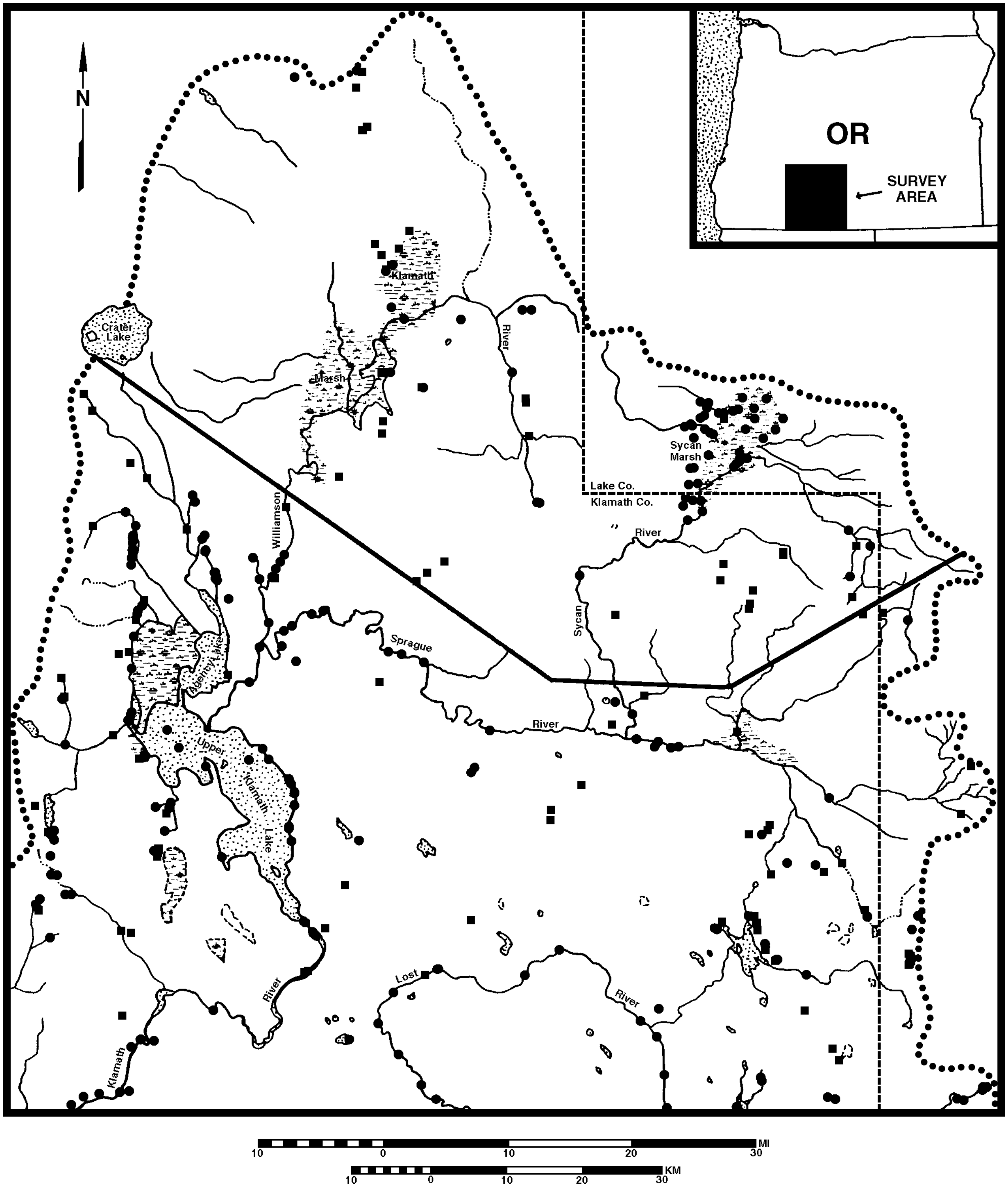


Figure 1. Survey area map (Upper Klamath drainage, Oregon). Inset shows location in state. Dotted border - UKL basin boundary; heavy line- extensive ash above (faunally depauperate); black dots - sites with mollusks; black squares - no mollusks. Dots may represent more than one site. Left map border is the Jackson-Klamath Co. line. Larger permanent water bodies dot-shaded; larger marshes also shown by standard pattern.

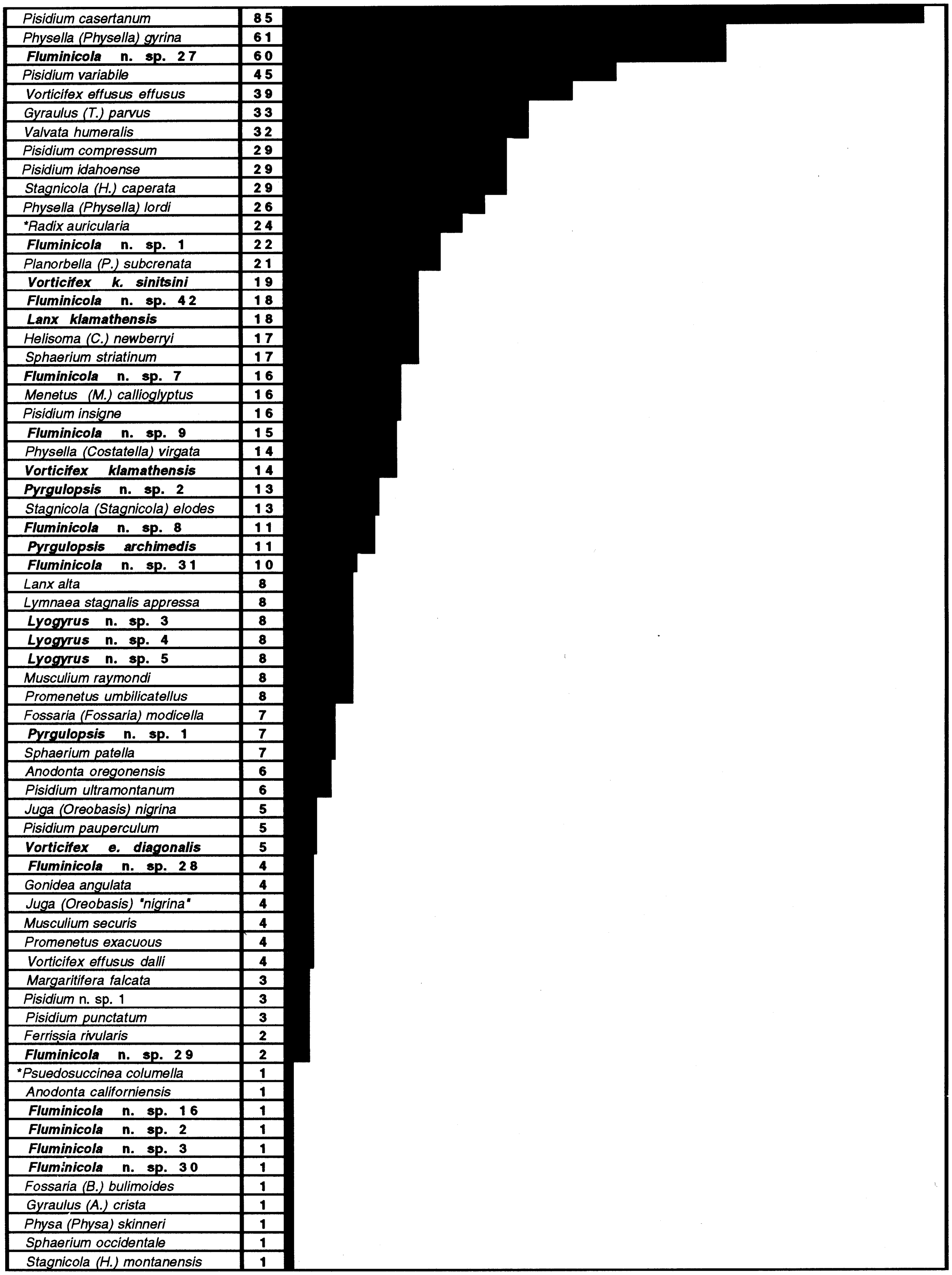


Figure 2. Number of sites ranking of the 69 freshwater mollusk species known from the Upper Klamath Lake drainage, based upon data collected through 1999. Boldface denotes endemic taxa.

considerable habitat complexity. The UKL meets this criterion as well, with numerous cold and hot springs, substrate variability from bedrock to muds, etc. Finally, ancient lakes are geologically old and persistent. 'Yonna" lake beds are Miocene, making this among the older systems if persistent. Continuity cannot be proven presently but can be inferred indirectly. Taylor (1966) reported about 10 mollusk species from the "Yonna". Outcrops recently discovered by Robert Nierath (Bonanza, Oregon) include additional forms (Table 1). Some "Yonna" taxa are extinct (very large *Vorticifex*, Payettiidae): but many are quite familiar from modern sites. Prominent are still-persisting strict endemics such as a carinate *Pyrgulopsis* resembling *archimedis*, *Lanx klamathensis*, *Carinifex* identical with the extant UKL endemic form *ponsonbyi*, and *Fluminicola* resembling or identical with 3 living forms. These taxa inhabit a number of characteristic habitats: cold, well-oxygenated mud substrates, often limnocrenes or submerged large springs in lakes (*Carinifex*); spring-influenced gravel to bedrock (hard) substrate of a large lake (*Pyrgulopsis archimedis*, *Lanx klamathensis*); large (*Lanx klamathensis*, some *Fluminicola*) cold springs; and small (some *Fluminicola*) headwater cold springs. Comparison of "Yonna" finds with extant faunas supports Miocene-Recent UKL habitat continuity, particularly prevalence of groundwater-influenced habitats.

Table 1. Currently known mollusk fauna of the "Yonna" Formation.

| SPECIES NAME | TYPE YONNA | NIERATH SITE | CURRENT UKL | COMMENTS |
|---|---|---|---|---|
| *Sphaerium* sp. | x | - | - | May be extinct form; several species in UKL currently |
| Payettiidae, indet. | x | - | - | Extinct family |
| *Valvata* sp. | x | - | x | Currently *Valvata humeralis* lives in UKL |
| *Juga* (*Calibasis*) sp. | ? | x | - | May be extinct taxon; other species of *Juga* (*Oreobasis*) live in area; *Calibasis* now is only a CA-OR relict |
| *Fluminicola* n. sp. 1 | x | x | x | Currently lives in UKL (endemic radiation) |
| *Fluminicola* n. sp. 2 | - | x | x | May be still-living spring species |
| *Fluminicola* n. sp. 3 | - | x | x | May be still-living spring species |
| *Lanx klamathensis* Hannibal, 1912 | x | x | x | Still survives in UKL and surrounding nasmodes |
| *Vorticifex* n. sp. aff. *packardi* (Hanna) | x | x | - | Extinct taxon; several related species currently live in area (endemic radiation) |
| *Helisoma* (*Carinifex*) *newberryi* (Lea 1858) | x | x | x | Fossils are the *ponsonbyi* form native to Upper Klamath Lake currently |
| *Physella* sp. | x | x | x | May be form still surviving in UKL |
| *Pyrgulopsis* cf. *archimedis* Berry, 1947 (carinate) | - | x | x | Live carinate forms only in UKL, Pyramid Lake, Bonneville Lake basin |
| *Pyrgulopsis* sp. cf. *intermedia* (Tryon, 1865) | - | x | x | This or very similar species still lives in surrounding springs |
| **TOTAL** | **9** | **10** | **9** | Note that total fauna for drainage is about 70 taxa |

The large number of undescribed *Fluminicola* species deserves special mention. Hershler & Frest (1996) demonstrated the 'genus" to be non-monophyletic. Likely, it will eventually be split into several clades. At least one such appears to be unique to the UKL. UKL endemic *Fluminicola* diversity is comparable to that of areally more extensive drainages (Figure 3), such as the 50,000 km$^2$ Rogue-Umpqua study area (Frest & Johannes 2000a) and the even larger Upper Sacramento system (Frest & Johannes 1995b, 1997). Each drainage has several discrete endemic hotspots, with membership in each largely or entirely unique.

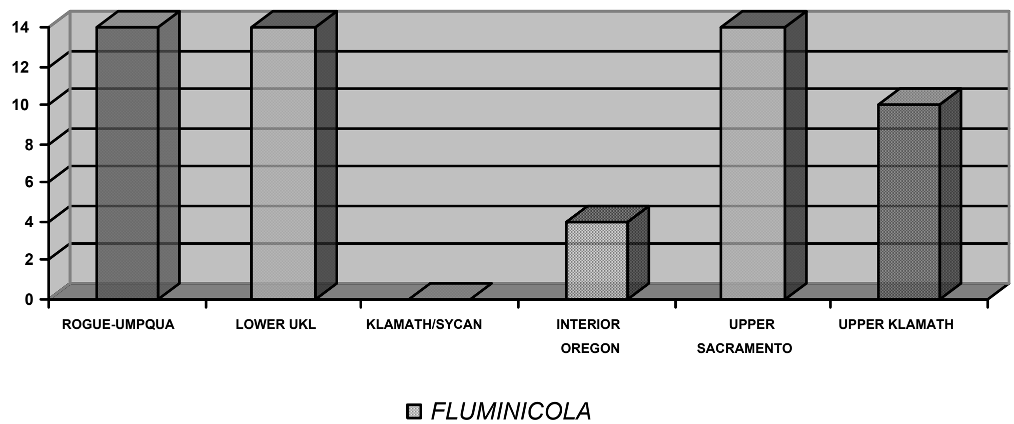


Figure 3. Comparison of the number of endemic *Fluminicola* species in various drainages. Note absence of genus from the Klamath and Sycan marsh area but high diversity in the rest of the Upper Klamath Lake drainage (UKL)

Collection of many sites in closely contiguous drainages allows for some comment upon diversity patterns and land management practices. For example, we have roughly 100-120 cold spring sites on the Rogue/Umpqua drainage (largely Medford BLM), the UKL (largely Winema National Forest) and immediately adjacent parts of the Oregon Interior basins (largely Fremont National Forest), a set of contiguous drainages along a west-east transect. Though sites are roughly equal in number, the proportion with *Fluminicola* present declines drastically from west to east (Figure 4). Diversity also varies somewhat, with that in Fremont National Forest considerably lower than that noted to the west (Figure 3). In general, grazing pressure appeared to us to vary inversely in intensity proportional to sites with *Fluminicola* in these three federal land units. The more striking drop in collective diversity could reflect a similar cause, although it is also possible that original Fremont National Forest diversity was lower in any case. So far, Oregon Interior Basin *Fluminicola* diversity does appear generally low. These observations are only suggestive and need much further study.

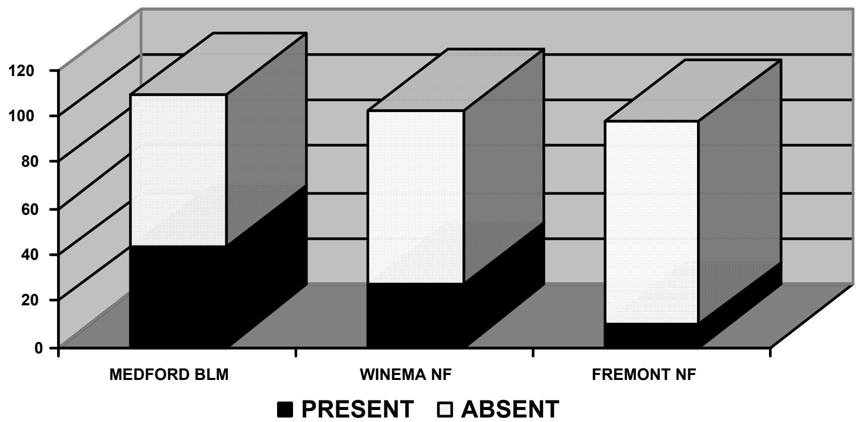


Figure 4. Comparison of the number of spring sites with and without *Fluminicola* species in various drainages. Note relatively high proportion of sites with this genus in Medford BLM as compared to Fremont NF lands.

We emphasized above the historical aspect of biogeography and the role of exceptional (geologic and landscape in scale) physical disturbances in affecting rates of speciation and endemism. Some additional supporting evidence may be cited. Pleistocene Pluvial lakes originating in the Pleistocene seem to show little endemism and that essentially always at the species level. These lakes also seldom have large (diverse) mollusk faunas. One example is Pleistocene Lake Bonneville, which appears to have had only two strict endemics, *Stagnicola bonnevillensis* and *S. kingi* (Taylor & Smith 1981, Taylor & Bright 1987) despite its large size. The Bonneville Basin, however, did have older, though impersistent, lakes, and springs in the basin still have perhaps a dozen endemic *Pyrgulopsis* species, in at least two distinct hotspots (Hershler, 1998). None seem to have been widespread either in Lake Bonneville or surviving remnants, such as the Great Salt Lake, Sevier Lake, or Utah Lake. It is older lakes, such as Butte Valley Lake and Lake Idaho, that have extinct or endemic genera, such as the unique, limpet-like physid *Hannibalina*, enigmatic forms such as "*Platytaphius*" (Hanna, 1963), or the many Lake Idaho endemics (Taylor, 1985).

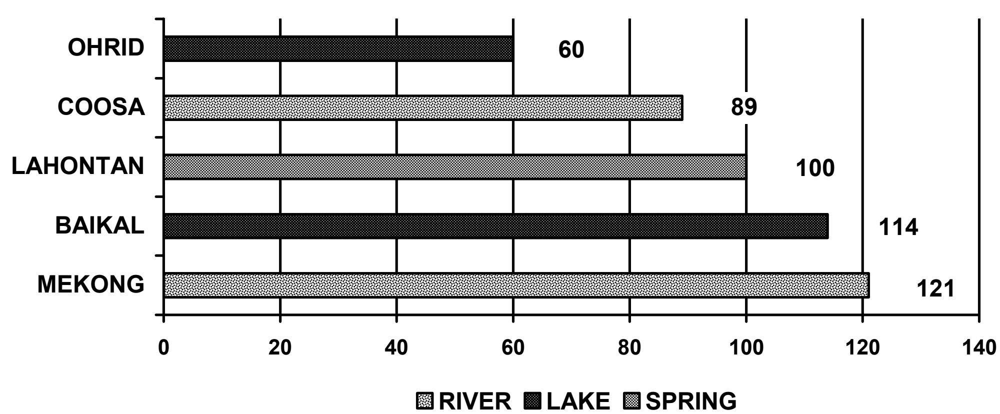


Figure 5. Taxa diversity in some exceptional freshwater mollusk habitats. Sources include Davis (1979, 1982) and Taylor (1988). Number of taxa on value axis.

Table 2. Geographic occurrence of 22 strict endemic Upper Klamath Lake drainage freshwater mollusks.

| NAME | OCCURRENCE | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | UPPER KLAMATH LAKE | LINK RIVER | ADJACENT LARGE SPRINGS | ADJACENT SMALL SPRINGS | NW SPRINGS | NE SPRINGS | LOST RIVER | WILLIAM-SON / SPRAGUE | OTHER |
| *Fluminicola* n. sp. 2 | | | X | | | | | | |
| *Fluminicola* n. sp. 3 | | | | | | | | | X |
| *Fluminicola* n. sp. 7 | | | | | X | | X | | X |
| *Fluminicola* n. sp. 8 | | | | | | | | | |
| *Fluminicola* n. sp. 9 | | | | | | X | | | |
| *Fluminicola* n. sp. 27 | | | X | X | | X | | X | |
| *Fluminicola* n. sp. 28 | | | | | X | | | | |
| *Fluminicola* n. sp. 29 | | | | X | | | | | |
| *Fluminicola* n. sp. 30 | | | | | | | X | | |
| *Fluminicola* n. sp. 31 | | | | | | | | | X |
| *Fluminicola* n. sp. 42 | | | | | | | X | X | |
| *Lanx klamathensis* | X | X | X | | | | | | |
| *Lyogyrus* n. sp. 3 | | X | | | | | | X | |
| *Lyogyrus* n. sp. 4 | X | | X | | | | | | |
| *Lyogyrus* n. sp. 5 | | | X | | X | | | | |
| *Pyrgulopsis archimedis* | X | X | | | | | | | |
| *Pyrgulopsis* n. sp. 1 | X | X | | X | | | | | |
| *Pyrgulopsis* n. sp. 2 | | | | | | | X | X | |
| *Vorticifex effusus dalli* | X | X | | | | | | | |
| *Vorticifex effusus diagonalis* | | | | | | X | | X | |
| *Vorticifex klamathensis klamathensis* | X | X | X | | | | | | |
| *Vorticifex k. sinitsini* | | | X | | | X | | | |
| **TOTAL** | 6 | 6 | 7 | 3 | 3 | 4 | 4 | 5 | 3 |
| **ONLY** | 0 | 0 | 1 | 1 | 2 | 2 | 3 | 0 | 2 |
| **1 + 2** | 2 | | 20 | | | | | | |
| **1 + 2 + 3** | 6 | | | 16 | | | | | |
| **1 + 2 + 3 + 4** | 8 | | | | 14 | | | | |

The 6980 YBP Mount Mazama eruption (Alt & Hyndman, 1995) had profound effects upon about 1/3 of the UKL drainage, which remains deeply ash-covered. Springs are still frequent; but the mollusk fauna differs considerably from that farther south. As compared to roughly 70 natives (26 genera), with 29 endemics, Klamath and Sycan marshes have *ca*. 30 native species (15 genera), with possibly no freshwater strict endemics (Figures 3, 4). Regionally characteristic genera (*Fluminicola*, *Lyogyrus*, and *Pyrgulopsis*) are missing. The fauna is especially depauperate in spring forms. Only one genus responsible for UKL endemic species flocks even survives here now (*Vorticifex*). Even though much impacted, numerous southern UKL colonies and populations could repopulate the northern UKL. It is indicative of the slow rate of mollusk migration, and has management implications, that few have in nearly 7,000 years. Taxa characteristic of impermanent habitats are more common here than elsewhere in the UKL: 3 species are so far unique in the drainage to the Mount Mazama-affected region; and a fourth, *Sphaerium* (*Herringtonium*) *occidentale*, a very rare taxon in the drainage and in the West generally, is almost common here.

A longstanding debate in malacology has concerned the ecological origins and sites of maximum diversification for the modern freshwater mollusk fauna. Some, like Russell-Hunter

(1978), have argued that most diversification takes place in lakes and that the highest sympatric diversity occurs in such settings. Others (Davis, 1979, 1982, Taylor, 1988) have noted comparable or higher diversity in streams. Both Hutchinson (1957) and Taylor (1988) emphasize that most lakes are ephemeral. The current abundance of lakes is a short-lived result of Pleistocene glaciation, and, on average, streams are probably more geologically persistent. The large endemic mollusk faunas of ancient lakes have been cited in support of Russell-Hunter. Certainly, the phenomenal diversity of such lakes as the extinct Lake Pannon (Geary et al., 2000) and Lake Idaho (Taylor, 1985) or extant Lake Baikal are striking. But strong endemism is also a feature of such lakes. There is no evidence of extensive spread of lake-originated taxa.

Table 3. Ecology of 22 strict endemic Upper Klamath Lake drainage freshwater mollusks.

| NAME | HABITAT | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | ANCIENT LAKE | ANCIENT LAKE SPRING | RIVER LAKE | RIVER LAKE SPRING | LARGE SPRING POND | SPRING SOURCE | SPRING RUN | RIVER | RIVER W/ SPRING INFLUX |
| *Fluminicola* n. sp. 2 | ■ | | ■ | ■ | ■ | | ■ | ■ | ■ |
| *Fluminicola* n. sp. 3 | ■ | ■ | ■ | ■ | ■ | | | ■ | ■ |
| *Fluminicola* n. sp. 7 | ■ | ■ | ■ | ■ | | | | ■ | ■ |
| *Fluminicola* n. sp. 8 | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | |
| *Fluminicola* n. sp. 9 | ■ | ■ | ■ | ■ | | ■ | | ■ | ■ |
| *Fluminicola* n. sp. 27 | ■ | ■ | ■ | ■ | | | | | |
| *Fluminicola* n. sp. 28 | ■ | | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| *Fluminicola* n. sp. 29 | ■ | ■ | ■ | ■ | ■ | | ■ | ■ | ■ |
| *Fluminicola* n. sp. 30 | ■ | ■ | ■ | ■ | ■ | | | ■ | ■ |
| *Fluminicola* n. sp. 31 | ■ | ■ | ■ | ■ | | | | ■ | ■ |
| *Fluminicola* n. sp. 42 | ■ | ■ | ■ | ■ | ■ | | | ■ | ■ |
| *Lanx klamathensis* | ■ | | ■ | | | | | ■ | ■ |
| *Lyogyrus* n. sp. 3 | ■ | ■ | ■ | | ■ | ■ | ■ | ■ | |
| *Lyogyrus* n. sp. 4 | ■ | | ■ | | | | | ■ | ■ |
| *Lyogyrus* n. sp. 5 | ■ | ■ | ■ | ■ | ■ | | | ■ | ■ |
| *Pyrgulopsis archimedis* | ■ | | ■ | | ■ | ■ | ■ | ■ | ■ |
| *Pyrgulopsis* n. sp. 1 | ■ | ■ | ■ | | ■ | | | ■ | ■ |
| *Pyrgulopsis* n. sp. 2 | ■ | ■ | ■ | ■ | | | | ■ | |
| *Vorticifex effusus dalli* | ■ | | ■ | | ■ | ■ | ■ | ■ | ■ |
| *Vorticifex effusus diagonalis* | ■ | ■ | ■ | ■ | | ■ | | ■ | ■ |
| *Vorticifex klamathensi klamathensis* | ■ | | ■ | | ■ | ■ | ■ | ■ | ■ |
| *Vorticifex k. sinitsini* | ■ | ■ | ■ | ■ | | ■ | | ■ | ■ |
| **TOTAL** | **0** | **7** | **0** | **7** | **9** | **13** | **14** | **2** | **4** |

And, such diverse and long-lived lakes are truly exceptional. Moreover, determining fossil lake actual standing diversity is problematic, and there is a tendency to cite figures for the lake's whole life span. Both Taylor (1988) and Davis (1979, 1982) provide examples of stream species flocks comparable in diversity to those in ancient lakes. In the western U.S., spring habitats are exceptionally important to mollusk biodiversity. Recent Great Basin work (Hershler 1994, 1998, 1999, references therein) indicates that the Miocene-Pliocene Lahontan and Bonneville drainages still retain > 100 springsnail species. This compares well with ancient lake and stream diversities (Figure 5). Clearly, several major habitat types can produce large endemic swarms. In the UKL, spring habitats are foremost in significance as regards mollusk biodiversity. Only 12 of the 22 strict endemics are closely associated with the current Upper Klamath Lake (Table 2); only 8 strictly so, and many of the "ancient lake" taxa occur elsewhere in the drainage. Some strict endemics are found only in more isolated drainages, such as the Lost River. Habitat-wise, taxa occurring only in the current lake itself are a small minority (Table 3). Most strict endemics are spring-associated; and only 2 reasonably can be considered strict stream endemics. Spring-lake and river lake-spring (limnocrenes, with or without through-flowing streams) habitats are important here: but so are small springs and spring runs. Current condition of Upper Klamath Lake (hypereutrophic and volumetrically much reduced) no doubt understates its long-term role as a speciation locus. However, Table 2 and the individual species maps in Frest & Johannes (1998) show that speciation has occurred throughout the geologically older parts of the drainage, with only the area covered heavily by Mount Mazama ash now seemingly devoid of strict endemics. The Deschutes headwaters above Bend are similarly depauperate, here also due to very recent lava flows and eruptions.

**SUMMARY**

A baseline freshwater mollusk survey (> 400 sites) of the Oregon UKL drainage was conducted between 1995 and 2000. Similar 1993 - 2000 surveys in adjoining drainages help place this malacofauna in a regional context. The UKL has exceptionally high endemism (at least 22 taxa, 19 or more undescribed) and diversity (> 70 taxa), in comparison to most western U. S. drainages. Those adjacent tend to be lower in $\gamma$ diversity or endemism or both. Many sites have relatively low $\alpha$ diversity. Most taxa, and almost all strict endemics, are gastropods. A minority are directly associated with the current lake; but most are associated with the UKL's abundant springs. Endemism is concentrated in two families, Hydrobiidae (*Fluminicola s. l.*, *Lyogyrus s.l.*) and Planorbidae (*Vorticifex*). The current fauna has mixed biogeographic affinities, with a basic Washingtonian fauna supplemented notably by Great Basin taxa and with some Oregonian influence as well. But most diversity may result from gradual accumulation in an ancient lake basin. The current Upper Klamath Lake itself is hypereutrophic; but this is likely a relatively recent phenomenon. Earliest lake deposits so far found ("Yonna" Formation) indicate an age of at least 5.5-5.6 MYBP (late Miocene). Some taxa and some habitats appear to persist from that period, while others are extinct or more recent in origin. There are an unusual number of relatively intact cold springs spread through all parts of the drainage which harbor endemics, often only in portions of the current UKL and excepting the areas heavily affected by Mount Mazama ash falls (about 1/3 of the drainage). The UKL does exhibit a typical western pattern of high headwater endemism (Frest and Johannes, in press) and more particularly of headwater spring endemism.

Geologic events have much to do with the origin and distribution of UKL mollusks. The Lake likely originated as one result of Miocene-Pliocene block faulting. There is evidence of volcanism in various portions of the system starting from the Late Miocene-Pliocene (including pelagonite in the "Yonna") into the Pleistocene. Miocene-Pliocene mountain building to the west likely increased runoff and ground water volume even as the rise of the Cascade Range tended to increase aridity in interior Oregon generally. The UKL would have been little affected by Pleistocene glaciation, as it lies mostly south of well-documented continental ice. Local mountain glaciation in the adjacent Cascades might have had relatively minor effects. The Late Pleistocene pluvial period in interior Oregon had its local representative (the extensive Lake Modoc) but there is little evidence of long duration of this lake; and connection of the former interior UKL drainage to the Klamath River also seems to date from the Late Pleistocene. Post-Pleistocene events largely involve increased desiccation, size reduction, and development of flowing river systems. The 6980 YBP Mount Mazama eruption had drastic effects upon freshwater mollusks in *ca.* 1/3 of the UKL heavily blanketed by volcanic ash (pumice). Many UKL genera with local endemic species flocks or Great

Basin affinities are still absent. Freshwater diversity here is about 29 species, none strict endemics and all but about 3 also present in the remainder of the drainage. The UKL has been strongly modified by humans recently. Species loss or extirpation is likely to have occurred and to continue unless preventative measures are taken.


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## HABITAT, WILDLIFE, AND WATER MANAGEMENT ON LOWER KLAMATH NATIONAL WILDLIFE REFUGE, A COMPARISON TO THE HISTORIC PAST

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Lower Klamath National Wildlife Refuge (LKNWR) lies within the Klamath Reclamation Project (Project) and represents the fragmented remains of historic Lower Klamath Lake. The goal of the refuge is to preserve habitat for endangered species, migratory wetland birds, and numerous resident and breeding wildlife species. LKNWR supports a similar assemblage of wildlife as occurred in the original lake and marsh system; however, the 60-80% reduction in wetland habitats has reduced historic wildlife numbers. To compensate, and to the extent practical, the Service uses water management and a variety disturbance factors to mimic historic ecological processes thereby recreating many of the endemic habitats and wildlife present in the original system. The Refuge is host to the largest fall population of staging waterfowl in the Pacific Flyway (1.8 million birds in fall 1997) and winters the largest concentration of bald eagles (200-900 birds) in the Lower 48 states. In addition, the refuge hosts large numbers of colonial nesting waterbirds and a diverse array of “sensitive” wildlife species. Within the confines of a low water delivery priority within the Project, wetland wildlife resources are maintained on approximately 33,000 acres of intensively managed habitat.

## STATUS OF THE OREGON SPOTTED FROG *(RANA PRETIOSA*) IN THE KLAMATH BASIN

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The Oregon Spotted Frog is currently a federal Candidate Species. It was petitioned for listing in 1989 and listing was deemed "warranted but precluded due to other priorities" in 1993. The Oregon Spotted Frog is known from eight historical locations in the Klamath Basin in Oregon and California. Surveys conducted during 1994-1999 revealed the presence of five populations in the Klamath Basin. An extensive population exists on the Klamath Marsh National Wildlife Refuge while other populations occur at Fourmile Creek, Jack Creek, Buck Lake, and Wood River Wetland. In 2000, we located two unreported populations along the Middle Williamson River and Crane Creek. We will present information on recent surveys, monitoring programs, the potential for wetland restoration projects and future study plans.

## WALKING THE FENCE - BALANCING FISHERIES, WILDLIFE AND CULTURAL CONCERNS WHILE IMPLEMENTING THE DEVELOPMENT OF SHASTA VALLEY WILDLIFE AREA

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Balancing fisheries, wildlife and cultural concerns has been a challenge while implementing the development of Shasta Valley Wildlife Area. Managed by the California Department of Fish and Game and located in central Siskiyou County near Yreka, the Wildlife Conservation Board acquired the 5,657 acres area in 1991. The wildlife area features a diversity of habitats including managed wetlands, riparian, native grasslands and farmed uplands. The Little Shasta River, a Chinook salmon and steelhead spawning stream, supplies water for the management of the area. Riparian and native grassland restoration is ongoing. An active environmental education program involves students from throughout Siskiyou County. Cattle grazing and sharecrop grain farming are incorporated into the management of the wildlife area.

This paper will summarize efforts by the California Department of Fish and Game to effectively develop and manage the wildlife area. Developing guidelines as a water user to enhance fisheries values has been a central theme in the development and management of the wildlife area.

## ASSOCIATIONS BETWEEN STREAM SIZE AND ABUNDANCES OF AMPHIBIANS AND SMALL MAMMALS IN A NORTHWESTERN CALIFORNIA WATERSHED.

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We evaluated patterns of association between stream size and abundances of amphibians and small mammals in a northwestern California watershed. We sampled populations at 42 stream sites and eight upland sites within a 100-km$^2$ watershed in 1995 and 1996. Stream reaches sampled ranged from poorly defined channels that rarely flowed to 10-m-wide channels with perennial flow. Aquatic vertebrates and terrestrial vertebrates were sampled along three 45-m-long transects. Vegetation characteristics were strongly associated with measures of stream size. Compared to upland sites, mean numbers of plant species in the herbaceous layer were significantly greater along

streams with active channel widths as small as 0.9 m. Larval Pacific giant salamanders (*Dicamptodon tenebrosus*) were found only in stream reaches with continuous flow or in channels 2.4-m wide, and larval tailed frogs (*Ascaphus truei*) were found only at sites with nearly continuous flow. Allens chipmunks (*Tamias senex*) and deer mice (*Peromyscus maniculatus*) occurred at nearly every site sampled but were more abundant at reaches along larger streams. None of the vertebrate species evaluated was significantly associated with intermittent streams having channels less than about 2-m wide and drainage areas less than about 10 ha. Our results provide additional information on the ecological role of small, intermittent streams.

## RESPONSES OF NATIVE HERPETOFAUNA TO FLOW REGIME MANAGEMENT ON THE MAINSTEM TRINITY RIVER OF NORTHWESTERN CALIFORNIA: TWO CASE STUDIES

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We studied the effects of dam-altered flow regimes on the foothill yellow-legged frog (*Rana boylii*) and the western pond turtle (*Clemmys marmorata*) on the mainstem Trinity River from 1991 to 1994. We compared both population responses, and related changes in riparian and aquatic habitat attributes, between the damned mainstem and the undamned southfork Trinity. Two factors appear to be negatively impacting the foothill yellow-legged frog: (1) loss of required open cobble bar which has been replaced by riparian forest along much of the mainstem; and (2) loss of annual cohorts as the highly vulnerable eggs masses are detached and flushed from natural deposition sites by artificial flow increases that fail to mimic the natural flow regimes that the frogs have evolved to respond to when selecting sites for depositing eggs. The pond turtle appears to be negatively impacted by changes in habitat suitability along the mainstem resulting from increased flow velocity and decreased water temperatures, both of which can decrease available rearing and foraging habitat and increase the need for suitable basking sites. The mainstem population is skewed toward older individuals who are apparently not being replaced by new recruits at the same rate as those in the South Fork population.

# PART 4: RESTORATION ACTIVITIES IN THE KLAMATH BASIN

## HUNTER CREEK STREAMBANK STABILIZATION AND HABITAT RESTORATION PROJECT
## (POSTER)

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The Hunter Creek Streambank Stabilization and Habitat Restoration Project was a cooperative effort to improve instream and riparian habitat for salmon and steelhead. The project is located on the lowermost portion of the creek, just a few thousand feet from the Klamath River estuary. The improvements took place on private land managed for cattle grazing in Del Norte County.

Approximately 1300 linear feet of stream were restored utilizing complex log and boulder instream structures, channel modifications, riparian planting, and cattle exclusion fencing. Heavy equipment was utilized for the meander formation, old car body removals (40 in all), and instream structure placement. California Conservation Corps (CCC) crews planted trees and put up cattle exclusion fencing.

This project is a great success story of cooperation between a private landowner and state and federal agencies to restore our ailing fisheries. Instream structures have formed large pools where none existed, provided habitat for adult and juvenile salmonids (observed), and helped stabilize eroding banks. Tree planting and exclusion fencing are restoring a riparian corridor where none had existed for decades.

This project was implemented by the C.C.C., Klamath Service District. It was sponsored by the US Fish and Wildlife Service (USFWS) Jobs-in-the-Woods Program. Cooperators included the California Department of Fish and Game, USFWS, Caltrans, and the Bessette Ranch (landowner).

## ESTABLISHING SUCCESS MEASURES FOR ABATING THREATS IN 1ST TO 3RD ORDER LOW GRADIENT STREAMS IN THE UPPER KLAMATH BASIN

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Using the *Conservation by Design* planning method we evaluated 1st to 3rd order low gradient streams at Sycan Marsh. These *Systems* provide habitat for bull and redband trout and endemic aquatic fauna. Highest rated *Stresses* to these systems include (1) Extraordinary competition and predation (Brook trout); (2) Modification of water levels; changes in natural flow patterns; (3) Thermal alteration; (4) Habitat destruction or conversion; and, (5) Altered composition/structure. *Sources of Stress* were defined and *Strategies* developed to abate threats and enhance the viability of the conservation targets. *Success Measures* for restoration actions (*Strategies*) considered landscape features, flow regime, stream channel slope, channel width and range in thalweg depth.

We discuss channel dimensions that are easily measured, have a high level of precision and influence the biomass for salmonids ($R^2$=0.83, p<0.0001). We present methods that identify and quantify restoration opportunities to protect biodiversity. At Sycan Marsh restoration of *Systems* has increased the quality and extent of habitat for endemic native fauna.

## A WILDLIFE AND FISH FRIENDLY GRAZING PROGRAM

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We are involved in several separate projects, cooperating with various agencies to enhance habitat for endangered Lost River and shortnose suckers on the public and private lands on which our cattle graze.

The centerpiece is a grazing plan which combines private and public riparian and upland areas into a system which maximizes ecological benefits to the resource while maintaining an economically viable cattle operation. In cooperation with the USFS, after consultation with the USFWS, and with the assistance of a host of others[1] we have implemented a pasture rotation system which distributes hot season use into the adjacent, historically under utilized, uplands. Improvements including wells, pumping equipment, water troughs, and fencing, have been installed with funding from many sources[2], the USFS, and ourselves. Additionally treatment of juniper encroachment has been funded by U. S. Fish and Wildlife Service and ourselves, in an effort to reestablish the historical artesian spring flows which feed connected potential habitat for the suckers, as well as favor the re-establishment of understory for wildlife and watershed values.

## BASELINE AND PRE-RESTORATION BIOLOGICAL AND WATER QUALITY MONITORING FOR THE ROOT RANCH CROOKED CREEK SYSTEM

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Jim and Valerie Root, the owners of the Root Ranch on the lower Crooked Creek system in Oregon, have undertaken numerous ecosystem restoration projects to restore and enhance the form, function (physical, chemical and biological) and composition of the aquatic, riparian and upland systems associated with lower Crooked Creek. Initial efforts have included cattle exclusion, bank stabilization, planting of riparian vegetation, and the construction of a spawning creek. Activities in

2000 included experimental restoration of form and function to 3 test reaches of Crooked Creek. Restoration activities slated for 2001-2003 include construction of a treatment wetland for improvement of water quality in runoff from a pasture grazing system, and a dam removal/stream channel improvement project for Agency Creek.

Establishment of baseline and pre-project condition through monitoring is a crucial element for demonstrating restoration effectiveness as well as transferability of restoration techniques. The parameters monitored derive from project goals and objectives addressing physical, chemical, and biotic measurements. Here we present the results of the baseline biological and water quality conditions for Crooked Creek, Agency Creek, the Spawning Creek, and the wetland pasture system. A comparison of macroinvertebrate and fisheries monitoring among the 3 aquatic systems will be presented. Preliminary results indicate that pre-project juvenile habitat condition and macroinvertebrate food resources lack diversity within the 3 test reaches on Crooked Creek, and that habitat (including substrate) features within both the spawning creek and Agency Creek provide rearing for young-of-year and 1+ redband rainbow trout, as will as a more diverse macroinvertebrate community than Crooked Creek. The relevance of these results as well as water quality monitoring will be discussed relative to restoration monitoring, the necessity for pre- and post-project monitoring, and guidance for future restoration activities.

## RESTORATION OF THE WILLIAMSON RIVER DELTA: A PROGRESS REPORT

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The Williamson River Delta was an extensive (approx. 7000 acres) emergent wetland-floodplain on Upper Klamath-Agency Lake. By 1950, the entire delta had been diked and drained for agriculture. Between 1996 and 1999, The Nature Conservancy with the support of project partners including NFWF, NRCS, USFWS, Pacificorp, Cell Tech and the Klamath Tribes, acquired 6900 acres of this land with the intent of restoring wetland habitats and river geomorphology. Among other benefits, this restoration is expected to increase habitat for endangered sucker species and reduce nutrient and sediment loads to the lake. Beginning in 1998, more than 2000 acres were flooded seasonally to promote wetland plant germination. By the summer of 2000, this acreage had been colonized by several wetland plant species. Reconnection of these wetlands to the lake and river began in the fall of 2000. Approximately 1000 ft of levee was removed to connect 270 acres of restored wetland to Agency Lake. An additional 103 acres were connected to the river by removing 3800 ft of levee. Levee material was used to narrow the adjacent river channel approximately to its historical width. Biological and water quality monitoring will commence in 2001 to assess the functional value of these newly restored habitats.

## RESTORATION THROUGH STREAM FLOWS AND MECHANICAL MODIFICATION (PAST AND FUTURE)

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Within less than a decade after the completion of the Trinity River Division conditions in the Trinity River below the project changed. Low, stable flows had resulted in the loss of spawning, rearing and pool habitat. Tributary sediment was no longer being moved through the system, but instead became entrenched in the riparian zones that had developed along the river channel banks. In the early 1970's gravel for spawning was added to the river, late 1970's came the cleaning-out of historical resting pools, in 1980's some additional flows were added to the ongoing projects. The late 1980's and early 1990's brought to light the need for rearing habitat. Through the past 35 years we have learned a lot about the relationships between flow, habitat and species needs. But we have only begun to understand how we will balance the environments of humans and other species. With the Record of Decision in place we can once again get back to trying to help restore the resources of the Trinity River. It will take both water flowing down the river and mechanical modification to assist in our efforts to restore the Trinity River.

## THE CROOKED CREEK CHANNEL NARROWING PROJECT

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The Crooked Creek Restoration Project was developed to address the degraded channel conditions within the nearly two miles of Crooked Creek contained within the Root Ranch. Initial efforts included cattle exclusion in 1994, bank stabilization using bio-technical methods in 1997, and planting of riparian vegetation.

Crooked Creek has experienced two types of planform changes due to land use changes in the past 150 years: (1) In the past, grazing has likely resulted in removal of riparian and wetland species, bank trampling, and channel widening, and (2) Channelization of lower Crooked Creek resulted in the total loss of several hundred feet of channel length and more importantly, loss of meanders and channel complexity. Remnants of the historic channel are visible along the lower creek and provide documentation of the channel geometry that we believe characterized the creek in an undisturbed condition.

Project construction occurred in September 2000 and involved the following elements: (1) Restore form and function to 3 experimental test reaches of Crooked Creek by narrowing the channel to its estimated pre-disturbance condition; (2) Create extensive new riverine wetland fringe areas adjacent to the active channel on fill surfaces; (3) use bio-technical methods to stabilize new channel boundaries and create additional habitat by placement of woody debris; (4) Utilize construction methods that will lead to more rapid formation of undercut bank habitat features; (5) Expand existing pools in these degraded areas by excavation, while allowing one site to respond to the narrowing without further intervention; (6) Create areas of greater substrate complexity by placement of gravels; and (7) Improve the extent of riparian vegetation along the channel.

## A PRIVATE PROPERTY OWNER'S AQUATIC RESTORATION EFFORTS

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Over the last eight years, Valerie and Jim Root have operated a 600 acre cattle ranch that borders the Wood River and Crooked Creek. The ranch owners have attempted to optimize the use of the entire ranch property by siting each activity of the ranch on land that is ideally suitable for that activity. Consideration has been given to dry lands activities, irrigated pasture, wetlands, riparian zones and actual creek restorative activities. The ranch owners are attempting to graze cattle on a sustainable basis while restoring ecologically sensitive areas of the ranch such as dry lands, wetlands and creeks to their optimal form and function. All restorative efforts are carefully planned, implemented sensitively and monitored for both baseline condition and the changes.

The Root's have worked cooperatively with both Government agencies and neighbor property owners in the Wood River Valley. They are pleased to share the results of their projects and monitoring activities.

## THE USE OF HISTORICAL INFORMATION TO ESTABLISH BASELINE CONDITIONS FOR ECOLOGICAL RESTORATION

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The use of historical data, including photography, General Land Office survey records, government records, and journals, to determine baseline conditions within watersheds will be presented. Historical conditions must be examined to understand how an ecosystem once functioned naturally and how it might best be restored. The historical record provides evidence on what natural conditions to mimic, what factors contributed to the degradation and what physical conditions need to be recreated during the restoration process. While some ecosystems can be restored naturally if given time, many systems require human intervention to improve their condition and functionality. Many types of historical records are available to assist in recreating historical conditions. Such information can be relied upon to: (1) establish the historical presence of riparian keystone species (e.g., willow [Salix spp.]), (2) determine stream widths, (3) document change in stream meander pattern, (4) change in the composition of plant communities, (5) change in water table level, (6) measure erosion and associated soil loss, and (7) determine the consequences of temporal change in vertebrate population density.

**DAM REMOVAL ON THE KLAMATH RIVER (POSTER)**

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The Klamath River Hydroelectric Project of southern Oregon and northern California spans 64 river miles, yet has affected the entire Klamath River from its source to its mouth by altering the flow of water, sediment, nutrients, and biota.

The Klamath River, once the third largest producer of salmon on the West Coast of the United States, was historically dominated by spring run chinook salmon. Access to the upper basin, where the majority of spring salmon once spawned, was blocked by the project in 1918, and remains so today.

Owned and operated by PacfiCorp, the project generates up to 157 megawatts of electricity and includes seven hydro facilities and one non-hydro facility, consisting of five major dams and three major water diversions. This project is due for relicensing in 2006 by the Federal Energy Regulatory Commission (Permit No. 2082).

This exhibit provides an overview of one possible option for removing the dams associated with this project. Factors considered include the sequence and timing of dam removal, dealing with accumulated sediment, minimizing impacts on the river ecosystem, flooding, and post-removal rehabilitation. Also included in this evaluation is the Link River Dam, owned by the Bureau of Reclamation.

## APPROACHES TO RIPARIAN RESTORATION USED BY THE SHASTA CRMP

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The Shasta CRMP has led the way in the Klamath basin in utilizing a variety of innovative approaches to the fisheries restoration, protection and data gathering. We will take a quick look at several of these approaches, including livestock exclusion fence design details and the rationale behind them, instream livestock watering arrangements, fish screening, with an overview of two very different designs, bioengineered bank protection, and real-time voice and computer accessible flow and temperature data access.

With each of these, we can talk about other approaches we've seen, what works and what doesn't in our experience, and answer questions and share suggestions.

## UPDATE ON SCOTT RIVER DREDGE TAILINGS FLOODPLAIN RESTORATION PROJECT

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Tailings piles from past gold dredging have substantially reduced floodplain width along 4.7 miles of the Scott River near Callahan, California. Studies indicate that the historic floodplain width along the tailings reach varied from 500 to 1,500 feet, and the current floodplain width varies between 100 to 600 feet. Lateral erosion is high, and the floodplain is widening on an average of 4 feet per year. An additional 1.8 miles of river below the tailings are being impacted from coarse sediment deposition originating from erosion within and above the tailings reach. Past dredging activities and current unstable conditions have resulted in loss of pools, perennial flows, and riparian vegetation. It is hypothesized that restoration efforts consisting of floodplain widening and provisional channel reconstruction will set the stage for natural recovery of the system. Most of the affected reach of river is privately owned, consisting of 20 landowners. Signed landowner agreements have been obtained for about 80 percent of the affected land base to date. The first phase of the project consists of restoration design, permits, CEQA/NEPA, and interim streambank stabilization, and is being funded in part by a Jobs-In-The-Woods grant administered by the U.S. Fish and Wildlife Service. The second phase will consist of initial floodplain widening by moving tailings to the side, and the third phase will consist of removal of tailings from the river corridor through commercial gravel quarrying.

## THE WOOD RIVER CHANNEL AND WETLAND RESTORATION PROJECT: 1997-2001

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The Wood River Channel and Wetland Restoration Project was developed to restore form, function, and structure for the Wood River channel, delta and adjoining wetlands. Modification of the lower Wood River began in 1906 for navigation and drainage purposes and complete channelization occurred in the 1960s to allow construction of levees to convert adjacent wetlands into agricultural land. Oregon Trout began restoration project planning in 1996 with funding from the USFWS Klamath Basin Ecosystem Restoration Program. Major construction occurred during construction seasons in 1998-2000. Phase Three involving restoration of the historic delta channel was just recently completed in January 2001. The project has numerous partners including U.S. Fish & Wildlife Service, Oregon Department of Fish & Wildlife, U.S. Bureau of Reclamation, Bureau of Land Management, Jim Root Ranch, The Klamath Tribes, Oregon Dept. of Environmental Quality, Pacificorp and U.S. Forest Service. The project design consists of re-constructing a slightly modified version of the historic meandering channel, utilizing remnants of that channel where feasible and emphasizing bio-engineering techniques.

A variety of innovative design and construction techniques were used, including installation of vinyl sheetpiling to define new meander bends and provide turbidity control while the new channel was being constructed, use of a suction dredge to remove accumulated sediments from remnants of the historic channel, bio-engineering of new streambanks using rootwads, boulders, wetland soil and vegetation blocks, coconut fiber blankets and rolls, willow transplants and cuttings, and extensive wetland species revegetation. A detailed construction sequence was developed to minimize impacts to a variety of species including endangered fisheries resources. Due to substantial streamflow even in summer months, all channel construction work required operation of excavators on barges and hauling of all construction materials on barges. Earthwork included about 100,000 cubic yards of fill placement to eliminate the dredged channel. Colonization of the fill by transplanted and naturally germinating wetland species has been phenomenal.

## VEGETATION-HYDROLOGY RELATIONSHIPS IN RESTORED WETLANDS OF THE WILLIAMSON RIVER DELTA

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Since 1996, The Nature Conservancy with the support of 7 partners including NFWF, NRCS, USFWS, BOR, Pacificorp, Cell Tech and the Klamath Tribes has been converting agricultural lands on the Williamson River Delta back to their historical wetland state. Beginning in 1998, several fields encompassing more than 2000 acres were flooded seasonally (winter flooding, summer drawdown) to establish wetland vegetation. These fields were surveyed during fall 2000 to assess the extent of wetland plant colonization and the relationship between plant species composition and hydrology. By this third year of flooding, most common wetland taxa (e.g., Eleocharis, Juncus, Scirpus, Sparganium, Typha) had colonized the fields and distinct zonation patterns had begun to develop with upland, facultative wetland, and obligate wetland species occupying areas of increasingly longer hydroperiod. Specifically, obligate wetland species were restricted largely to areas that were either permanently flooded or exposed to late summer drawdowns. However, hydrology alone did not explain plant distributions as fields with similar hydroperiods often differed in terms of species dominance. Other factors such as soil type, seed availability, and previous farming practices may have contributed to these differences in wetland vegetation among fields.

## LONG TERM CASE STUDY: RIPARIAN MEADOW RESTORATION IN THE UPPER SPRAGUE RIVER WATERSHED

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### ABSTRACT

Typical of riparian meadows in the Upper Sprague River watershed, the project case study area had been grazed by cattle, season-long, every year since the early 1880's. Prior to World War II, the site had experienced year-round livestock use including winter hay feeding of cattle on snow bound meadows. Since the 1950's cattle use had been mostly seasonal, but continuous and season-long, without rotational grazing to provide plant rest and recovery. As a result, streambanks were denuded of protective vegetation and eroded during annual high water events. Stream channels were down cut and water tables seasonally depleted. Meadow vegetation had shifted to sagebrush and weak-rooted annual forbs and grasses.

Over a twenty-year period, adaptive management of the study area successfully achieved the goals of halting erosion, capturing sediment, re-vegetating streambanks, improving meadows with deep-rooted perennial grasses and sedges, and restoring water tables while continuing to provide economic returns from summer cattle grazing. Practices included strategic conventional and electric fencing, improved irrigation management, installation of check dams, rotational livestock grazing and wildlife habitat protection. Annual monitoring and maintenance of implemented practices has been a key feature of the project. Photo documentation of project results was obtained during the study period.

## RIPARIAN RESTORATION IN THE UPPER SPRAGUE RIVER WATERSHED

### Watershed Characteristics

The Upper Sprague River watershed experiences extreme seasonal stream flow variations. At the project site high creek flows during snowmelt runoff can reach 400 cubic-feet per second (cfs) while low base flows during summer months, maintained by upstream irrigation storage reservoirs and numerous small springs, are about two to five cfs, or less. The high elevation of the project site at 5100 feet results in a short growing season and frequent summer frosts. Annual precipitation averages around twenty inches, but summers are dry, and winters are characterized by continuous snow cover from November thru March.

Dominant vegetation types in the area are ponderosa pine (*Pinus ponderosa)* and mixed conifer uplands, with a transition zone of big sagebrush (*Artemesia tridenta*) and western juniper (*Juniperus occidentalis)*, and seasonally wet meadows composed of grasses, sedges (*Carex* spp.) and rushes (*Juncus* spp.) along perennial streams. Dry, degraded meadows are dominated by silver sage (*Artemesia cana*) and weakly-rooted grasses and forbs. The most productive riparian areas, natural meadows suitable for livestock grazing, are in private ownership. The project site discussed herein includes a perennial tributary of the Sprague, adjacent meadow and timbered slopes.

### Historical Background

Beaver (*Castor canadensis*) were nearly extirpated from Sprague River tributaries by the fur trade by the early 1800's, resulting in loss of their natural woody debris gradient control dams and increased stream erosion. By the 1880's European settlers had instituted year round cattle use on privately held lands that continued thru the 1940's. Winter cattle use had heavy impacts on fragile stream banks and channel bottoms. Meadows were ditched to improve drainage for haying, and then irrigated to improve seasonal water distribution, sometimes causing increased erosion. Logging and other access roads were often constructed directly thru stream corridors with little regard for erosion and effects on stream morphology.

Although the extent of winter grazing was drastically reduced after area roads were improved, season-long (spring, summer, fall), continuous grazing after the 1950's and continuing until the present further degraded riparian areas. Quick-fix erosion control projects consisting of earthen levees, check dams, and stream channelization actually exacerbated erosion problems, as did the removal of water-loving woody "phreatophytes" such as willows (*Salix* spp.) and black cottonwoods (*Populus trichocarpa*).

### Erosion!

The most serious riparian problems in the Upper Sprague river watershed are related to soil erosion, especially the down-cutting of streambeds, resulting in lowered water tables and gully erosion in tributaries. Bank-stabilizing sedges, rushes and willows and other large woody species were lost due to anthropogenic and natural forces, depleting vegetative diversity and exacerbating seasonally active streambank erosion. Spring flooding, often accompanied by ice floes, erodes the denuded streambanks. Degraded stream channel morphology, turbidity and water temperature problems are commonly observed results.

### Project Goals: Landscape Vision

Riparian restoration was initiated along one-half mile of a tributary of the Sprague River in

1981. In the project area a set of outcomes and a landscape vision were formulated:

- Erosion controlled, sediment captured.
- Water tables raised, creating non-structural (soil profile) water storage.
- Stream flow prolonged, water release timing enhanced, and water quality improved.
- Diversity of plants restored, improving forage production for livestock, vegetative streambank stability and wildlife habitat.
- Sustainable, low input agricultural system supported, relying mostly on sunlight, soil, water and gravity, with limited energy, chemical, and capital inputs.
- Profits from cattle grazing support restoration investment**.**

Photo 1. Pre-project riparian condition: Downcut streambed, wide shallow channel, lowered water table, unstable erosion-prone soils, silver sage invading meadow plant community.

Tools chosen to accomplish these goals at the project site were based on readily available resources: Irrigation, rock check structures and better cattle management through fencing and strategic, rational or rotational grazing.

**Irrigation**

Century old Oregon water rights and remnants of a pioneer era irrigation system offered the ability to improve seasonal water distribution on the overgrazed riparian meadow and place more water in the soil profile, especially along excessively drained stream banks. Beginning in 1981, maintenance and gradual rehabilitation of the old system allowed gravity irrigation to enhance plant growth in the seasonally dry meadows and along the stream corridor, especially along dry, excessively drained banks.

Perennial meadow grasses began to crowd out Silver sage within two seasons. Sedges and rushes along the stream responded rapidly, capturing sediment and stabilizing and narrowing the channel width, but willows required more than a decade to reach bank height in most locations.

Water temperatures were monitored during the summer months of 1995-1997 using digital recording devices. Higher water table in the irrigated meadow increased influent, high quality water flow to the stream, lowering maximum stream daily temperatures by about three degrees Fahrenheit along the half-mile irrigated section.

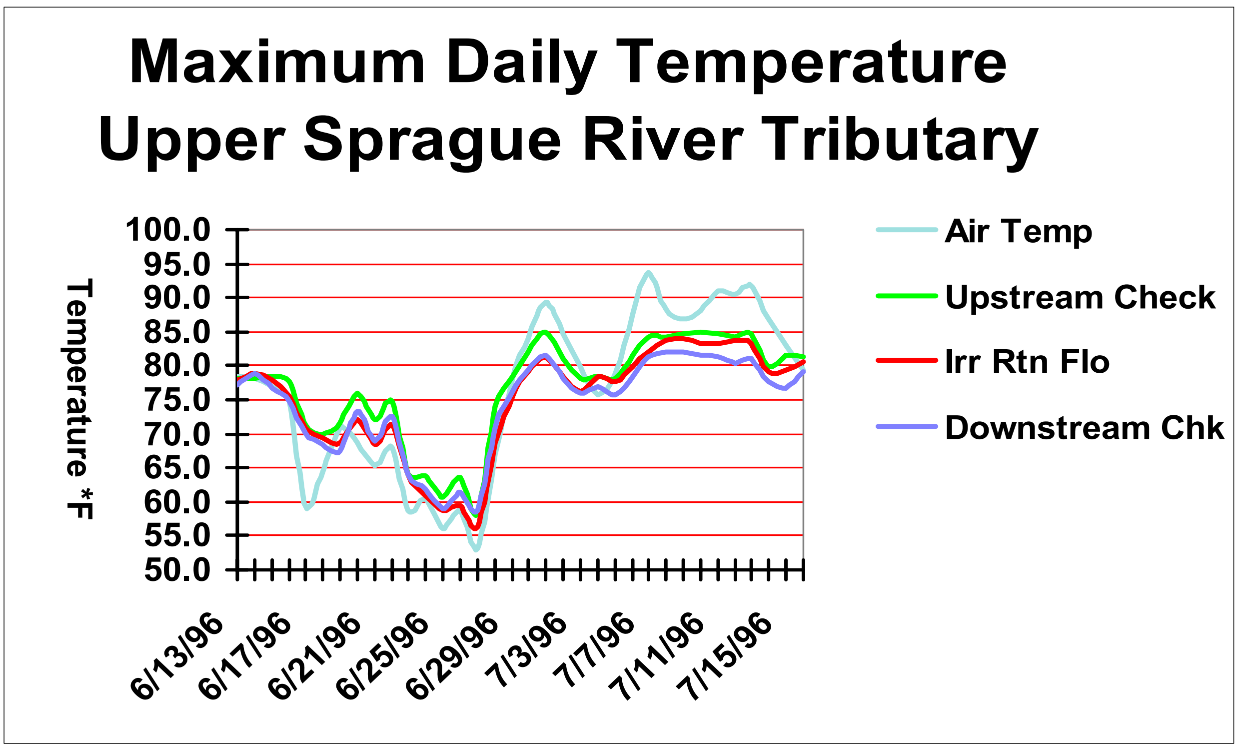


Figure 1. Water and ambient air temperature, irrigated meadow, Upper Sprague River tributary, summer 1996.

**Rock Check Structures**

Four cost shared rock check structures were built in 1985 in order to quickly raise water tables and dissipate excess hydraulic energy of spring floods. State and federal fill permits were obtained, and a cost share program with the United States Department of Agriculture (USDA), Agricultural Conservation Program in effect at the time was utilized to assist with the construction costs. Technical specifications of the USDA. Soil Conservation Service (SCS, presently Natural

Resources Conservation Service) were employed. Cattle were excluded from the structures to enhance the herbaceous and woody vegetation growth that contributes to their stability.

The landowner assumed maintenance responsibility for the structures, which included periodic replacement of rock that proved to be too small for the extreme flood flows experienced some years. Nevertheless, the long term result of the structures has been positive, meeting the basic goal of raising the streambed and capturing sediment upstream of each check. Protection and maintenance of these type structures is required for success!

**Cattle Management**

Cattle represent both a problem and an opportunity in riparian restoration. Livestock grazing is the most important agricultural enterprise in the Upper Sprague watershed. Inappropriate timing, duration and intensity of grazing can result in loss of critical vegetation types and erosion of fragile

Photo 2. Rock check weir construction in creek channel under watchful eye of USDA Soil Conservation Service technician (holding survey rod), August 1985.

soils. Yet these riparian meadows, which are unsuitable for most other types of agriculture, can produce high seasonal yields of quality forage and support profitable cattle ranching operations, which can in turn, help fund restoration efforts.

The key to successful grazing management is to utilize various forage types (wet meadow, dry meadow, transition, forest) at strategic times, at appropriate plant growth stages. See Riparian Area Grazing Management, 1997. Following high intensity, short duration grazing, extended rest allowed plants to recover. Productivity of meadow grasses, both native and endemic, introduced species continues to increase after more than two decades of improved cattle management.

At the project site, non-permanent electric fencing inside a conventional barbed wire perimeter fence proved to be an economical and effective way to achieve proper utilization levels. Fragile streambanks, gullies and other sensitive areas were completely excluded from grazing for extended periods. Cattle were rationed appropriate grazing areas on a weekly basis. The regular monitoring and maintenance required of these fences and livestock also put management and labor on the ground at strategic times for the implementation and maintenance and of restoration project features.

Photo 3. Cows excluded from creek by nearly invisible electric fence, August 1991.

**Fish and Wildlife Habitat**

Non-permanent electric fencing was also used to protect critical aquatic, riparian, and upland habitats. Fish and wildlife habitats were enhanced by increasing vegetative biodiversity and structure, and by prolonging availability of seasonal wetlands.

Improved "Green Line" stability and reduced stream temperature and turbidity was documented by monitoring studies using methods found in the Oregon State University, Department of Rangeland Resources, Riparian Restoration and Monitoring Workshop Handbook. Willow recovery was enhanced by manually planting stem cuttings. Attempts to plant native Black cottonwood and hybrid poplar cuttings along the silty clay loam streambanks were unsuccessful, most plants dying within three years.

Numerous species of waterfowl, upland birds, raptors, rodents, coyotes and mule deer frequent the irrigated meadows of the project site. Redband and other trout species, crayfish and frogs are found in the creek and adjacent seasonal wetlands. Other occasional visitors include pelicans, sandhill cranes, pronghorn antelope and the wily wapiti.

Photo 4. Willow shaded creek channel with dense soil-stabilizing riparian vegetation. Cattle graze meadow in upper right distant background, July 2000.

**Conclusions**

Most degraded riparian areas will not self-heal in our lifetimes, even without further negative impacts. Deeply cut stream channels dewater adjacent riparian areas, and these excessively drained soils have little capacity to recover once vegetation shifts away from species that create a stable stream edge greenline. Hundred of miles of Sprague River and tributaries are in marginally stable, degraded condition, even those from which livestock have been permanently excluded.

Tools for riparian restoration and enhancement are available, but landowner and agency personnel education is required to address the associated opportunities and complex implementation problems. Projects are not self-sustaining. Long term commitment and management incentive is essential to project success. Hydraulic forces can destroy check structures and create, rather than heal gullies. Fences begin falling down as soon as they are built. Unmanaged livestock can destroy riparian vegetation and accelerate erosion.

Plan, monitor, repair, and repeat! Only sustainable, profitable land use enterprises will support long term restoration efforts. Cooperation, not regulation appears to be the essential key, as lack of knowledge and appropriately applied resources has so far rendered ineffective those environmental laws designed to enhance water quality and wildlife habitat in the Sprague River system. It is encouraging however to see several cooperative, voluntary riparian restoration projects on private lands being undertaken in recent years that follow the general principles applied in this project.

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## WOOD RIVER WETLAND MONITORING-THE FIRST FIVE YEARS

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In 1994, with the support from a local citizen's advisory group, the Bureau of Land Management (BLM) purchased the 3,200 acre Wood River Ranch. The primary goal of the acquisition was to restore the majority of the property to a functioning wetland, for the purpose of improving water quality and quantity and to improve habitat for two endangered fishes (Lost River sucker and shortnose sucker). A secondary goal was to improve habitat for other wildlife species. Additional objectives of this restoration project are to provide public recreation and environmental education. Other secondary goals are to coordinate with other county, state, federal and tribal governments and agencies to monitor restoration activities and provide opportunities for research.

In 1995, a comprehensive monitoring plan was completed, and baseline monitoring began. Parameters that have been monitored during the past five years include, vegetation (species, change and noxious weeds), water quality (temperature, nutrients, ph, do), channel morphology, waterfowl (use and production), spotted frog populations, yellow rail populations, neo-tropical migrant birds, bald eagles, and fish.

The results will be presented for vegetation, water quality, waterfowl, and fish. Data analysis, long term predictions and lessons learned will be discussed.

## SEASONAL WETLAND/CROPLAND ROTATION ON TULE LAKE NATIONAL WILDLIFE REFUGE--AN INTEGRATED PEST MANAGEMENT APPROACH

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Wetlands and croplands on Tule Lake and Lower Klamath National Wildlife Refuges provide a majority food source for the Pacific Flyway waterfowl. Croplands within the refuges constitute the largest commercial farming program on federal lands within the United States. As a condition for allowing farming on the refuges, the croplands must be managed in a manner which is consistent with waterfowl management.

Currently, Tule Lake NWR supports a fraction of its past waterfowl use, species diversity has declined, and its value to agriculture has diminished. In an effort to balance agriculture and wildlife issues, a seasonal wetland/cropland rotational management program (flood fallowing) is currently being implemented. The purpose of this program is to reduce soil-borne pests using Integrated Pest Management and reestablish the seasonal wetlands that mimic the ecological processes that created Tule Lake's productive wetlands.

## U.S. FISH AND WILDLIFE SERVICE INVASIVE SPECIES DIRECTIVES WITH IMPLICATIONS TO THE KLAMATH BASIN NATIONAL WILDLIFE REFUGE COMPLEX IN CALIFORNIA AND OREGON

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Invasive species issues are complex in nature and global in scope. Because Invasive Species may have undesirable ecological impacts on endangered species, trust species and their habitats, the U.S. Fish and Wildlife Service is addressing invasive species issues at the international, national, regional, state and local levels using an interdisciplinary approach. Existing federal legislation, state, and county laws and regulations have legally compelled the U.S. Department of the Interior and the us Fish and Wildlife Service into action resulting in the formulation of invasive species policy, and the development and implementation of invasive species management plans. Guiding Federal legislation regarding invasive species dates back to the 1900 Lacey Act, administered by the us Fish and Wildlife Service, crafted to prevent the intentional introduction of certain categories of animal species determined to be "injurious to human beings, to the interests of agriculture, horticulture, forestry, or to wildlife or wildlife resources of the United States." More recently, President Clinton's 1999 Invasive Species Executive Order established the National Invasive

Species Council to develop a National Invasive Species Management Plan. The implications of invasive species impacts and their management to the Klamath Basin National Wildlife Refuge Complex in California and Oregon, will be discussed.

**WESTERN JUNIPER: WATER SUCKING WEEDS OR MONEY TREES**

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The growing of an Ecology based Western Juniper Industry at REACH 1998 to Today: markets explored & established; "green" products developed & tested; processing & packaging demands; restoration of rangeland, wildlife habitat, and water release. The successes and failures in forging common ground with the Environment, Ranchers, Federal Agencies, State agencies and Business economic development.

RESULTS: Earth in harmony with industry; starting with Rangeland healing through selective removal of juniper residue; continuing with conversion into earth healing ecology products; and at the same time sustaining community jobs including people with disabilities. See Juniper Added Value Products: erosion control mats; in-stream topsoil filters; wattles; non-point source, storm drain filters; ODOT & WDOT stream protection; EcoZorb for HazMat cleanup; Slug-Out mulch; Noah's Choice bedding for your favorite rat, iguana, and snake. "FREE Aromatherapy samples to attendees!!"

**SALMON RIVER NOXIOUS WEED MANAGEMENT WITHOUT CHEMICAL HERBICIDES**
**(POSTER)**

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Poster describes the SRRC Noxious Weed Management Program on the Salmon River, which has provided a viable approach to controlling these invasive species at a subbasin level without utilizing chemical herbicides. The activities and results from our Noxious Weed Management Program that has taken place since 1994 will be displayed, as will information related to Cooperation, Communication/Education, Prevention, Inventory, Ground Work-Elimination, Monitoring, Fundraising and Restoration Training Workdays that the SRRC has held in the Salmon River since 1993. SRRC has held regular events involving all of its areas of focus and has coordinated over 1,000 volunteer person days associated with Noxious Weed Management in the Salmon River.

## ROAD DECOMMISSIONING WITHIN THE KARUK ANCESTRAL TERRITORY, MID-KLAMATH RIVER BASIN

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The Karuk Tribe of California is developing a tactical watershed division to expedite watershed restoration activities within the Karuk Ancestral Territory in the Mid-Klamath River Region. Water quality effects from eroding forest roads have been well documented. Within the Territory, the U.S. Forest Service has identified over 2700 km of forest road as having a high or moderate erosion hazard potential. The Tribe in collaboration with the Six Rivers and Klamath National Forests, the Northern California Indian Development Council, Inc. and TerraWave Systems, Inc. are developing an action strategy that systematically implements remedial measures to reduce cumulative watershed effects by upgrading or decommissioning these roads. Since 1999, TerraWave Systems has provided project management, terraform engineering and heavy equipment operations training to the Tribe's watershed division. After intensive classroom and field modules on road decommissioning, division staff began apprenticing their acquired skills on the partnership's top priority--Steinacher Road. Estimated to cost $2.58 million dollars, the Steinacher project is the largest road decommissioning project in the Klamath River system to date. The project will remove 150 000 $m^3$ erosion potential (17 900 $m^3$/km) with road crossing excavations up to 52 000 $m^3$ in size.

## TRANSPORTATION PLANNING AND EROSION PREVENTION ON THE SIX RIVERS NATIONAL FOREST

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Roads are the leading management related source of sediment input into water courses on the Six Rivers National Forest. Because roads provide the greatest erosional risk from land management activities extensive efforts throughout the Forest have been made to inventory roads. Road related data has been gathered that helps identify which roads have the greatest current and future threat to water quality. Almost all of roads within the Lower Trinity and Orleans Ranger Districts have been inventoried and significant portions of the Smith River NRA and Mad River have also been inventoried. The Six Rivers has used this information to identify road restoration and upgrading opportunities. Initially the road restoration efforts were focused on site specific roads but through adopting broader interdisciplinary transportation planning, road related restoration and upgrading has been expanded exponentially. Through the assistance of grant programs such as the Trinity River Restoration Program and the State SB271 program, Forest Service has been able extend its funding and to date, 167 miles of road have been decommissioned, with the majority of miles occurring on the Lower Trinity and Orleans Ranger Districts within the Klamath Basin. How successful this restoration effort has been in flood proofing the road system will be determined through future storm events and monitoring. The Six Rivers is in the process of developing long-term monitoring and tracking of storm driven road sediment contribution for the purpose of adaptive management.

## USE OF ROAD SEDIMENT SOURCE INFORMATION IN ROADS ANALYSIS AND WATERSHED RESTORATION PLANNING (POSTER)

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The intent of new Forest Service policy for transportation planning is to balance the benefits of road access with the potential adverse effects of roads on other resources. This new science-based approach (*Roads Analysis: Informing Decisions About Managing the National Forest Transportation System, USDA Forest Service, 1999*) is being used to achieve road systems that are safe and affordable, respond to both public and agency needs, and have minimal environmental impacts. Road sediment source (RSS) inventories and analyses are currently being conducted on National Forest lands within mid-Klamath River watersheds. They provide information critical to meeting the goals of roads analysis.

RSS information is necessary in assessing the risk of environmental damage posed by roads and weighing it against the benefits those roads provide. Hazard and risk are determined on the basis of road characteristics, geomorphic factors, and potential impacts to key resources. RSS information is analyzed spatially in a GIS framework. Roads Analyses using RSS information allow watershed restoration work to be prioritized so that the most critical and most cost-effective restoration projects are implemented first.

## WATERSHED LEVEL ROAD INVENTORIES ON PRIVATE FORESTLAND

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As part of the management of the its forest resources Timber Products Company activity participates in local watershed organizations. The local watershed organizations have brought together the appropriate stakeholders to propose, plan and implement watershed level forest road inventories.

Road inventories on Company forest land have been cooperative efforts between the South Fork Trinity CRMP, Scott River Watershed Council, French Creek WAG, local Resource Conservation Districts (RCD), Natural Resource Conservation Service (NRCS), United States Forest Service (USFS) and other private forest land owners.

Watershed level road inventories have many benefits for a private forest landowner trying better mange its forest resources. From these road inventories projects have been designed and roads repaired, upgraded or abandoned which can improve watershed conditions for anadromous salmonids. Watershed level inventories also help the Company steer through the sometimes choppy seas of State and Federal regulatory permits that are required to harvest timber in the State of California. Currently, completed or on-going watershed level road inventories cover more 42% of the Company forest land ownership including a total of 342 miles of private forest roads.

Lessons learned from the road inventories completed indicate that there are several areas to improve.

One, integrating other processes that identifies roads for maintenance, upgrade or abandonment. Two, continue to develop common road inventory data collection forms, terminology and in the field collection techniques. Three, watershed organizations need to continue to find ways to increase the use of computer technology in field collection and database management. Four, development and establishment of effectiveness monitoring techniques for watershed level road improvements. Continuing to work on these four general categories of improvement will ensure success of the existing programs and promote more wide spread use of watershed level road inventories in the future.

## ROAD DECOMMISSIONING: HOW EFFECTIVE IS IT?

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The effectiveness of road decommissioning in Redwood National and State Parks was evaluated following a 12-year return period storm in January, 1997. We measured erosion and sediment yield from 61 km of decommissioned roads, which encompassed about 300 road reaches and 200 stream crossings. Treatment of stream crossings involved excavating culverts and associated road fill and reshaping streambanks. Road reaches were treated with a variety of techniques, which included decompacting the road bench, placing unstable road fill in more stable locations, and reestablishing natural drainage patterns. Post-treatment erosion on road reaches was related to method of treatment, geomorphic setting (upper, mid-slope or lower hillslope), and date of treatment. Treated roads in upper and mid-slope positions contributed an average of 10 and 135 $m^3$ of sediment/kilometer of treated roads (20 and 285 $yd^3$/mile), respectively, whereas roads on lower hillslopes contributed 550 $m^3$ of sediment per km of road (1160 $yd^3$/mile) into stream channels. On gentle, convex upper hillslopes, minimal treatment (rip and drain and partial outslope) were effective in stabilizing the roads. On mid-slope roads, more intensive treatment was needed. Road reaches in steep, lower hillslope positions had the highest erosion rate in this study, no matter what

type of treatment method was used. This fact points to the need to either avoid road construction or improve construction techniques in these geomorphically sensitive locations, because mitigation through road removal is not totally effective at these sites. Erosion inventories in adjacent catchments indicate that untreated roads can produce 1500 to 4700 m3 of sediment/km. Thus, although road removal treatments do not completely solve the erosional problems associated with unpaved roads, they do substantially reduce sediment yields from abandoned logging roads.

## FOREST ROAD SEDIMENT SOURCE INVENTORY: APPLICATIONS

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Roads are important and costly structures, with pervasive, persistent and potentially cumulative impacts on steep forested land. Roads contribute the highest per acre sedimentation rate of all watershed disturbances, averaging 58 times background from landsliding and 290 times background from surface erosion.

Summary information has been compiled on 3,813 inventoried sites on nearly 1,200 miles of road. Eighty percent of these sites were channel crossings. Diversion potential existed at 49% of the sites. Approximately 16% of the road length was hydrologically connected to natural stream courses. Estimated total fill volume at all channel-crossing sites is estimated at 1,756,453 cubic yards, an average 600 cubic yards per site.

In order to prioritize work, each site was rated by considering: [1] risk of failure, [2] consequences of failure (sediment delivered), and [3] impacts of failure (to beneficial uses). For example, a highly rated site could be one with an undersized pipe, geologic instability upslope, large fill volume with diversion potential, on an anadromous fish stream. We found that 54% of the total fill volume at channel crossings was attributed to just 10% of the highest ranked sites. These findings suggest that targeted restoration can substantially reduce road-related sediment delivery and can accelerate watershed recovery.

## ARE WE DECOMMISSIONING THE RIGHT ROADS?

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The presentation will review what has been clear for some time, that is, watershed health necessitates controls on disturbance. There is some threshold - different for each watershed based on the "sensitivity" of the land - and if disturbance is pushed beyond this point, chronic and episodic degradation is likely.

The devastating impact of excessive disturbance resulting in degradation is clearly evident in the Klamath Mountains. Like much of the West - much of the Klamath River Basin is very sensitive to disturbance. The steepest lands - the forest mountains - have been extensively logged. Tens of thousands of miles of native surface and gravel roads are in place along with hundreds of thousands of culverts and crossings - many of them undersized, deteriorated or non-functional. The majority of these roads are poorly maintained. Road crossings - and in some cases entire road systems - are subject to catastrophic failure with associated stream scouring or other flood effects. Fisheries values, recreation and "favorable conditions of flow" have been compromised on most of the watersheds in the Basin (see Olsen, 1998? and Nawa 1997?).

We know how to identify those roads which cause the greatest risks (Weaver and Hagans, date) but - with a significant minority of exceptions – we are not decommissioning those roads. The question is why?

I will explore the many forces working AGAINST decommissioning those roads which pose the greatest risks. These include: manager resistance, staff/specialist resistance, cooperator/timber industry resistance, social/county resistance. I will give real life examples, case histories, of decisions which did not do what needs to be done. I will give examples of individual roads that were upgraded which should have been decommissioned and I will give examples of whole systems of roads that should be decommissioned but which managers are holding onto like a kid with candy.

I will discuss the institutional arrangements for "restoration" which are currently operating in the Klamath River Basin and question whether these arrangements will result in reducing road disturbance to manageable levels. This will lead to policy recommendations - actions which restoration leaders could take to improve performance on "restoration" in general and "road decommissioning" in particular.

## ROAD RELATED RESTORATION PROJECTS-SOUTH FORK TRINITY RIVER

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The Trinity County Resource Conservation District (TCRCD) and the Natural Resources Conservation Service (NRCS) have been working on road-related restoration and maintenance projects within the South Fork of the Trinity River drainage, above Hyampom, since 1997. With the Yolla Bolly Wilderness as the South Fork headwaters, all of the projects lay within designated Tier 1 Key Watersheds, valued as habitat refugia for anadromous salmonids.

Most of this work has been funded by the Trinity River Task Force, through the Bureau of Reclamation, though recently California Dept. of Fish and Game grants have contributed to this effort. Cooperation between the TCRCD, NRCS, South Fork Coordinated Resource Management Planning group (SFCRMP), Hayfork Ranger District, Timber Products Co., Simpson Timber, and private citizens has lead to an inventory to implementation approach within the South Fork basin. From road inventories and the resulting stream crossing analysis, priority site treatments include upgrading existing culverts to accommodate higher flows, construction of critical dips to eliminate diversion potential at stream crossings and disconnecting inboard ditches entering stream crossing. The TCRCD/NRCS have also decommissioned roads as a part of this cooperative project. This effort continues with future inventories and projects planned, the objective to reduce road related sediment from the South Fork of the Trinity River and to improve fisheries habitat and water quality.

This presentation will highlight various maintenance and road decommissioning projects accomplished to date within the South Fork of the Trinity River. In addition we'll have tips on logistics, appropriate spoil areas and addressing problems encountered during stream crossing excavations.

## WATERSHED RESTORATION ON THE HOOPA VALLEY INDIAN RESERVATION

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## ABSTRACT

The Hoopa Valley Indian Reservation is a 90,000-acre forest that is a small portion of the ancestral lands of the Hupa people. Timber management began in 1945 and over the past 55 years 645 miles of logging roads have been built. Average road density is 4.6 lineal miles per square mile, with 31% of the Reservation having more than 5.0 lineal miles per square mile. To reduce impacts from roads, the Tribe began "decommissioning" roads starting in 1985. To date more than 34 miles of road have been storm proofed. The majority of the road storm proofing has been funded from Option 9 Jobs in the Woods funds under the Northwest Forest Plan and from the Trinity River Task Force. The Tribe itself has funded over $100,000 of watershed restoration. Various types of watershed restoration have been undertaken at Hoopa ranging from road obliteration, road decommissioning, and stormproofing to simply removing culverts. Costs have varied between $5.50/yard to $7.35/yard removed. Virtually all of the work has been completed by Tribal logging contractors including at least one job where the contractor who originally built the road in 1977 storm proofed the same road in 1996. Over 90,000 yards of material have been removed.

## INTRODUCTION

The Hupa people have lived in the immediate vicinity of the Hoopa Valley Indian Reservation since time immemorial. The 90,000-acre Reservation is located in northwestern California at the confluence of the Trinity and Klamath Rivers and is composed of about 80,000 acres of mixed evergreen hardwood and old growth Douglas-fir forests and about 5,000 acres of mixed conifer forests. The balance of the Reservation is composed of about 5,000 acres of river bottom grasslands located along the Trinity River in the community of Hoopa.

Most of the early road system was built around Indian trails and early settler routes including the Redwood Creek to Hoopa trail and the Hoopa to Orleans path. The 1931 Annual Forestry Report shows there were about 35 miles of roads (graveled or paved) and about 32 miles of trails including graded trails (wagon routes).

## FOREST MANAGEMENT PRE 1964

Sporadic logging began in the early 30's with salvage logging of burns and harvest of green trees for local wood consumption. The first true timber sale took place in 1948 on the former Hoopa to Orleans trail (now Mill Creek road). True forest management began in approximately 1954 with the first timber inventory and timber sale contracts. Roads were built as needed to facilitate timber management so that just prior to the 1964 flood about 10,225 acres (about 25% of the total area harvested to date) had been logged. Good data about date of road construction does not exist throughout the Reservation, However, about 48% of the road system in the Pine, Mill and Tish Tang Creek drainages had been built prior to 1964 based on the road construction history conducted by Pacific Watershed Associates (PWA, 1990a, PWA, 1990b, and PWA 1995).

**TABLE 1**
**ROAD CONSTRUCTION HISTORY ON 3 OF 8 MAJOR WATERSHEDS COMPRISING 41% OF THE HOOPA VALLEY INDIAN RESERVATION**

| Period of Construction | Pine Creek Length of Road Built | Mill Creek Length of Road Built | Tish Tang Length of Road Built | Total Length of Road Built | Cumulative Length of Road Built |
|---|---|---|---|---|---|
| | Miles | | | | |
| Before 1944 | 19.1 | 15.3 | 0.0 | 34.4 | 34.4 |
| 1944-1962 | 30.0 | 27.9 | 2.9 | 60.8 | 95.2 |
| 1963-1965 | 14.3 | 10.8 | 10.5 | 35.6 | 130.8 |
| 1966-1972 | 15.6 | 29.8 | 19.1 | 64.5 | 195.3 |
| 1973-1977 | 8.8 | 18.0 | 5.4 | 31.4 | 226.7 |
| 1978-1990 | 16.0 | 19.8 | 9.6 | 45.4 | 272.1 |

## FOREST MANAGEMENT POST 1964

After the 1964 flood as well as the Columbus Day windstorm of 1962 an aggressive salvage logging effort began. As table 2 above shows, annual road construction between 1944 and 1962 averaged about 3.4 miles per year. In the 2 years after the flood, road construction averaged about 11.8 miles per year. Road construction slowed somewhat in the period 1966 to 1977 and averaged about 9.2 miles per year.

By the mid to late 60's, the annual cut was approaching 40 million board feet per year and there were 7 sawmills in the Valley. By 1976 the cut was recognized as being substantially in excess of sustained yield (BIA, 1976 white paper). Although the local BIA concerns about harvest in excess of sustained yield were based on timber inventory and growth, the Tribal Council was beginning to have concerns about water quality, impacts to fisheries and heavy use of herbicides. In fact, herbicide use was banned in 1978. By 1984 a new Forest Management Plan (FMP) was in place that took into account lower intensity management of the viewshed, stream protection zones, smaller clearcut sizes and an Allowable Annual Cut of 13.5 MMBF. By 1980 there were no sawmills left in the Valley.

**FOREST MANAGEMENT POST 1990**

In 1991 the spotted owl was listed and the Tribe's remeasurement of its timber inventory had been completed. At the same time the Tribe's forestry department recognized there was not much good old-growth timber left to cut. Also the forestry department began looking at the adverse impact the 35,000 acres of clearcuts were likely to have on wildlife populations over the next 150 years.

In 1994 the Tribe adopted a new FMP (Hoopa Tribal Forestry, 1994) with 26 land use zones and substantially different silviculture. Clearcutting was reduced to 10-acre blocks that had to have 3-5 trees per acre. Logging on steep slopes was restricted and many miles of stream-zones were allocated to no cut status. Several culturally important areas were set aside in no cut zones and mushroom management areas were dedicated.

The implementation of the FMP led to interest by the Forest Stewardship Council and the Tribe in determining whether the Tribe's management might be ecologically certifiable. The Tribe was certified by Smartwood in 1999 and completed its first annual audit in 2000.

**CURRENT SITUATION**

The road system resulting from the logging of the past 50 years is substantial. Table 2 below summarizes the road system as it currently exists today.

As table 2 shows, about 165 miles of road are closed due to brush regrowth, landslides, etc. Unlike many ownerships, the Tribe does not like to block roads to restrict winter access, nor do they like to decommission roads through obliteration. Roads are left open to facilitate hunting and gathering. Some gathering does indeed occur during the winter (mushrooms and acorns).

| TABLE 2, ROAD SYSTEM ON HOOPA VALLEY INDIAN RESERVATION, 2001 | |
|---|---|
| **Road Type** | **Miles** |
| Highway 96 | 14.9 |
| County roads | 16.3 |
| Arterial | 132.6 |
| Collector | 162.8 |
| Local | 117.6 |
| Subtotal open roads | 444.2 |
| Local, closed | 165.3 |
| Decommissioned | 35.9 |
| Blocked | 9.7 |
| Abandoned | 9.3 |
| Subtotal closed road | 220.2 |
| Total roads | 664.4 |

## MEASURES OF CUMULATIVE EFFECTS OF ROAD SYSTEM ON RESERVATION

An analysis of the cumulative watershed effects of roads and logging has been completed on the Reservation (Blomstrom and Neisen, 2001) in partial fulfillment of the terms and conditions of the Tribe's Smartwood Certification. Table 3 below is excerpted from Blomstrom and Neisen's work and provides an overview of the road density and "road-stream crossing density" by subwatershed on the Reservation.

Other measures of the impact of roads and logging on cumulative effects to water quality and stream processes have been developed, although these metrics are not in and of themselves measures of cumulative effects. Documentation of these metrics is contained in two major reports recently issued by the USDA Forest Service: Forest Roads: A Synthesis of Scientific Information, June 2000 (USFS, 2000), and Roads Analysis, Informing Decisions About Managing the National Forest Transportation System, August, 1999 (USFS, 1999). Many of these same metrics are included in the Regional Ecosystem Offices' 8/11/00 draft of the Aquatic and Riparian Effectiveness Monitoring Program for the Northwest Forest Plan (REO, 2000) which is designed to test the effectiveness of the Northwest Forest Plan standards and guidelines on anadromous fish and aquatic habitat. Important metrics described by the Forest Service that are "indicators of analysis of water/road interactions" include the following:

- Slope position as an indicator of road hazard
- Slope Class as an indicator of road hazard
- Stream channel proximity as an indicator of road hazard
- Bedrock geology as an indicator of road hazard
- Geomorphology as an indicator of road hazard
- Road density as an indicator of road hazard
- Predicted stream crossings as an indicator of road hazard
- Risk of road stream crossing failure
- Relative potential for shallow landsliding as an indicator of road hazard.

A key metric being used at Hoopa is the number of predicted (or actual) stream crossings either per square mile of land or per lineal mile of road. There are an estimated 575 stream/road "intersections" of perennial (class 1 and 2) streams on the Reservations 658 miles of roads and a staggering 3,325 road-stream "intersections" of intermittent class 3 streams on the Reservations road system (Blomstrom and Neisen, 2001).

**TABLE 3**
**MEASURES OF CUMULATIVE WATERSHED EFFECTS**
**OF FOREST ROAD SYSTEM ON THE HOOPA VALLEY INDIAN RESERVATION.**

| WATERSHED | Area | Road System | Road Density | Decom-missioned roads | Density After Decom-missiong | Stream-Road Crossings No. crossings/sq.mi. of watershed | | |
|---|---|---|---|---|---|---|---|---|
| | Acres | Miles | Mi/ Sq.Mi. | Miles | Mi/Sq.Mi. | USGS Blue-line | Class 1&2 | Class 1, 2 & 3 |
| BEAVER | 2,061 | 14.0 | 4.35 | 0.0 | 4.35 | 0.31 | 5.59 | 12.11 |
| BULL | 4,200 | 31.2 | 4.75 | 0.5 | 4.68 | 1.22 | 1.22 | 29.26 |
| HOPKINS | 3,799 | 40.1 | 6.76 | 0.2 | 6.73 | 1.01 | 2.36 | 41.95 |
| HORSE LINTO | 999 | 6.8 | 4.38 | 0.0 | 4.38 | 0.00 | 0.00 | 0.64 |
| HOSTLER | 6,661 | 47.5 | 4.57 | 0.0 | 4.57 | 0.67 | 1.15 | 21.62 |
| KLAMATH FACE | 1,183 | 4.8 | 2.58 | 0.0 | 2.58 | 0.54 | 0.00 | 18.40 |
| LOWER VALLEY WEST | 1,736 | 13.7 | 5.04 | 0.0 | 5.04 | 1.84 | 4.05 | 10.32 |
| MILL NORTH | 7,508 | 49.6 | 4.23 | 3.0 | 3.98 | 0.94 | 1.19 | 22.33 |
| MILL SOUTH | 9,319 | 70.8 | 4.86 | 14.0 | 3.90 | 1.03 | 2.13 | 26.10 |
| MILL SUBTOTAL | 16,826 | 120.4 | 4.58 | 17.0 | 3.93 | 0.99 | 1.71 | 24.42 |
| MOONS | 383 | 2.0 | 3.29 | 0.0 | 3.29 | 0.00 | 3.34 | 8.36 |
| PINE EAST | 7,325 | 47.1 | 4.11 | 3.3 | 3.83 | 1.83 | 2.71 | 15.38 |
| PINE WEST | 5,490 | 42.9 | 5.00 | 6.0 | 4.31 | 3.03 | 6.99 | 21.45 |
| PINE SUBTOTAL | 12,815 | 90.0 | 4.49 | 1.9 | 4.03 | 2.35 | 4.54 | 17.98 |
| RAIN ROCK | 422 | 0.3 | 0.42 | 0.0 | 0.42 | 0.00 | 0.00 | 0.00 |
| SOCTISH | 5,927 | 37.1 | 4.00 | 1.9 | 3.80 | 1.94 | 3.67 | 17.17 |
| SUPPLY | 7,187 | 56.3 | 5.01 | 4.4 | 4.62 | 4.01 | 6.77 | 21.19 |
| TISH TANG | 8,372 | 61.4 | 4.69 | 2.6 | 4.50 | 1.53 | 2.75 | 20.87 |
| TRINITY GORGE EAST | 3,604 | 21.6 | 3.84 | 0.0 | 3.84 | 1.42 | 1.24 | 23.26 |
| TRINITY GORGE WEST | 6,337 | 47.3 | 4.78 | 0.0 | 4.78 | 1.41 | 6.06 | 17.98 |
| TRINITY MOUTH EAST | 342 | 2.7 | 5.03 | 0.0 | 5.03 | 0.00 | 0.00 | 37.39 |
| TRINITY RIVER | 330 | 0.0 | 0.04 | 0.0 | 0.04 | 1.94 | 1.94 | 1.94 |
| UPPER VALLEY WEST | 4,239 | 39.0 | 5.88 | 0.0 | 5.88 | 2.42 | 3.62 | 11.47 |
| VALLEY EAST | 3,355 | 22.1 | 4.21 | 0.0 | 4.21 | 1.14 | 0.57 | 14.12 |
| TOTAL | 90,776 | 658.2 | 4.64 | 35.7 | 4.39 | 2.13 | 4.08 | 27.69 |

## EROSION FROM FOREST ROAD SYSTEM

Roads are acknowledged as the largest single contributor to sediment and erosion in forest management practices (Durgin, 1989, Scientific Review Panel, 1999). In the Critical Sites Erosion Study of California State regulated timber harvest plans, Durgin stated that roads account for only 4% of the surface area of forest management operations yet contribute 76% of the erosion associated with forest management operations. In scientific work conducted just west of the Reservation in Lacks Creek, Rice (1999) states that "Road related erosion has long been cited as a major source of sediment in streams draining logged areas" and quotes numerous studies to back up this claim. In the same study Rice estimated **annual** road related erosion at 69 cu. yds./mi. (130 tons/mile/year).

The Tribe's Forestry Department initiated a study in the summer of 2000 (Oldenburg, 2001) to determine the annual production rate of sediment from all forest roads on the Reservation. The study used an adaptation of the methodology developed by Rice to determine erosion from logging roads in Lacks Creek. One hundred twenty five plots were randomly installed on various roads within the forested portions of the Reservation to determine annual erosion from logging roads. PRELIMINARY data (Table 4, below) from this study shows that roads on the Reservation produce the following annual amounts of erosion.

**TABLE 4**
**ESTIMATED EROSION FROM LOGGING ROADS ON THE HOOPA VALLEY INDIAN RESERVATION, (OLDENBURG, 2001)**

| Type of Road | Miles of Road | $Yds^3$/ Mile/ Year | Estimated $Yds^3$/year | Estimated tons/year |
|---|---|---|---|---|
| Highway 96 | 14.9 | n/a | N/a | N/a |
| County roads | 16.3 | n/a | N/a | N/a |
| Arterial | 132.6 | 124 | 16,440 | 32,879 |
| Collector | 162.8 | 204 | 33,202 | 66,404 |
| Local | 117.6 | 202 | 23,764 | 47,528 |
| Local, closed | 220.0 | 94 | 20,680 | 41,360 |
| Total | 664.2 | | 94,085 | 188,171 |

Although total erosion is estimated at approximately 188,000 tons per year there has been no estimate of the amount of delivery of erosion from roads to the Reservation's stream system. A study to be conducted in the summer of 2001 is intended to determine the amount of sediment delivered to Reservation streams from erosion on logging roads.

## RATIONALE FOR WATERSHED RESTORATION PROGRAM

Due to the potential impact of roads on water quality, the Tribe has been steadily decommissioning roads on the Reservation for the past 14 years. Among other provisions, the FMP has a goal of having a road density of no more than 4.0 lineal miles of road per square mile outside of the Valley viewshed and no more than 2.0 lineal miles of road per square mile in the Valley viewshed. Given that annual erosion from logging roads on the Reservation produces about 300 tons/mile/year of erosion, the Tribe's Fisheries Department in particular has been a strong advocate for decommissioning roads to reduce potential impacts to fisheries. The Forestry Department has also looked at watershed restoration as a way to reduce road maintenance costs and to mitigate logging related cumulative effects.

Besides reducing road surface erosion and potential impacts to fisheries through erosion related sedimentation, the Forestry Department in particular has looked at watershed restoration to reduce future road costs associated with culvert failures. The operative principle with respect to culverts within the Tribe's Natural Resource Departments is not IF culverts will fail, but WHEN will they fail. The Forestry Department in particular is concerned about the amount of road construction completed after the flood, particularly in the period between 1965 and 1970. Based on the road construction history detailed in Table 2 applied to the Reservation road system as a whole, an estimated 66% of the total current road system of 658 miles has been built SUBSEQUENT to the 1964 flood. Thus, this road system has not been tested by a 50 or 100-year event sized storm. In addition, for roads built prior to 1975, the design life of the culverts has normally been reached and many are rusted and potentially at risk of failure. With approximately 380 culverts on perennial streams and 2,200 culverts on intermittent streams having been installed after the 1964 flood AND having been in place for up to 35 years, there is a potential that a 10 or 25 year return interval event could cause substantial problems to the road system on the Reservation

Thus the following factors have led to the substantial watershed restoration program at Hoopa:

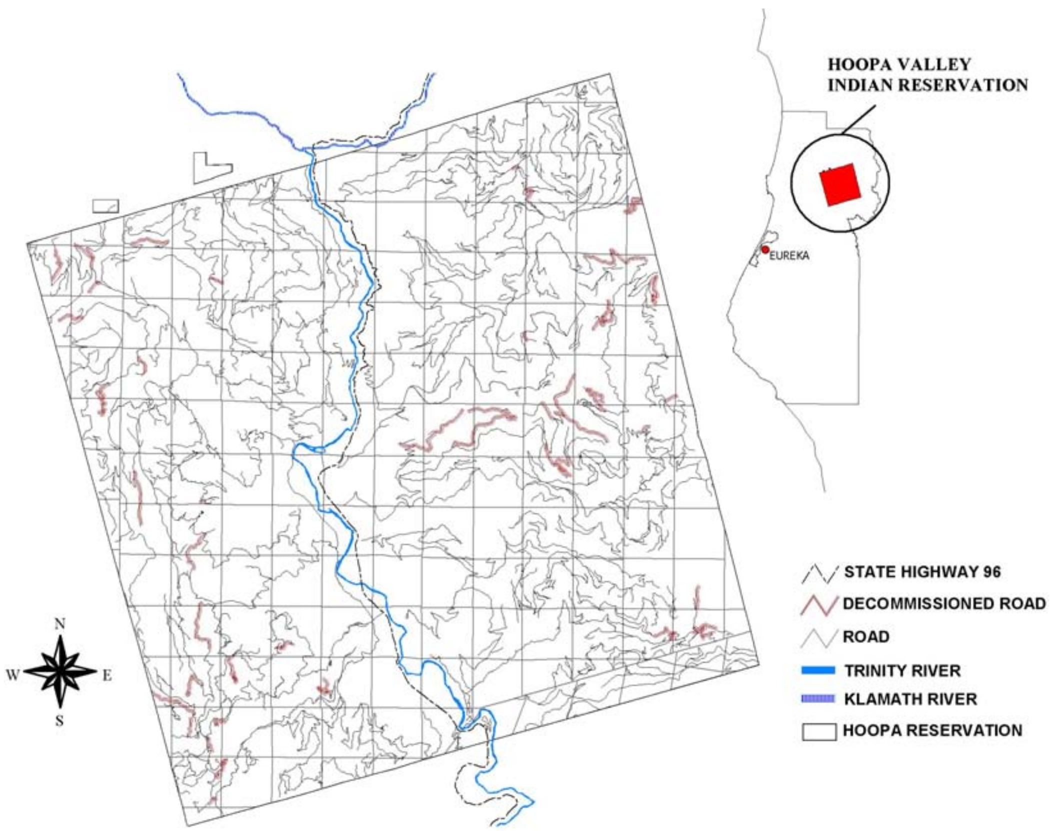
- There is a high road density in some very important watersheds, particularly Mill, Pine and Tish Tang Creeks
- About 65% of the road system has been built after the 1964 flood and not been tested by a 50 or 100 year storm event,
- There are an estimated 575 and 3,325 intermittent stream-road crossings on the 658 miles of the Reservations forest road network,
- Roads produce about 300 tons/mile/year of erosion of which an unknown amount is delivered to the Reservation's stream system.

## WATERSHED RESTORATION PROGRAM

Overall, the Tribe has decommissioned about 35.7 miles of the 658 miles of road on the Reservation (see Table 4 and map next page). Most, but not all of the subsequent watershed restoration work has been preceded by watershed assessments. Besides the three assessments completed by Pacific Watershed Associates, the Tribe itself completed it's own assessment on Supply Creek (Hoopa Tribal Forestry, 1998).

The Tribe has completed various types of watershed restoration since the initial work started in 1984. Virtually none of the work has involved road obliteration, which the Tribe defines as the complete removal of the road prism and recontouring the slope back to the approximate condition before road construction. Most of the work has involved road decommissioning, or in today's terminology stormproofing. The Tribe currently distinguishes between decommissioning or stormprooofing (stormproof (D)) associated with reducing the connection between the road system and the stream system and stormproofing (stormproof (U)) associated with upgrading the existing road network by installing rolling dips, critical dips at culverts, enlarging culverts to 100 year return interval sizes, removing berms, etc. Decommissioning (or stormproof (D) has generally entailed the removal of all culverted stream crossings and removing failing fills in locations where the fill might fail directly into class 1 and 2 creeks. In stormproof (D), roads generally are not ripped, nor are they mulched or planted. Road upgrading (stormproof (U)) generally entails berm removal, installation of rolling dips, installing critical dips over stream crossings and occasionally road rocking. The Tribe has rocked many miles of the existing road network through timber sale funds, however timber sale funded road rocking is not considered part of the watershed restoration program.

The Tribe's emphasis for stormproof (D) has been in highly important anadromous streams such as Pine, Supply, Mill and Tish Tang Creeks. Within these watersheds, the Tribe has concentrated on stormproofing roads, which are closer to class 1 and 2 streams, rather than roads higher up in the drainage. Many of the lower slope roads were installed after the 1964 flood to provide access to salvage flood damaged timber. Thus, many of the roads installed after the flood, particularly in Mill Creek were located very low on the hillslope and many had failed before the restoration program began in 1990.




**Watershed Restoration Work 1984-1990**

The Tribe began decommissioning a limited number of roads in the Supply Creek and Tish Tang Creek watersheds in the mid 1980's because these road segments were obviously going to fail directly into known anadromous fish bearing streams on which significant amounts of in-stream work had already been completed. These two roads segments, comprising about 0.8 miles total were "decommissioned" by pulling failing fills back onto the stable road prism and removing several crossings. This work was done under contract with the BIA road department, however the source of the funds is unknown.

**Watershed Restoration Work 1990-1995**

Funding provided by the Trinity River Task Force during the period 1990-1995 funded the Pine Creek and Mill Creek Watershed Assessments in 1990 and the Tish Tang Creek Watershed Assessment in 1995. These assessments included substantial on-the-ground review of roads that were likely to fail, with every site ranked from high to low depending on the chance of failure. In Mill Creek there were an estimated 53 sites having 67,900 yards of high future sediment delivery and 108 sites with a moderate potential to deliver 58,897 yards of material. PWA estimated there was a total of 445,000 yards of potential sediment that could be delivered, however 317,000 yards were from inner gorge debris slides not directly associated with roads where treatment success was considered very low.

Using Trinity Task Force funding, Jobs in the Woods funds, and tribal funds from timber sales, many of the high and moderate priority sites were treated in Mill Creek, and a lesser number were treated in Tish Tang and Pine Creek. Table 6 below summarizes the work throughout the Reservation including areas not originally covered by a watershed assessment. During this period, a total of 107,000 yards of potential future sediment were removed from stream crossings and failing fills.

**Watershed Restoration Work 1995-2001**

During this period there was a greater emphasis on treating sites in Pine Creek and Tish Tang Creek. In addition, the Tribe applied for Jobs in the Woods funding to complete a watershed assessment of the Supply Creek drainage in the southwest portion of the Reservation. The Tolts-coch chwlin (Supply Creek) watershed assessment was completed in January 1998. Jobs in the Woods funding was received in 1998 to complete work on approximately 148 sites identified in the Watershed Assessment which contain about 193,000 yards of material that are either highly likely or moderately likely to fail. In addition, work in other lower priority anadromous drainages on the Reservation in support of timber management has pointed to the need for watershed restoration of potentially failing road segments in the Soctish, Hostler and Hopkins drainages. These projects are being funded with a mix of National Marine Fisheries Service Salmon Restoration funds and with Tribal funds earmarked for mitigation of timber management effects.

| TABLE 5<br>VOLUME AND COST OF MATERIAL REMOVED,<br>WATERSHED RESTORATION PROJECTS 1990-2000,<br>HOOPA VALLEY INDIAN RESERVATION | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Total Yds Expected** | **Treat-able** | **Yards removed to date** | **WA initial Cost est.** | **Actual Cost** | **WA initial $/yds** | **Actual $/yd** |
| Mill Creek Pre 1996 | 445,000 | 128,000 | 60,863 | $213,021 | $401,087 | $ 3.50 | $6.59 |
| Mill Creek Post 1995 | | | 8,494 | $ 29,729 | $ 46,906 | $ 3.50 | $5.52 |
| Pine Creek Pre 1996 | 102,000 | 45,000 | 27,252 | $149,886 | $157,244 | $ 5.50 | $5.77 |
| Pine Creek Post 1995 | | | 5,597 | $ 19,590 | $ 29,700 | $ 3.50 | $5.31 |
| Tish Tang Post 1996 | 13,575 | 10,670 | 2,465 | $ 18,118 | $ 18,167 | $ 7.35 | $7.37 |
| Tish Tang Post 1996, 2000 | | | 2,350 | $ 8,225 | $ 14,300 | $ 3.50 | $6.09 |
| Subtotal | 560,575 | 183,670 | 107,021 | 438,568 | 667,404 | $ 4.10 | $6.24 |
| Supply Creek JIW 1999, On | 193,000 | n/a | 5,520 | $ 8,446 | $ 41,437 | $ 1.53 | $7.51 |
| Supply Creek, JIW 1999 Off | | | 7,631 | $ 11,675 | $ 60,180 | $ 1.53 | $7.89 |
| Soctish Crk, 1998 TS mitigation | n/a | n/a | 2,500 | n/a | $ 18,781 | n/a | $7.51 |
| Mill 2000 TS mitigation | n/a | n/a | 1,348 | n/a | $ 7,391 | n/a | $5.48 |
| Hopkins 2000 TS mitigation | n/a | n/a | 5,450 | n/a | $ 26,475 | n/a | $4.86 |
| Subtotal other | | | 22,449 | | $154,264 | n/a | $6.87 |
| Total | | | 129,470 | | $821,668 | n/a | $6.35 |
| **Source of Funds** | | | | | | | |
| Funding From K & T task force | | | | | $173,805 | | |
| Jobs in Woods Funding | | | | | $484,000 | | |
| Tribal Funding (TS mitigation) | | | | | $163,863 | | |

## CONCLUSION

During the past 16 years about 35 miles of road have been decommissioned on the Reservation "saving" about 129,700 yards of material from potentially being deposited into Reservation streams. The majority of the work has taken place in the Mill Creek drainage which had nearly 30 miles of road constructed within 2-3 years after the 1964 flood to access flood damaged timber. Many of these roads were low on the slope, built with Humboldt crossings ("log culverts") and were constructed with large fills on extremely steep slopes. Most of these roads have been decommissioned. Road density in the 16,800 acre Mill Creek drainage (Reservation portion only) has been reduced from about 4.58 lineal miles of road per square mile to 3.93 lineal miles of road per square mile.

Road decommissioning has concentrated in the highest priority anadromous streams on the Reservation including Mill, Tish Tang, Supply and Pine Creeks. The watershed restoration program effort was guided by watershed assessments that targeted individual sites by ranking their future delivery potential as high to low.

Today the Tribe is refining its approach to where to decommission roads based on its GIS cumulative watershed effects analysis that has been completed on a subwatershed basis for the Reservation as a whole.

Although the Tribe has continued to build roads to support timber management, most of these roads are high up in the watershed. The road decommissioning program has focused on roads low in the watershed, with the result, that while in many instances, overall net road mileage may increase after timber sale implementation even with road decommissioning as mitigation, the overall impact is expected to be substantially less than without decommissioning given the location of the roads being built and the roads being decommissioned.

The Tribe has received funding from numerous sources including Trinity River and Klamath River Task Force funds and USDI Bureau of Indian Affairs Jobs in the Woods Funds. Funding to complete watershed assessments in Soctish and Hostler Creeks has been provided by the National Marine Fisheries Service Salmon Restoration Program in light of the need to fund restoration wherever coho salmon are found on the Reservation. Direct Tribal cash funding has also been used and comprises about 20% of the $821,000 spent on decommissioning.

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## WATERSHED RESTORATION PLANNING AND IMPLEMENTATION IN THE LOWER KLAMATH SUB-BASIN

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Klamath River anadromous fish populations have declined dramatically over the past several decades. In order to reverse these downward trends in the Lower Klamath Sub-basin, the Yurok Tribe initiated a long-term restoration program in 1995 in conjunction with Simpson Timber Company and the California State Coastal Conservancy.

To address the lack of essential baseline data, YTFP gathered physical habitat, water quality, upslope condition, and biological inventory data on over 200 tributary miles within the sub-basin. The major problems identified were common to all watersheds and were linked to past and present land management, including widespread loss of habitat diversity and complexity, excessive sedimentation, decreased channel and streambank stability, presence of anthropogenic fish barriers, and altered stream hydrography.

The Watershed Restoration Program conducts an upslope erosion inventory throughout one of the 24 tributary watersheds each year, resulting in prioritization of identified treatment sites and estimation of treatment costs. A training program provides staff with the heavy equipment skills necessary to decommission road segments, outslope roads, pull stream crossings, and treat other identified priority areas. To date crews have decommissioned several miles of roads in McGarvey, Ah Pah, and Tectah Creeks and treatment is continuing as funding allows. YTFP is following upslope restoration with necessary in-channel and riparian restoration activities such as anthropogenic barrier modification, stream bank stabilization, and riparian planting. In addition, YTFP has implemented a series of long-term monitoring projects within drainages that have received implementation activities. These monitoring projects are designed to monitor biological and physical conditions over time in order to assess trends and effectiveness of restoration activities.

## COMPETING, COMPLIMENTARY, AND/OR REPLACEMENT STRATEGIES FOR WATERSHED RESTORATION IN THE KLAMATH BASIN

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The long-term prognosis for restoring the beneficial uses in the Upper Klamath Basin is dependent on identifying the underlining hydrological and biological responses within an acceptable conceptual economic and institutional framework. This paper will attempt to identify and developed the critical hydrological and biological responses and test them against the existing and proposed scientific, economic and institutional frameworks.

There is low probability that the outcome of current restoration activities meet any of the resource and economic goals of the basin in-spite of a wide range of structural and management intervention, human and natural beneficial uses will continue to be lost. Many of the existing and proposed institutional criteria and constraints dealing with the allocation and storage of water are competing with those that support biological resources

This paper will attempt to focus a discussion on the spatially explicit restoration activities within the Upper Basin and will develop a conceptual implementation matrix, which optimizes both the structural, and the institutional interventions to best utilize an adaptive management approach to the restoration effort. A working hypothesis for feasible restoration objectives in the Klamath system will be presented along with the monitoring requirements necessary to test the hypothesis.

## OVERVIEW OF RESTORATION PROJECTS COORDINATED BY THE KLAMATH TRIBES

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The Klamath Tribes' Natural Resource Department has been coordinating the development and administration of ecosystem restoration projects in the Upper Klamath Basin watershed. These projects are focused on improving watershed conditions, and fish and wildlife populations of concern to tribes, the general public, and resource managers throughout the Basin. This presentation will provide an overview of the Tribes' restoration program, and will present information on projects that have implemented, and projects currently in progress.

## THE FIVE COUNTIES SALMON CONSERVATION PROCESS SUMMARY OF ACTIVITIES AND FUTURE DIRECTION

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The Counties of Del Norte, Humboldt, Mendocino, Siskiyou, and Trinity formed a conservation process to address local government interaction in the listing of the coho salmon in the Trans-Boundary ESU. The Counties chose to be pro-active with the listing of salmonids in an effort to avoid adverse social impacts and assure a coordinated approach to these listings. The boundaries of these counties are not based on watershed lines and they recognized that watershed based solutions would be necessary. The counties committed to the conservation strategy based on the principles of education and incentive activities first and new regulation as a last resort:

This cooperative effort has led to the following accomplishments:
--An empirical watershed prioritization for counties to pursue grants for salmon conservation efforts.
--A three year roads, salmonids and water quality training program for road managers and operators.
--A migration barrier inventory of county roads in these counties.
--Funding to remove 15 barriers on County roads, including three completed in the fall of 2000, two of those in the Klamath/Trinity basin.
--Funding for a roads erosion inventory program of County Roads, including new software and the results from the first 150 miles of inventory
--Development of a water quality manual for County road managers
--Support for the development of various local ordinances and incentive programs
The process has established a very active relationship with the state and federal agencies charged with administration of the respective Endangered Species Acts, CEQA and NEPA, permitting and general program support.

## KLAMATH BASIN ECOSYSTEM RESTORATION OFFICE: WATERSHED RESTORATION ACTIVITIES

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The Klamath Basin Ecosystem Restoration Office (ERO), located in Klamath Falls Oregon, was established in 1993 to address effects of water quality and habitat on endangered fish in the upper and lower basins and to plan and coordinate habitat restoration activities between existing federal, state, local agencies, tribes, and private landowners. ERO, in collaboration with the Hatfield Upper Basin Working Group, was charged with providing advice to Senator Hatfield and performing restoration activities with the spirit and intent of maintaining economic integrity and meeting Federal trust responsibilities. Funding for these projects comes from several U.S. Fish and Wildlife Service and Bureau of Reclamation programs. Since 1994, approximately 1.8 million dollars has been allocated each year for restoration activities. ERO has provided funding and technical assistance for approximately 250 restoration, planning, outreach/education, and monitoring projects. Examples of projects that exemplify the goals of the restoration programs are presented.

# PART 5: TRINITY RIVER MANAGEMENT AND RESTORATION EFFORTS

## SPAWNING GRAVEL QUALITY IN THE TRINITY RIVER MAINSTEM AND TRIBUTARIES

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The quality of Chinook salmon spawning gravels was studied on the mainstem Trinity River and on key tributaries. Eight known spawning areas on the mainstem between Lewiston Dam and Junction City were sampled for intragravel permeability and particle size distribution to: provide baseline data for long-term monitoring; determine longitudinal distribution of gravel quality; estimate the rate of survival to emergence for salmon eggs; and investigate the relationship of permeability to gravel quality. Additionally, one site was sampled on each of eight large tributaries to the Trinity River. Two bulk samples were taken at each site using a modified McNiel method with a 2' diameter sampler which yielded 400-700 kg per site.

Preliminary results indicate decreasing gravel quality downstream with the lowest survival rates for Chinook eggs to emergence downstream of Grass Valley Creek. The relationship between permeability and particle size distribution is being analyzed and early indication shows a significant correlation between permeability and several gravel quality indexes including % fines < 1mm, Fredle index, and Tappel and Bjorn survival rates to emergence.

## TRINITY RIVER FLOW EVALUATION AND RECOMMENDATIONS

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The Trinity River Flow Evaluation Study (TRFE) culminates several years of effort by several organizations to develop a plan to fulfill fish and wildlife protection mandates that date back to 1955. The TRFE recommends a mechanical channel rehabilitation program, increased instream flows to provide aquatic and floodplain habitats and maintain channel morphology, a sediment management program, and an adaptive management plan to assure recommendations meet objectives. Annual volumes of water released from Lewiston Reservoir will vary according to five different water year classifications to meet different geomorphologic objectives. Intra-annual flow variability accomplishes three management objectives: (1) baseflow releases to provide salmonid habitats; (2) releases to mimic spring snowmelt hydrographs, which simultaneously aid smolt outmigration and help create and maintain alluvial features critical for salmonid and other species habitats; and (3) releases to meet water- temperature objectives for adult salmonids and outmigrating salmonid smolts.

Channel rehabilitation will create a more appropriate riparian function and eliminate channel constrictions that isolate the channel from the floodplain and reduce instream habitat at moderate flows. Sediment management includes reduction of fine sediment storage and supplementation of course sediment that was eliminated by the construction of Lewiston and Trinity Dams.

## SCIENTIFIC COMPONENTS OF THE TRINITY RIVER ADAPTIVE ENVIRONMENTAL ASSESSMENT AND MANAGEMENT (AEAM) PROGRAM

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One of the most significant components in the recently signed Record of Decision for the Trinity River Mainstem Fishery Restoration is the Trinity River Adaptive Environmental Assessment and Management (AEAM) program. The AEAM program is a formal, systematic, and rigorous program of learning from the outcomes of management actions, accommodating change, and improving management. While our level of understanding of river ecosystems are improving, river ecosystems are very complex, and managing the Trinity River will always face significant uncertainty. The AEAM program promotes responsible, science-based progress in the face of this uncertainty while avoiding “trial and error,” “charging ahead blindly,” or being “paralyzed by indecision” common to restoration programs. A properly functioning AEAM program.

1. Defines goals and objectives in measurable terms;
2. Documents/evaluates baseline conditions with respect to goals and objectives.
3. Develops testable hypotheses of how to achieve goals and objectives through management actions;
4. Uses data and models to predict river response to management actions before implementing management actions;
5. Implements and monitors management actions.

6. Re-evaluate objectives, refines hypotheses, improves models, and improves management;
7. Continually self-examines AEAM science, management, and policy via external peer review

The AEAM process is a cooperative integration of water operations, resource management, scientific research, and public/stakeholder input. This presentation will provide an overview of the framework of the proposed Trinity River AEAM, but will focus on the scientific components, and how these are intended to convey important information to river managers.

## PHYSICAL HABITAT MODELING OF STREAM CHANNEL REHABILITATION IN THE TRINITY RIVER: A COMPARISON OF EXISTING AND POTENTIAL FUTURE AQUATIC HABITAT

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Physical habitat modeling was conducted on portions of the Trinity River to compare existing aquatic habitat area and quality to potential future habitat. Existing conditions were represented by river cross-sections measured for the Trinity River Instream Flow Study. Potential future conditions were represented by cross-sections placed in channel areas recontoured by heavy equipment into "natural" shape and meander patterns for the Trinity River Restoration Program. Modeling of existing mainstem habitat showed the Weighted usable Area (WUA) aquatic habitat index decreasing as flows increased above 300 cubic feet per second, then increasing again above flows of 1500 cfs. The WUA habitat index for the recontoured channel showed more moderate decreases as flow increased above 300 cfs and then a generally increasing WUA above 600-700 cfs. There is some variation in WUA index response depending on the fish species and life stage modeled. These results can be used to help evaluate potential benefits of Trinity River restoration actions.

## HONEY, I SHRUNK THE CHANNEL

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The mainstem Trinity River below Lewiston was once alluvial. Large, alternating point bars provided salmonid habitat diversity over a wide range of annual flows. Following implementation of the Trinity River Division in the early 1960's, the two key ingredients maintaining an alluvial channel were critically altered: flow and sediment. With the snowmelt hydrograph eliminated and winter floods greatly reduced, alternating point bars were encroached by woody riparian vegetation. By the early 1970's, the mainstem was reduced to a narrow trapezoidal channel isolated from its

former floodplain. The Trinity River is dramatic proof that a single species approach to resource management does not work. Any restoration strategy must address ecosystem integrity. A set of ten alluvial river attributes was developed to help shape an ecosystem restoration strategy for the mainstem Trinity River below Lewiston. These attributes include several key fluvial processes that must be reinstated to the Trinity River mainstem if recovery of the ecosystem and its salmonid populations is to succeed.

## EVALUATION OF THE EFFECTS OF THE TRINITY RIVER CHANNEL RESTORATION PROGRAM ON HERPETOFAUNA ABUNDANCE AND HABITAT AVAILABILITY

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Part of the effort to restore habitat within the mainstem Trinity River includes constructing side channels and re-contouring areas with fossilized riparian berms. These channel modifications are intended to increase the availability of shallow and low velocity water along the river margin in order to provide habitat for aquatic species, such as juvenile fish and amphibians. However, they may also benefit terrestrial wildlife by increasing usable habitat within the riparian zone. In this study, we compared habitat availability and occurrence of herpetofauna at two pilot restoration sites and two sites with fossilized berms (unaltered control sites) in the Trinity River. During May and June of 2000, we conducted visual encounter surveys, area-constrained transect surveys, and habitat surveys. The results of habitat surveys indicated that the channel rehabilitation sites were characterized by more diverse habitat and less vegetative cover than the control sites. Furthermore, the visual encounter and area-constrained transect surveys suggested that the channel rehabilitation sites exhibited greater species diversity than the controls. Use of habitats by herpetofauna at all sites was independent of habitat availability. This suggests that herpetofauna distribute themselves selectively amongst available habitat.

**Paper presented in reduced sized images of PowerPoint slides below. To view full sized slides using Microsoft PowerPoint (.ppt file), click here. To view full sized slides using Adobe Acrobat Reader (.pdf file), click here.**

# Effects of the Trinity River Channel Restoration Program on Herpetofauna Abundance and Habitat Availability: A Pilot Study

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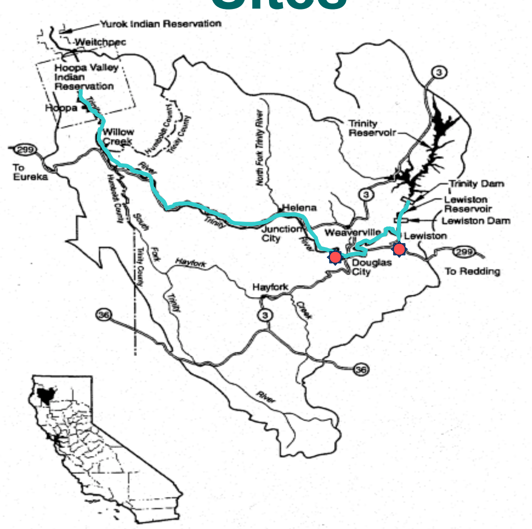
## Background

- Wilson (1993) reported change between 1960 and 1989
  - Riparian vegetation increase
  - Open-water habitat decrease
  - Open gravel bars decreased
- Hampton (1995) and Evans (1980)
  - Straighter, narrower and deeper

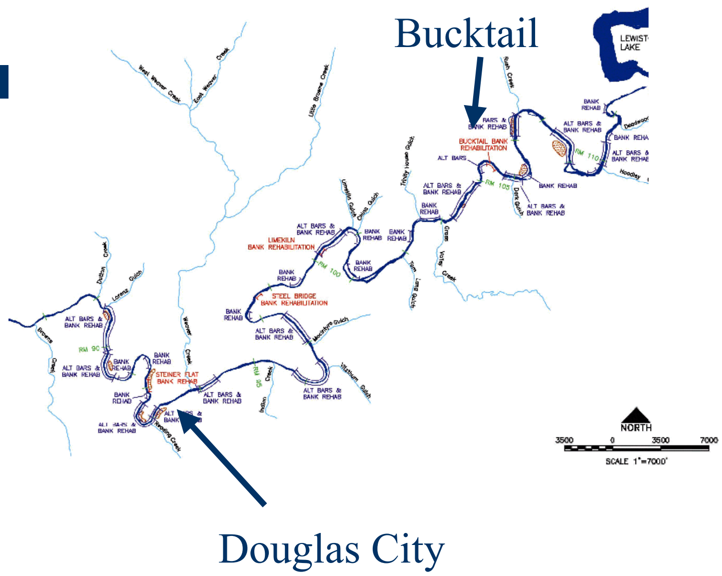
# Background

- Foothill yellow legged frog and western pond turtle (Reese 1998) rearing and breeding site decrease (Lind et al 1996).
- Nine pilot channel restoration projects built in 1988.
- River restoration is common but post project evaluation is not (Kondolf et al 1996).

# Map of Trinity and Project Sites



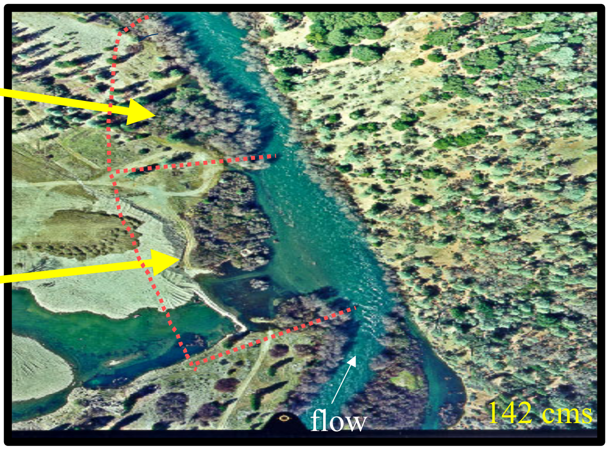
## Map of Project Sites




## Study Sites

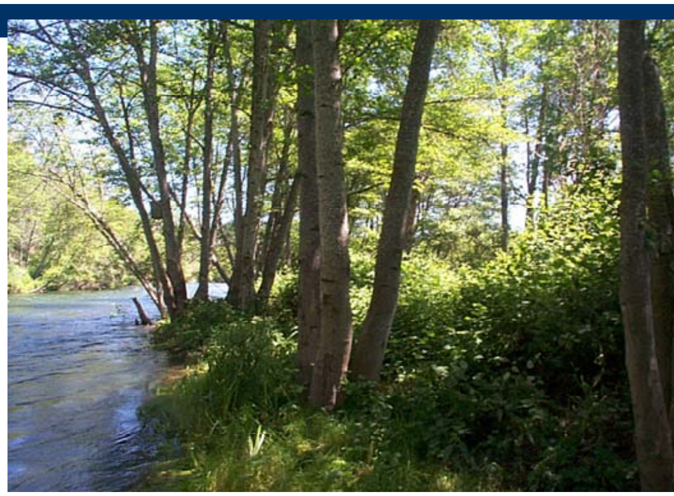
- Two restoration and control site pairs
  - Douglas city
  - Bucktail

# Bucktail Restoration and Control Sites



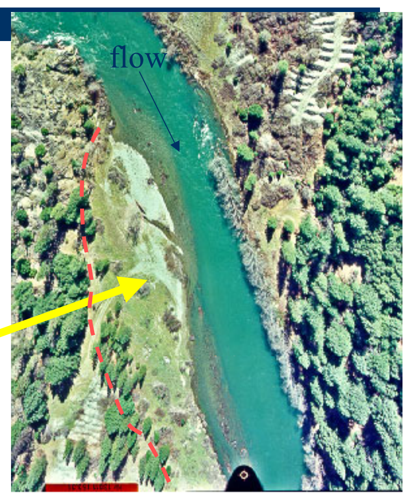

# Bucktail Restoration Site

# Bucktail Control Site



# Douglas City Restoration Site

at 142 cms

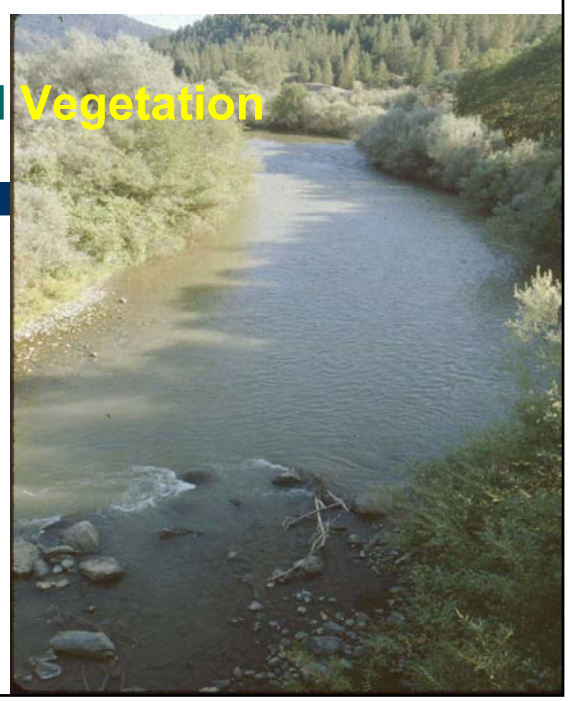



Douglas City Restoration Site


Douglas City Restoration Site

## Douglas City Control Site


## Encroached Vegetation



## Objectives

- Develop future study methods.
- Develop a faunal list
- Herpetofauna species
  - Are frogs/reptiles more abundant at restoration sites?
  - Are frogs/reptiles more diverse at restoration sites?

## Objectives

- Herpetofauna habitat.
  - Is habitat more diverse at restoration sites?

# Methods: Habitat

- To generate list of species occurrence, we utilized visual encounter survey.
  – Weekly surveys, 18 may – 28 June.
- For density, we performed area constrained transect surveys perpendicular to the shoreline.
  – Weekly surveys, 6 june - 28 June.
- For habitat diversity, we GPS quantified habitat at each site.

# Visual Encounter Survey Technique

## Pacific Gopher Snake


## Western Yellow Belly Racer

# Bullfrog

# Pacific Treefrog

# Rough-Skinned Newt

# Western Pond Turtle

# Northern Alligator Lizard

# Foothill Yellow Legged Frog

# Common Garter Snake

# Western Toad

# Results: Amphibian List From May-June

| | Restoration | Control |
|---|---|---|
| **Amphibians** | | |
| **Western Toad** | 6 | 1 |
| **Pacific Treefrog** | 11 | 2 |
| **Foothill Yellow-legged Frog** | **15** | 3 |
| **Bullfrog** | 3 | 0 |
| **Rough Skinned Newt** | 1 | 0 |
| | | |
| **Total Amphibians** | 36 | 6 |
| Species number | **5** | **3** |

## Results: Reptile List From May-June

| | Restoration | Control |
|---|---|---|
| **Reptiles** | | |
| **Western Yellow Belly Racer** | 9 | 1 |
| **Western Fence Lizard** | **49** | 25 |
| **Northern Alligator Lizard** | 0 | 1 |
| **Southern Alligator Lizard** | 0 | 1 |
| **Pacific Gopher Snake** | 6 | 2 |
| **Western Pond Turtle** | 1 | 0 |
| **Common Garter Snake** | 2 | 0 |
| **Western Aquatic Garter Snake** | 1 | 0 |
| | | |
| **Total Reptiles** | 68 | 33 |
| **Species** | **6** | **5** |

## Results: Species Diversity

| Shannon's diversity indices using VES data | | |
|---|---|---|
| | Channel Restoration Sites | Control Sites |
| Week 1 | .440 | Not Done |
| Week 2 | .562 | Not Done |
| Week 3 | .621 | .301 |
| Week 4 | .295 | .677 |
| Week 5 | **.543** | 0.00 |
| Week 6 | **.374** | 0.00 |

## Mean Relative Herpetofauna Abundance

| | Channel Restoration Sites | Unaltered Control sites |
|---|---|---|
| Pacific treefrog | 5.1 | 3.0 |
| Foothill yellow-legged frog | 3.4 | NO |
| Western toad | 3.4 | NO |
| Western fence lizard | 8.4 | 5.8 |
| Western terrestrial garter snake | 1.7 | NO |
| Southern alligator lizard | NO | 5.9 |

NO=None observed

## Results: Habitat Diversity

| | CRS | Control |
|---|---|---|
| No vegetation | 19 | 18 |
| Grass | **48** | 25 |
| Forb | 7 | 11 |
| Ceanothus | 0 | 0 |
| Blackberry | 1 | 0 |
| Mixed shrub | 0 | 4 |
| Willow | 14 | 8 |
| Dead willow | 0 | 0 |
| Alder | 0 | 1 |
| Cottonwood | 0 | 0 |

| | CRS | Control |
|---|---|---|
| Blackberry | 5 | **29** |
| Conifer | 1 | 2 |
| Dredge Pile | 0 | 0 |
| Manzanita | 0 | 0 |
| Oak | 0 | 0 |
| Downed Tree | 0 | 0 |
| Debris Pile | 2 | 0 |
| Other | 0 | 0 |

## Results: Habitat Diversity

| | Channel restoration sites | Unaltered control sites |
|---|---|---|
| sand / silt | 64.2 | 81.5 |
| small gravel | 19.9 | 2.8 |
| large gravel | 4.1 | 15.8 |
| cobble 2-4" | 11.2 | 0 |
| cobble 4-6" | 0.2 | 0 |
| cobble 6-8" | 0 | 0 |
| cobble 8-10" | 0 | 0 |
| bedrock | 0.4 | 0 |
| large cobble >10" | 0.1 | 0 |

## Analysis and Recommendations

- Survey only treated area
- Study period from April-July
- Use at least four site pairs
- Transect surveys should use more transects/per site
- Retest original hypotheses

## Acknowledgements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- This project was funded by the Trinity River restoration program.

## A TEMPERATURE MODEL OF THE TRINITY RIVER

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The SNTEMP model of the Trinity River was developed to better describe the temporal and spatial effects of Lewiston Dam releases (both release temperature and magnitude) on downstream water temperatures under variable hydrometeorological conditions. Using the calibrated model, simulations were conducted to observe the sensitivity of various factors on downstream water temperature. Such evaluations included simulations that had variable conditions represented by: 1) a range of dam-release water temperatures represented from historical conditions and/or those predicted from a temperature model of Lewiston Reservoir (BETTER model); 2) variable dam releases magnitudes; and 3) a wide range of hydrometeorological conditions represented by hypothetical year types represented by hot-dry, median, and cold-wet hydrometeorological conditions, as well as historical years. Simulations of these variable conditions provided a good understanding of the system behavior and were valuable for assisting in development of temperature recommendations for the Trinity River during the spring and summer months.

## TRINITY RIVER FISHERIES RESTORATION POLICY AND HISTORY: 1980-2000

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## THIRTY YEARS OF TRINITY FISHERY RESTORATION AND POLICY

**Abstract**

The impact of the Trinity dams on the river's fishery has been a concern since the authorizing legislation for those dams in 1955. By the late 1960s it was clear to agency scientists that anadromous fish populations on the Trinity were declining and that dams were at least partly responsible for the decline. Three Environmental Impact Statements have attempted to assess the river's health and provide viable restoration direction. Four Acts of Congress, several Interior Solicitor's opinions, two flow studies, and more than $100 million for assessment, monitoring, and restoration represents a long-term bipartisan political commitment to Trinity fishery restoration. These developments are discussed here as a framework for understanding the purpose of the December 19, 2000 Record of Decision.

**Introduction**

The Record of Decision of December 19, 2000 to restore the anadromous fishery on the Trinity River represents the culmination of more than 30 years scientific study and more than four Acts of Congress spanning 40 years. The 2000 flow decision was the third change in the Trinity flow schedule made by a Secretary of the Interior, and represents a thirty-year bipartisan attempt to restore Trinity River anadromous fish populations, and may not be the last. Each flow decision has been the result of science-based policy and provides a model for other river systems.

**Damming the Trinity**

In the 1950s dam building was on the increase in the United States. There was political pressure to expand the Central Valley Project: to open up agriculture to new lands in the San Joaquin Valley and to help support the explosive population growth in Los Angeles. The mainstream view of water in the west, virtually unchanged since the mid mid-19$^{th}$ century is summed up by this 1952 plan for the development of the Trinity by the U.S. Bureau of Reclamation: "Thus a large surplus of upper [Trinity River] basin water which now has no utility to the area can be converted to power need in the north coast counties and conserved for irrigation in the water short Central Valley" (USBR, 1952).

In 1954, a series of hearings was conducted in Congress for the passage of an act to authorize the construction of the Trinity River Division of the Central Valley Project (CVP). These hearings were held in the House Subcommittee on Irrigation and Reclamation of the Committee on Interior and Insular Affairs. California Congressman Clair Engle was an enthusiastic sponsor of this bill. The stated purpose of the proposed Act was

> "For the principal purpose of increasing the supply of water available for irrigation and other beneficial uses in the Central Valley of California…" (P.L. 84-386)

and this lofty goal had many supporters by the time this bill came up for a vote. Initially, though, there was substantial resistance to this idea. The municipal governments of both Humboldt and Trinity County expressed concern about their access to future Trinity water for a growing population (U.S. House of Representatives, 1954). Specifically, they had concerns that county water rights under Area of Origin provision in California State Water Law would be restricted if the U.S. Bureau of Reclamation was allowed to claim rights to unappropriated water in the Trinity River.

A representative of the Yurok Tribe expressed a concern of many local residents of how the loss of Trinity water would impact the local economy. The Bureau of Reclamation at that time was already taking a substantial amount of water out of the Klamath River, of which the Trinity is the largest tributary, and had recently constructed the Copco dam. Since that dam had been constructed, fish kills on the lower Klamath had become more common. The loss of Trinity River would make this situation worse. Would a similar situation be created on the Trinity River with a new dam?

In 1955, a year later, Congress authorized construction of the Trinity River Division of the CVP (P.L. 84-386). To address the water rights concerns, a provision was added to give Humboldt County the right to appropriate 50,000 acre-feet annually from the Trinity River. The following provision addressed fish and wildlife concerns:

> "…the Secretary is authorized and directed to adopt appropriate measures to insure the preservation and propagation of fish and wildlife, including, but not limited to, the maintenance of the flow of the Trinity River below the diversion point at not less than one hundred and fifty cubic feet per second for the months July through November…"

Construction began the next year and water was first impounded in 1960, eliminating 109 miles of spawning habitat for anadromous fish. Diversions to the Sacramento basin began in 1963. The capacity of the Trinity reservoir was 2.5 million acre-feet. The initial combined generating capacity of the Trinity River Division was 397 MW. A fish hatchery was created below the Lewiston dam to mitigate for the anadromous spawning habitat forever lost by the dams, constructed without fish passage facilities. The initial annual instream fishery flow regime for the Trinity River was 120,500 acre-feet, less than one-half the flow of the driest year of record.

**First Signs of Trouble**

In the first 17 years of dam operations, up to 90% of the annual flow was diverted to the Central Valley. The summer low flow was 150 cubic feet per second (cfs), as prescribed by the 1955 Act. As soon as four years after full operation of the dams, the first signs of trouble appeared. One of the first symptoms noted was sedimentation of the streambed: spawning riffles were covered and deep pools filled (USF&WS, 1980). With the loss of high flows to the Trinity River, and a large increase in largely unregulated timber harvest in the basin, the sediment delivered by the tributaries was no longer flushed through the mainstem Trinity. This symptom of dam impacts had been noticed on other California rivers with large dams. A statewide task force was formed in 1967 to deal with the problem. At the same time fisheries biologists recorded rapidly declining populations of spawning salmon and steelhead in the Trinity. To deal with this problem, the Trinity River Basin Fish and Wildlife Task Force was formed in 1971, funded initially by its member agencies. Beginning in 1976, Congress began appropriating funds to agencies to implement studies aimed at restoring Trinity anadromous fish populations. Through its many studies, the Task Force concluded that there were three fundamental causes for fisheries decline in the Trinity River (USF&WS, 1980):

1. Excessive streambed sedimentation
2. Inadequately regulated harvest
3. Insufficient streamflow

Sedimentation seemed the easiest cause to tackle first, and many millions of dollars were, and continue to be, spent in the Trinity basin to reduce the input of fine sediment to the mainstem Trinity River, primarily from Grass Valley Creek. This tributary stream drains a sub-basin with a surface layer composed of a high erodible material known as decomposed granite. Intensive, largely unregulated, timber harvest in the sub-basin in previous decades had exacerbated the erosion problem. This sedimentation problem caught the attention of Congress, which passed the 1980 "Trinity River Stream Rectification Act" (P.L. 96-335), funding a sand dredging program on the mainstem Trinity downstream from Grass Valley Creek and the construction of a debris dam on Grass Valley Creek.

In the late 1970s two scientific studies were commissioned to supply information to design a fisheries restoration plan. The first was designed to recommend an overall basin fish & wildlife plan (Frederickson, Kamine, and Associates, 1979) and the second was an instream flow study (USF&WS and J.P. Hoffman, 1980). Using the findings of these studies, and several others commissioned by the Task Force, the U.S. Fish & Wildlife Service undertook an Environmental Impact Statement (EIS) in 1980 to recommend changes in the Trinity River flows. The 1980 EIS reported that the population of spawning wild chinook salmon above the North Fork Trinity River had declined from a pre-dam level of 50,000 to 5,200. The Lewiston hatchery added 5,900 to that total. The decline in wild chinook salmon since the construction of the dam was thus nearly 90%. With the hatchery component added, the decline was still 78%. The wild steelhead trout population declined from the pre-dam 24,000 to 6,200. The hatchery added 700 to that total. The decline in wild steelhead since the construction of the dam was thus 74%.

**Attempts to Restore the Fishery**

Of the three fundamental causes of fisheries decline identified by the Task Force, the Interior Department chose to address the management of river flows next. Of the three causes, this one was completely under the Department's control. The stated purpose of the 1980 EIS was to

> "…manage river flows below Lewiston Reservoir to make possible the restoration of chinook salmon and steelhead trout populations towards those levels that prevailed in the Trinity River system before the Trinity River Division of the Central Valley Project was placed in operation in 1963."

The legal mandate for fisheries restoration was two-fold: the statutory requirement in the TRD authorizing legislation, and the federal tribal trust obligation to protect Indian treaty rights. Eight alternatives were analyzed, from the no action alternative, at 120,500 acre-feet in all years, the statutory minimum in the authorizing legislation, to the 340,000 acre-feet in all years recommended by the 1980 flow study. Several of the alternatives used the concept of a "water-year type" to prescribe flow schedules. Three water year types were specified: normal, dry, and critically dry. The determination of the water year type was tied to predicted basin water yield, and was aimed at both mimicking natural conditions and making more water available for economic purposes when water was scarce. The alternative chosen by Interior Secretary Cecil Andrus in his 1981 Secretarial Decision and Issue Document used the following schedule:

| | |
|---|---|
| Normal water years | 340,000 acre-feet |
| Dry water years | 220,000 acre-feet |
| Critically dry water years | 140,000 acre-feet |

The alternative chosen was estimated to cause average annual losses to agriculture of $1.8 million dollars over the existing condition, but would be accompanied by an increase of $4.5 million in average annual fisheries-related revenue. Estimated replacement power costs ranged from $5 million for geothermal, to $11.3 for oil.

The benefits to fish of increased flows were primarily two-fold: more suitable physical channel habitat and more suitable spring, summer, and fall temperatures. Assigning a 100% habitat value to the 340,000 acre-feet alternative, the EIS estimated that the existing condition of 120,500 acre-feet provided only a 20% relative habitat index value and only 22% of the predicted chinook spawner escapement—an often-used measure for returning adult anadromous fish. The alternative chosen had an estimated 88% relative habitat value and a 91% predicted chinook spawner escapement .

Concurrent with the 1980 EIS to develop an optimal flow schedule was the development of a basin management plan by the Task Force to deal with the other causes for anadromous fish decline in the basin. The eleven-point plan, developed over seven years, was analyzed in a 1983 EIS. Congress responded with the passage of the 1984 Trinity River Basin Fish and Wildlife Management Act (P.L. 98-541). This legislation contained three primary components:

1. The creation of the "Trinity River Basin Fish and Wildlife Management Program" in the Interior Department. Specific activities to be addressed were the rehabilitation of fish habitat,

modernization of the Trinity fish hatchery, and a program to monitor the success of the restoration on an annual basis.

2. The official establishment of the advisory group, the "Trinity River Basin Fish and Wildlife Task Force." This group was to be composed of 14 members from specified agencies and stakeholder groups. This provision replaced the less official, group by the same name that had been meeting since 1971.
3. Congress appropriated funds for the management program and Task Force, including an annual appropriation of $2.4 million for ten years for operation, maintenance, and monitoring. The 1984 Act thus served as a long-term commitment to Trinity fishery restoration.

As a continuing acknowledgement of the federal trust responsibility to the basin's Indian tribes, the legislation contained language mandating non-interference with fishing rights. The legislation also contained language that for the first time quantified restoration targets:

> "…the Secretary… shall formulate and implement a fish and wildlife management program for the Trinity river Basin designed to restore the fish and wildlife populations in such basin to the levels approximating those which existed immediately before the start of the construction… and to maintain those levels."

This idea of restoration as a return to pre-dam fish population levels has proven to be a challenging goal, and one that, according to the 1999 Draft EIS, is not necessarily achievable with the dams in place even with a run-of-the-river flow regime. Following the expiration of the ten years of guaranteed appropriations, Congress reauthorized the 1984 Act in 1996 for three additional years (P.L.104-143). The Task Force was also expanded to 19 members to include additional stakeholders. Additional language mandated that restoration objectives were

> "to be measured not only by returning adult anadromous fish spawners, but by the ability of dependent tribal, commercial, and sport fisheries to participate fully through enhanced in-river and ocean harvest opportunities, in the benefits of restoration".

**Scientific Influence on Policy Increases**

By 1990, it became clear that ten years of increased flows had not yielded the increase in fish population as expected. Several drought years had resulted in even less tributary accretion flow, and the Hoopa Valley Tribe filed an administrative appeal for additional water for the Trinity. The Interior Department relied on the latest scientific findings from the USF&WS that indicated that the flows during dry and critically dry water years were too low and that the 340,000 acre-feet schedule had a 56% relative habitat value for chinook, not a 100% value, as had been reported in the 1980 EIS. As a stop-gap measure, Interior published an Environmental Assessment to modify the 1981 flow schedule. Based on these findings, Secretary Manuel Lujan mandated in 1991 that the 340,000 acre-feet schedule was to be used for all water year types through the 1996 water year. This new flow schedule had been previously recommended unanimously by the Task Force.

Over the next few years, evidence began to build that not only the Trinity River Division, but other facilities of the Central Valley Project were responsible for the decline of fish and wildlife resources and water quality in California, especially in the San Francisco Bay/Delta. Most anadromous fish runs on the Sacramento River, as well as the Delta smelt were either listed or were candidates for listing under the Endangered Species Act (ESA). In 1992 Congress passed the Central Valley Project Improvement Act (CVPIA) under the leadership of Bay-area Congressman George Miller and New Jersey Senator Bill Bradley. Though the primary thrust of this legislation was to reallocate water to the Bay-Delta, one provision, known as "(b)(23)" addressed the impacts of the CVP on the Trinity River:

> "…in order to meet Federal trust responsibilities to protect the fishery resources of the Hoopa Valley Tribe, and to meet the fishery restoration goals of the Act of October 24, 1984. Public Law 98-541"

Through this legislation the Interior Secretary was directed to complete the ongoing Trinity River Flow Evaluation Study (TRFES) after consulting with the Hoopa Valley Tribe and to forward the TRFES recommendations to Congress by December 31, 1996. These recommendations were to be based on the best available scientific data and were to be used to promulgate permanent instream fishery flow requirements for the Trinity River Division of the CVP, following the concurrence with the recommendations by the Hoopa Valley Tribe.

Between 1991 and 1993 a series of restoration projects were implemented on the mainstem Trinity River. According to the best available science, the lack of rearing habitat for the fry life-stage of anadromous salmonids was the primary limiting factor in anadromous populations on the Trinity River. This slow water habitat had been reduced primarily by riparian vegetation that had encroached on gravel bars where it had trapped sediment and formed berms that prevented high water from spreading out on to gravel bars. If the riparian vegetation could be removed, and the accumulated fine sediment removed, and gravel bars reshaped to mimic a more natural geometry, then the river would then be reconnected with its floodplain, with additional slow-water habitat. Higher peak flows, would of course be needed to maintain these vegetation-free gravel bars over the long term. Fortunately, there were several above normal water years in the first six years following the completion of these "Feather Edge" sites. The scouring power of the higher peak flows, including the unusual 1997 "New Year's day flood" has served to maintain much, but not all, of this restored habitat. Higher scheduled spring releases, timed to coincide with the natural snowmelt cycle, are needed to maintain a healthy, functioning river.

**Focus on Harvest and Tribal Trust**

Harvest regulation came into focus following the passage of the Magnuson Act in 1976 (P.L. 94-265), designed to regulate commercial ocean harvest. The Pacific Fisheries Management Council was created in partial fulfillment of this Act and continues to regulate harvest, not only commercial, but also sport and tribal. Beginning in the 1970s, the issue of tribal harvest in the Klamath and Trinity basins was the subject of many legal battles and administrative documents. The 1981 Secretarial Issue Document contained language outlining the federal government's obligation to provide an adequate supply of fish for the Hoopa Valley and Yurok tribes. The 1984 Act reiterated this obligation. A 1987 EIS proposed conditions under which a tribal commercial fishery could be instituted in the Klamath basin. The 1992 CVPIA contained a restatement of trust obligations in the Trinity and an increased decision-making role in Trinity fisheries management for the Hoopa Valley Tribe. Finally, in 1993, the Interior Solicitor wrote an opinion that stated that the Hoopa Valley and Yurok Tribes jointly had the right to 50% of the harvestable surplus of fish in the Klamath and Trinity Rivers. This decision was challenged in court, and was ultimately upheld in *Parravano v. Babbitt* (837 F.Supp. 1034 (N.D. Calif. 1993)).

**Completion of the Flow Study and 1999 Draft EIS**

In 1999 the 12-year the Trinity River Flow Evaluation Study (TRFES) was completed, published jointly by the U.S. Fish & Wildlife Service and the Hoopa Valley Tribe. To determine optimal instream fisheries flows, it used not only the traditional habitat-based Instream Flow Incremental Methodology (IFIM), but relied heavily on the principles of fluvial geomorphology to determine the optimal stream channel morphology and sediment regime necessary for a healthy, functioning river. This "healthy river" concept was pioneered by the Arcata-based consulting firm of McBain & Trush and identified a variety of flows, along with a magnitude and duration for each, necessary to accomplish specific ecological objectives necessary to maintain a healthy river with a restored anadromous fish population. Important findings of the flow study were:

1. The lack of rearing habitat for the fry life-stage of anadromous salmonids was a primary limiting factor in anadromous populations.
2. Lower stream temperature, especially during the critical spring outmigration period, and summer low flows, are needed. The dam has altered flow regimes and caused deep pools to be filled with sediment so that cold water refugia no longer exist in the summer..
3. Higher spring peak flows were needed to scour willow seedlings from gravel bars to prevent encroachment and to convey sediment through the mainstem Trinity River to prevent aggradation and sedimentation of spawning habitat.
4. The existing static annual Trinity flow regime of 340,000 acre-feet was equal to the third-driest year in the 84-year historical record. This equated to a prolonged 35-year drought caused by the dams.
5. The flow levels mandated by the 1981 & 1991 Secretarial Decisions were inadequate for restoring the Trinity anadromous fishery.
6. Natural variability of streamflow is needed for a healthy river both within and between years. The existing flow regime did not contain enough variability.

The authors of the TRFES recognized that flow modification alone could not accomplish the goals of fishery restoration. It recommended several other restoration components. First was a continuation, at a larger number of sites, of the mechanical restoration of gravel bars, similar to those constructed during 1992 and 1993. Second was supplementation of spawning gravel in the first few miles below Lewiston dam to mitigate for the gravel trapped by the Trinity and Lewiston dams. Third was a watershed restoration program designed to reduce the input of fine sediment from tributary watersheds. And finally, because scientific knowledge and restoration practices are dynamic, and nature is unpredictable, an adaptive management program was recommended to respond to changing environmental situations.

As the TRFES was nearing completion, the U.S. Dept. of the Interior began to address its statutory obligations from the CVPIA and 1955 Authorizing legislation to restore the Trinity River fishery. The first step was to undertake an EIS. Impassioned public input from a wide variety of stakeholder groups at scoping meetings proved that the Trinity River and its resources are vitally important to many people. Six proposed action alternatives, including "No Action" were finally analyzed, from the "Maximum Flow" alternative, a run-of-the-river flow regime advocated by several environmental groups, to the "State Permit" alternative, which would reduce instream flows to those levels identified in the 1955 authorizing legislation.

The environmental analysis proved to be complex. For years, the Trinity River, largest tributary to the Klamath River, California's second largest, had been contributing water to California's largest river, the Sacramento, via a water diversion that required three tunnels and three reservoirs. And because of the Trinity River Division's connection the Central Valley Project, a scheduled change in Trinity flows would also affect water resources in the San Francisco Bay/Delta and even the San Joaquin Valley. The resulting EIS thus ended up having an analysis that was perhaps an order of magnitude more complex than it would have been, but for the inter-basin water diversions.

Of the six alternatives analyzed, only two were expected to achieve the fishery restoration goals and federal tribal trust protection mandated by the 1984 Act and the 1992 CVPIA. Those two were the Maximum Flow and Flow Evaluation alternatives. The latter was based on the TRFES and became the "Preferred Alternative." This Preferred Alternative prescribed, on average, an instream flow release of 595,000 acre-feet per year, an increase of 75% from the existing instream flow release, but still allowed an export of 52% of the Trinity's annual flow into the reservoir to be exported to the Central Valley.

Public interest in the Trinity River proved to be strong throughout California as evidenced by the more than 6,000 comment letters received in the two and a half months following the release of the Draft EIS in October, 1999.

Compliance with the ESA proved to be challenging because ESA-listed species in both the Trinity and Sacramento Rivers compete, in both a political and ecological sense, for the same water. Sacramento winter-run chinook, Central Valley spring-run chinook, Central Valley steelhead trout, the Sacramento splittail, and Delta smelt, are all ESA-listed species whose dire straits have been partially ameliorated by the diversion of Trinity water for 38 years. Now in an attempt to help the Trinity coho salmon, listed as threatened in 1997, and other tribal trust species, both the National Marine Fisheries Service (NMFS) and the USF&WS were faced with the task of trading off one ESA-listed species against another. In the Biological Opinions issued on the Trinity Draft EIS a gray area has emerged concerning the resolution for simultaneously satisfying the demands of competing ESA-listed species. The NMFS BO for the Trinity coho, and Sacramento/Central Valley species resulted in a no-jeopardy decision, yet indicated jeopardy would likely be forthcoming if the Preferred Alternative is not implemented in its entirety. At the same time, though, the USF&WS BO indicated that the entire CVP must be reoperated in the event the preferred Alternative is deemed responsible for moving the salinity barrier (known as "X2") in the San Francisco Bay/ Delta that defines habitat for Bay/Delta ESA-listed species. Is there a potential conflict here? No official direction exists in the ESA or within federal administrative agencies about how to best achieve a balancing act.

Earlier this spring, a similar exercise was carried out on the Klamath River, where two ESA-listed, tribal trust species in upper Klamath Lake competed with one ESA-listed, tribal trust species (and additional non-listed trust species) in the lower Klamath River for the same water. The problem was exacerbated in the Klamath River because the livelihood of several thousand family farmers, and two National Wildlife Refuges containing millions of migrating waterfowl and the ESA-listed bald eagle, also compete for the same water. The allocation for 2001 in the Klamath was decided primarily by determining a scientifically based compromise among fisheries biologists where neither group of fish received a fully ideal allocation of water.

This issue of simultaneously satisfying demands of competing ESA-listed species is likely to receive more attention from policy makers in the Klamath and other basins as the demand by a growing population for fixed water resources increases.

**2000 Flow Decision**

On December 19, 2000, Interior Secretary Bruce Babbitt signed a Record of Decision (ROD) mandating the implementation of the Preferred Alternative. The components of the selected alternative were precisely those recommended by the TRFES:

1. An increase of flows from 340,000 acre-feet regardless of water year, to flows that vary by five water year types, but average 595,000 acre-feet. This represents an increase, on average, of 75% for instream flows in the Trinity River. On average, more than half, or 52% of the Trinity's flows would still be diverted to the Central Valley. The annual flow schedule, along with peak releases, by water year type, are

| WY Type | Annual Flow (acre-feet) | Peak Flow cubic feet / sec |
|---|---|---|
| Critically Dry | 369,000 | 1,500 |
| Dry | 453,000 | 4,500 |
| Normal | 647,000 | 6,000 |
| Wet | 701,000 | 8,500 |
| Extremely Wet | 815,000 | 11,000 |

2. A gravel supplementation program to mitigate for gravel flow blocked by the dam.
3. 47 mechanical restoration projects. 44 will be similar to the Feather Edge projects and 3 will be side channel projects.
4. Fine sediment management of the tributary basins.
5. An Adaptive Management organization to respond to changing needs, subject to the constraints defined elsewhere in this document. Management of this new organization would be directed by the eight-member Trinity Management Council and would be advised by an Executive Director, a scientific advisory board, and by a stakeholder group which would take the place of the Task Force, whose charter has expired.

This plan represents the third, and most comprehensive flow decision by a third Interior Secretary, and is backed by thirty years of the best available science and three EISs and several Environmental Assessments. Of the three plans, this appears to have the best chance of success, if implemented.

The week before the Record of Decision was signed, however, the Westlands Water District in the San Joaquin Valley filed for a temporary restraining order to prevent Secretary Babbitt from signing the decision. Though that attempt failed, Westlands, joined by the Sacramento Municipal Utilities District and the Northern California Power Agency, have since obtained a preliminary injunction against instream flow levels above those specified for critically dry water years. Because 2001 is a critically dry year, no water scheduled for Trinity fish has been lost yet. Though backed by thirty years of science, and backed repeatedly by the administrative and legislative branches of the federal government, the ongoing goal of Trinity River fisheries restoration may ultimately be decided by the courts.

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## KLAMATH/TRINITY RIVER BASIN CO-MANAGEMENT

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The Hoopa Valley Tribe (HVT) has been a responsible resource manager since time immemorial. Historically, the HVT has managed its resources to reflect a balance with nature. For example, the HVT utilized traditional fish dams for selective harvest,- taking only what was necessary to meet its needs while allowing other fish to pass upstream. This practice allowed harvest by other users and more importantly, ensured that a sufficient number of spawners re-seeded successive generations. In contemporary times, the dam is not used to harvest fish, but the principle remains with management of the HVT fisheries.

The HVT and Yurok Tribes have a legal entitlement to “50 of the allowable surplus or a moderate standard of living which ever is less”. This is consistent with federal case law established United States v. Washington, 520 F.2d 676, 687 (9th Cir. 1975, “Boldt case”). The Boldt case established that the affected Tribes were to “co-manage” the fishery with state and federal managers. Within the state of California, the HVT has sought to increase its role as "co-manager" of Klamath/Trinity basin fish populations. This talk will focus on the HVT's role as "co-manager" of Klamath/Trinity Basin fish stocks.

## ADDRESSING IMPACTS TO FLOOD PLAIN PROPERTY FROM INCREASED TRINITY RIVER RELEASES

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The Record of Decision (ROD) signed by the Secretary of the Interior on December 19, 2000 directs the implementation of a new regime of instream flows below Lewiston Dam on the Trinity River. The total volume of water released to the Trinity River will be increased from the past level of 340,000 acre-feet annually to a range of 369,000 acre-feet to 815,000 acre-feet annually, based on hydrology determined as of April 1 of each year. Peak instream flow releases under this new operational scenario will be up to 11,000 cubic feet second (cfs) as compared to a maximum of 6000cfs under previous operations.

The practice of limiting past controlled dam releases below 6000cfs largely was dictated by the desire of the dam operators (U.S. Bureau of Reclamation) to minimize damage to property improvements constructed within the 100 year flood plain of the Trinity River. Increasing dam releases to 11,000 cfs are expected to impact a small number of private dwellings and other existing structural improvements as well as four existing bridges. The ROD states that "since infrastructure modifications represent a high priority activity for initiating flow changes, Reclamation will take appropriate steps in a timely manner to ensure that affected bridges, houses, and out-buildings are structurally improved or relocated or otherwise addressed before implementing recommended peak releases...". Implementing these actions will involve legal and philosophical issues as well as technical studies and engineering.

## THE RECORD OF DECISION AND ITS LITIGATION STATUS

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The Trinity River Record of Decision (Trinity ROD) was signed by former Interior Secretary Bruce Babbitt on December 19, 2000, based on information contained in the "Mainstem Trinity River Fishery Restoration EIS/EIR" which was completed in October, 2000. On March 19, 2001, Eastern Federal District Court Judge Oliver Wanger issued a Preliminary Injunction on behalf of plaintiffs Westlands Water District, the Sacramento Municipal Utility District and the Northern California Power Agency by limiting the increase in instream flows to an additional 29,000 acre-feet (369,000 af total) and ordering a supplemental EIS to disclose impacts related to California's energy problems and the Biological Opinions issued by NMFS and USFWS However, he also let stand the majority of the ROD, including the Adaptive Management Program, watershed restoration, channel restoration projects and bridge reconstruction components. In my presentation, I will provide an analysis of the judge's decision and what steps need to be taken to satisfy his order. I will disclose what is being done to implement the ROD, including the status of certification of the EIR by Trinity County, as well as other ongoing environmental compliance and permitting actions to meet a schedule for construction activities.

## ROAD RELATED RESTORATION PROJECTS SOUTH FORK OF THE TRINITY RIVER (POSTER)

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The Trinity County Resource Conservation District (TCRCD) has been working on road-related restoration and maintenance projects within the South Fork of the Trinity River drainage, above Hyampom, since 1997. With the Yolla Bolly Wilderness as the South Fork headwaters, all of the projects lay within designated Tier 1 Key Watersheds, valued as habitat refugia for anadromous and resident salmonids.

Most of this work has been funded by the Trinity River Task Force, through the Bureau of Reclamation, though recently California Dept. of Fish and Game grants have contributed to this effort. Cooperation between the TCRCD, South Fork Coordinated Resource Management Planning group (SFCRMP), Hayfork Ranger District, Timber Products Co., Simpson Timber, and private citizens has lead to an "inventory to implementation" approach within the South Fork basin. From road inventories and the resulting stream crossing analysis, priority site treatments include upgrading existing culverts to accommodate higher flows, construction of critical dips to eliminate diversion potential at stream crossings and disconnecting inboard ditches entering stream crossing. The TCRCD also has decommissioned roads as a part of this cooperative project. This effort continues with future inventories and projects planned, the objective to reduce road related sediment from the South Fork of the Trinity River and to improve fisheries habitat.

This presentation will highlight various maintenance and road decommissioning projects accomplished to date within the South Fork of the Trinity River. In addition we'll have tips on logistics, appropriate spoil areas and addressing problems encountered during stream crossing excavations.

# PART 6: UPLAND INFLUENCES ON THE WATERSHED: FIRE AND FIRE MANANGEMENT

## ECOLOGICAL AND WATERSHED IMPLICATIONS OF THE MEGRAM FIRE

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### ABSTRACT

The Megram fire burned 125,000 acres in 1999 in the same area where a 1996 major wind event led to high fuel accumulation. The effects of the fire on slope percent, slope position (upper, mid and lower slopes), vegetation type, seral stage, blowdown fuels and fuel treatments were analyzed and will be presented. Differences in fire severity based on these factors will be discussed along with the need for future treatments to reduce potential additional impacts to the watersheds. A comparison of burn severity will be made to other fires in the Siskiyou and Klamath Mountains to reflect differences in fire and suppression history.

Significant differences were determined within the Megram fire in burn severity by slope percent class, slope position, vegetation type, seral stage, and by fuel treatment. Of particular interest were the effects of logging and fuel treatment on fire behavior and burn severity. After the wind event and prior to the fire, some areas were salvage logged to remove large fuels. When the fire burned, these areas had been planned for or had undergone, follow-up treatments to reduce remaining fuels. These treatments ranged from no further treatment to almost complete removal of small diameter and fine fuels through under burning. The complete treatment resulted in significant reductions in high severity fire effects.

These results provide evidence that the practice of stand management in high fuel hazard areas, with specific fuel reduction goals, may prove to be valuable in reducing fire severity in forested environments. These results are particularly applicable to land managers in the Pacific Northwest where maintenance of late-seral and riparian habitat is a concern.

### INTRODUCTION

This paper is an abbreviated version of one submitted earlier for publication in the proceedings of the “Fire Conference 2000: The First Congress on Fire Ecology, Prevention and Management”.

During the latter half of the 1990’s, two major disturbance events took place within the Megram area. In the winter of 1995-1996, high intensity windstorms swept the northeastern, higher elevation portion of the Six Rivers National Forest, shearing the tops and breaking the boles of numerous trees across approximately 12,000 hectares (30,000 acres). This occurred both within and outside the Trinity Alps Wilderness. The stands most affected by the windstorm were early and mid-mature white fir (*Abies concolor*) ranging in age from 80-130 years. These stands originated following catastrophic fires from around the middle of the 19$^{th}$ and turn of the 20$^{th}$ century. Old-growth stands or individual large remnant trees were not significantly affected by these wind events. Pockets of mature trees within old-growth stands were damaged. The result was a large increase in fuel loading estimated to be as much as 360 metric tons/acre. Following these events, fuel treatment projects were initiated at strategic locations, specifically along roads and ridges. The intent was to provide anchor points and safer areas for fire suppression activities should a fire occur.

The second major disturbance event occurred in August 1999. Lightning storms ignited the Megram and Fawn Fires, a part of the Big Bar Complex, in the Trinity Alps Wilderness on the Shasta-Trinity National Forest. These two fires burned together in September and crossed the boundary of the Six Rivers National Forest. During the first month of the fires, they consumed mostly ground fuels with occasional crown fires making runs in steep terrain and heavier fuels. Fire behavior was weather, fuel and topography dependent. Stable air masses produced inversions and reduced crowning, creating conditions conducive to surface and ground fires. On September 27th, and again on October 16th, low-pressure weather systems produced high northeast winds and pushed the fire west, further into the Six Rivers National Forest. The fire made major crown fire runs within the Horse Linto Creek, Tish Tang Creek and Mill Creek drainages. These wind-driven runs contributed the highest frequency of stand-replacing fire and passed through the areas treated in the blowdown fuel reduction projects. When controlled in November, the Fire had burned a total of 50,587 hectares on both National Forests (125,000 acres) (USDA 2000).

Historically, the high elevation area involved in these two events was subjected to the highest frequency of lightning on the Forest. Fire suppression during the last century successfully reduced the extent of both small and large fires (USDA 2000) and probably contributed to significant increases in biomass (Talbert 1996).

**STUDY AREA**

The Megram area is located in the Klamath Mountains of northwest California, on the Six Rivers National Forest, in Humboldt County. It includes 26,530 hectares (65,550 acres) in three watersheds, Horse Linto Creek, Mill Creek and Tish Tang Creek. Elevation ranges from 366 to 1920 meters (1200-6300 feet). Vegetation types include conifer and mixed conifer/hardwood forests with interspersed alder stringers and mountain meadows. The white fir and tanoak (*Lithocarpus densiflorus*) series were the dominant vegetation types covering 41% and 39% of the area respectively. White fir and red fir (*Abies magnifica var. shastensis*) dominated on upper elevation sites. The mid and lower slope positions throughout the area were dominated by Douglas-fir (*Pseudotsuga menziesii*) and tanoak.

The study area contained the full array of forest seral stages, including shrub/forb, pole, early-mature, mid-mature, late-mature, and old-growth (Jimerson et al. 1996, USDA 1999). It had the highest amount of late-mature, 17 percent, and old-growth, 29 percent, in the central portion of the forest. Together these two seral stages account for 46 percent late successional forest vegetation and were mainly found in the white fir and tanoak series. Early-mature and mid-mature stands made up 19 percent and 20 percent of the study area respectively and were also found primarily in the white fir and tanoak series. Early seral vegetation was included in the shrub/forb and pole seral stages. They accounted for 9 and 5 percent of the vegetation in the analysis area (USDA 2000).

The study area is made up of the following land allocations: late successional reserve (LSR) (78%), wilderness (21%) and general forest (1%) (USDA and USDI 1994). Each allocation has its own set of management direction, with wilderness being the most restrictive. Late successional reserves cover the largest extent of the study area and allow limited vegetation treatments. All treatments described in this paper occurred within LSR.

## METHODS

High concentrations of blowdown related fuels were mapped in 1996 on the Six Rivers National Forest outside of the Trinity Alps Wilderness. Mapping of the blowdown consisted of walking the area and recording high concentrations of blowdown related fuels as polygons on aerial photos and project maps. These polygons were digitized on digital ortho-quads in ARC/INFO (ESRI 1991).

Following the wind events, areas outside of wilderness and identified roadless, with large amounts of blowdown on upper one-third slope and ridge top positions, were identified for fuel reduction projects. Treatment prescriptions were developed based on land allocation (Late Successional Reserve), and guidance found within the Six Rivers National Forest Land and Resource Management Plan, which incorporates the Record of Decision for the Northwest Forest Plan, Standards and Guidelines (USDA and USDI 1994). The prescriptions called for removal of blown down trees (tipped over) and snap top (broken topped) trees that had less than 20% live crown ratio remaining. Most trees in these stands had some portion of their tops broken off. Canopy closure was to be maintained above 60%, if present. Residual stand densities varied, depending on severity of wind damage, but stands generally maintained full stocking in terms of basal area and canopy closure. Canopy closure greater than 60% was desired based on requirements for northern spotted owl nesting and roosting habitat.

Fuel reduction treatments were planned for over 800 hectares and had been initiated on 641 hectares (1,583 acres). The treatments were designed to remove a significant portion of the large fuel component through salvage harvest and much of the smaller fuel through follow-up piling and burning. The post harvest follow-up treatments were in various stages of implementation when the fire occurred. These included:

1. no additional fuels treatment
2. slash was piled
3. slash was piled and burned
4. slash was piled, burned and the unit was understory burned.

Following the Megram Fire in 1999, burn severity was mapped in the same manner as the blowdown. The mapping was ground checked and updated in the summer of 2000. Burn severity was mapped in four categories: no burn (0% tree mortality), low burn (scattered individual dead trees, < 25% mortality), moderate burn (scattered or small groups of dead trees, 26%-70% mortality), and high burn (most trees killed, > 70% mortality).

## RESULTS

The moderate fire severity category was identified as the most extensive. It accounted for the highest frequency of burn (10,779 hectares, 54%). It was followed by the high severity category (6,116 hectares, 31%), low severity (2,435 hectares, 12%), and no burn category (675 hectares, 3%).

### Fire Severity by Slope Class

Fire severity was compared by 4 slope classes: < 20%, 20-34%, 35-65% and > 65%. No significant differences in fire severity were found between the 20-34% and 35-65% slope classes. These two classes were combined and fire severity was reanalyzed. Significant differences in fire severity were identified in the 3 remaining slope classes. The < 20% slope class had the highest frequency of no burn and low burn severity, 11% and 16% respectively. The combined 20-65% slope class had the highest frequency of high severity fire.

**Fire Severity by Slope Position**

Fire severity was examined on 3 slope positions; lower, middle, and upper 1/3 slopes. Significant differences were found in fire severity. For instance, lower 1/3 slope positions were characterized by moderate severity burn effects (63%) with a low frequency of high severity burn (20%). This is in contrast to the significantly higher frequency of high severity fire (40%) and significantly lower frequency of moderate severity burn (47%) in the upper 1/3 slope position. The middle 1/3 slope position showed the transition, in terms of burn severity, between upper and lower slope positions.

**Fire Severity by Vegetation Series**

The white fir series had the highest frequency of burned area (50 percent). It was followed by the tanoak series (24 percent), Douglas-fir series (9 percent), red fir series (9 percent) and a host of other vegetation types of lesser extent. These frequencies are somewhat reflective of the frequency of these series in the analysis area. When the series were analyzed independently, it is apparent that they differ significantly in frequency by fire severity category. For instance, the tanoak series had 66 percent of stands burned in the moderate severity burn category (26%-70% mortality), with only 16 percent in the high severity category (> 70 percent mortality). This contrasts with the white fir series, where 50 percent of stands burned in the moderate burn category and 36 percent in the high severity burn category. The red fir series shows even greater differences. It had 45 percent of stands burned in the moderate burn category and 44 percent in the high severity category. Red fir stands had significant infections of the parasite dwarf mistletoe (*Arceuthobium abietinum*) and cytospora canker (*Cytospora abietis*). This combination had caused both crown loss and high levels of mortality, which contributed to increased fuel loading.

**Fire Severity by Seral Stage**

Vegetation seral stages were differentially affected by fire. The highest frequency of affected hectares for all severities was in the old-growth seral stage (29 percent). In addition, 28 percent of the old-growth seral stage was affected by high severity fire. The high severity burn category normally had over 80 percent of the trees killed, which returned the seral stage to shrub/forb. This resulted in a significant loss of late seral habitat, one of the key features of the late successional reserve.

The highest frequency of high severity fire occurred in the early-mature seral stage. Here, due to the high degree of mortality, 39 percent of the early-mature seral stage was returned to the shrub/forb seral stage. The mid-mature and late-mature seral stages also suffered from high severity fire, with 30 percent and 26 percent of their extent being returned to the shrub/forb seral stage. These stands are very important, since they are the source of in-growth to the old-growth seral stage. In addition, the early seral stages, shrub/forb and pole showed high frequencies of stand replacing fire with 34% of their extent set back to time zero.

**Fire Severity by Blowdown Category**

In this analysis, the mapped blowdown polygons were compared to areas outside of the mapped blowdown polygons for differences in fire severity. High severity fire appeared to occur with significantly higher frequency in areas mapped with blowdown (46%) compared to areas without mapped blowdown (29%). In contrast, moderate severity fire appeared to occur with significantly higher frequency in areas without mapped blowdown (55% compared to 43%).

**Fire Severity by Fuel Treatment**

Outside of wilderness and roadless area, a variety of fuel reduction treatments were implemented following the 1995-96 windstorms. These treatments occurred in ridgetop and upper 1/3 slope positions within units identified as having high concentrations of blowdown-related fuels. Treatment units had the majority of blowdown generated large coarse woody debris removed through salvage harvest. In addition, most damaged trees with <20% live crown ratio were cut and removed. Background levels of snags and logs were maintained on all units. Removal of trees with <20% live crown ratio resulted in very small changes in overstory canopy closure because most of the wind damage resulted in sheared tops, rather than blown down trees. Stand treatments were designed to maintain at least 60% canopy closure where it existed after the blowdown event.

After harvesting, follow-up treatments to reduce fuels were at various stages of implementation prior to the fire. They included four treatments; no fuels treatment, slash was piled, slash was piled and burned, and slash was piled, burned and the unit was understory burned. Slash was defined as woody debris > 1 inch diameter and 3 feet long.

The analysis found significant differences in fire severity by treatment. The highest frequency of high severity fire occurred in stands with no follow up fuels treatment. Sixty-five percent of these stands suffered high severity fire. The background level for high severity fire in upper 1/3 slope positions was 39 percent. This indicates that large coarse woody debris removal without additional fuels treatment likely increases the risk of high severity fire.

Piling the slash resulted in a large reduction in high severity fire mortality (28%) compared to no treatment (65%). In comparison, burning the piled slash failed to significantly reduce high severity mortality (30%) when compared to piling without burning. When compared to the Fire in general, both treatments were below the overall frequency (39%) for high severity fire in upper 1/3 slope positions.

The most successful treatment in reducing high severity fire involved piling the slash, burning the piles, followed by understory burning. These treatments reduced high severity mortality to three percent of the area treated. An example comparison of this was two areas located immediately adjacent to one another on either side of a side-slope road. The stand below the road was untreated, including no large coarse woody debris removal. It was subjected to high severity mortality with over 90 percent of the trees killed. The treated stand above the road burned with low and moderate severity, where 10 to 25 percent mortality occurred.

## DISCUSSION

The primary disturbance agents in the study area watersheds were fire, logging, flood, wind, insects and disease, cattle grazing, and recreation. Historically, fire has by far had the greatest effect in shaping the vegetation seral stages of the area (USDA 1999).

**Fire Severity**

In Megram, in addition to blowdown related fuels, fire severity was related to slope class, slope position, vegetation type, and seral stage. Gentle slopes and lower 1/3 slope positions were characterized by the dominance of the tanoak series and old-growth seral stage. Low to moderate burn severity was prevalent, while steeper slopes and upper 1/3 slope positions were characterized by high severity fire. At higher elevations, the white fir and red fir series were subjected to high severity fire. Mature stands (early and mid) located on upper 1/3 and ridgetop positions were more susceptible to stand replacing fire due to structural homogeneity. They normally have a thick fine fuel layer and dead limbs forming a ladder into the canopy. The potential for high severity fire in these stands places adjacent old-growth stands at higher risk, as evidenced by the loss of old-growth in white fir and red fir. The younger seral stages, shrub/forb and pole, also showed high frequencies of stand replacing fire as a result of their homogeneous stand structure.

The addition of blowdown related fuels to areas that have had active/long-term fire suppression exacerbates the conditions described above. For example, unusually high concentrations of fuels in lower 1/3 slope positions may lead to greater incidence of stand-replacing fire.

**Fire Severity Comparison**

The Megram fire burned with higher severity when compared to the 1987 Silver and Longwood fires in southwest Oregon and the Thompson Ridge and Hayfork fires in northern California. For instance, the Silver fire showed 12% high severity fire and 33% moderate severity fire (Atzet et al. 1988), the Thompson Ridge fire showed similar effects, 14% high and 27% moderate severity fire (Taylor and Skinner 1998), and the Hayfork fire had approximately 7% high and 43% moderate severity fire (Weatherspoon and Skinner 1995). In comparison, Megram had 31% high and 54% moderate severity fire. Much of the Silver fire burned in wilderness where past fire suppression activities were limited. In addition, much of the area had burned previously in the 1930's (Atzet et al. 1988), which resulted in a more natural fuel profile. Thompson Ridge burned frequently between 1626 and 1992, which also contributed to a more natural fuel profile (Taylor and Skinner 1998). This contrasts with Megram, where aggressive fire suppression has taken place following World War II, resulting in stands that were denser and had a greater ladder fuel component (Talbert 1996). In fact, despite 284 recorded fires since 1911, the largest fire in the study area watersheds was only 185 hectares (460 acres) and only 7 fires were greater than 40 hectares (100 acres). Only 3 percent of the area has been affected by fire since 1911 (USDA 2000). In comparison, the Longwood fire had 27% high and 43% moderate severities. This area had a history of aggressive fire suppression similar to Megram, because of proximity to communities and private property. Neither the Silver, Thompson Ridge nor Longwood fires had recent major disturbance events that greatly increased fuel levels prior to the wildfires. The evidence suggests that the increased frequency of high severity fire in Megram is related to high surface winds during the fire, heavy fuel accumulations generated from the 1995-1996 wind event and aggressive fire suppression prior to the fire, resulting in increased biomass and ladder fuels. (USDA 2000).

**Fuel Treatment**

Both the treated and untreated areas were subjected to strong easterly winds. Since the wind pushed the fire through and beyond the treated stands, it appears that fire severity in these stands is directly related to the amount of fuel treatment. Sixty-five percent of untreated stands were subjected to stand replacing fire, while 3% of fully treated stands had stand replacing fire. Complete removal of surface fuels lead to low intensity surface fire, preventing crown fire or long duration ground fire from developing. Without full fuels treatment, surface fuels were still available to carry the fire, leading to a higher frequency of high severity fire. Approximately 30 percent of stands with partial treatments suffered stand-replacing fire.

**Post Fire Situation**

In much of the study area, the high severity fire resulted in crown fires, which killed most of the live trees without consuming the larger surface and blowdown created fuels. As the standing dead trees fall they will further contribute to higher fuel loads and, in combination with early seral vegetation, create a situation with high probability of stand-replacing fire in the future. Adjacent stands will also be put at higher risk due to this scenario. Evidence of this was gathered from the Hog and Yellow fires in the Salmon River drainage of the Klamath National Forest. The 1977 Hog fire burned under similar weather conditions and terrain as the Megram fire. The fire began under an inversion that led to a low intensity creeping fire. Once the inversion lifted high intensity fire became the norm, particularly in the upper 1/3 of the watershed. Post-fire efforts to reduce fire related fuels were carried out through salvage logging in parts of the area with the rest remaining untreated. In some areas concerns for decomposed granite (dg) soils lead the Forest Service to lop and scatter the standing dead material in an attempt to provide soil protection. In 1987 the Yellow fire burned in the same area as the Hog fire. In areas where the fuels were treated after 1977, the fire was of low-moderate intensity and controllable. In areas where the fuels were left behind curing for 10 years, in combination with invading brush, the fire burned out of control at high intensity. These high intensity burns resulted in much of the upper elevation slopes being left bare of vegetation cover. When the fall rains hit the area, it tended to mobilize the dg soils and move them down-slope in pulses, where they were eventually deposited in the anadromous fish baring streams at the base of the mountains.

## MANAGEMENT IMPLICATIONS

One objective of the Pacific Northwest Forest Plan and the Six Rivers National Forest Land and Resource Management Plan is to maintain or enhance late seral habitat. The results of this analysis indicate that well planned and completely executed fuel treatments can influence fire behavior and the fate of forest stands during a wildfire. These treatments may include salvage logging, fuel cleanup and use of prescribed fire.

The survival of the treated stands during the wind driven events of the Megram Fire also show that, even in the face of extreme fire behavior, treated stands may slow the spread of the fire. The analysis also shows that incomplete, or partial treatments are less effective or ineffective. Large fuel removal alone, without the follow-up treatment of smaller diameter fuels, may not provide adequate fuels reduction to prevent a fire from becoming stand-replacing.

The loss of early and mature seral stages has implications to the amount of late-successional habitat in the future. The current situation points to the need for aggressive fuel treatments in much of the area. This is due to the many thousands of hectares of standing dead trees, combined with remaining blowdown related fuels, creating a high fire hazard. Once this is combined with developing early seral vegetation, the threat to remaining stands increases. Treating high fuel hazard stands reduces the threat to existing late-successional habitat and maintains future ingrowth. These treatments may actually accelerate development of late seral characteristics in younger stands. This may allow us to maintain desirable levels of late-successional habitat in LSR's.

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# EFFECTS OF CLEARCUTS AND SITE PREPARATION ON FIRE SEVERITY, DILLON CREEK FIRE 1994

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## ABSTRACT

Fire severity was compared in clearcuts and uncut stands following the Dillon Creek Fire of 1994. The extent to which fire severity in clearcuts affected adjacent stands was also investigated. Factors that may have influenced fire severity such as fuel treatment, fuel type, aspect, slope, and elevation were evaluated in order to explain possible differences among these stands.

The Dillon Creek Fire occurred in Douglas-fir/hardwood forests located in the Klamath National Forest of northwestern California. A geographical information system (GIS) was used to compile information from LANDSAT imagery, post-fire aerial photography, and ground observations. Kruskal-Wallis analysis of variance, chi-squared tests of independence, and descriptive statistics were used to evaluate the data.

Clearcuts were more severely impacted by fire than uncut stands. However, clearcuts that were broadcast burned following harvest experienced less severe wildfire than clearcuts that were not broadcast burned. Additionally, areas adjacent to clearcuts had more severe fire than uncut stands farther away. The greater fire severity associated with clearcuts was due to the relatively higher proportion of flammable fuel types such as grass, shrub, and mixed hardwood. The grass fuel type had the greatest proportion of locations with high and moderate fire severity followed by shrub, mixed hardwood, and woodland fuel types. Higher elevations and gentler slopes had greater fire severity than lower elevations and steeper slopes. There were higher fire severity levels on east, southeast, south, and southwest facing slopes.

## INTRODUCTION

### The Dillon Creek Fire

During the summer of 1994, the Dillon Creek watershed in the Klamath National Forest, Siskiyou County, California, experienced a large fire. Numerous lightning strikes ignited small fires in the eastern portion of the watershed during the afternoons of July 20 and 21. Fed by heavy fuel loads and strong winds, the fires quickly grew. Fire intensity varied, depending upon weather conditions and available fuel. The inaccessibility of the terrain made suppression efforts difficult. Many of the fires grew together developing into a large fire complex which extended over 11,000 hectares and burned until early November (USDA 1995).

The majority of the vegetation within the burn (approximately 76%) experienced low levels of damage where less than 30 percent of the canopy was killed. Throughout these low damage areas, small pockets of trees suffered mortality and much of the ground fuel was consumed (USDA 1995). Eighteen percent of the burned area suffered moderate fire severity (30-69% canopy kill). The majority of the overstory was injured and about half was killed. On sites with high fuel concentrations, most of the understory and ground fuel was either killed or completely consumed by the fire (USDA 1995). The remaining portion of the burned area (5%) suffered a high degree of vegetative damage. Seventy to 100 percent of the canopy was killed and most of the understory and ground fuels were consumed. All that remained throughout many of these patches were blackened snags and charred ground (USDA 1995).

**Fire Ecology**

Fire is the primary agent of disturbance in the Klamath region (Atzet and Martin 1992, Skinner 1995, USDA 1995) and plays a major role in ecosystem development and maintenance. It aids in the creation of a more diverse landscape and affects late successional stand development (USDA 1995, Taylor and Skinner 1998). Historically, Native Americans recognized the benefits of light burning to suppress insect populations, clear the ground of shrubs and woody debris for easier travel, improve wildlife habitat, encourage desired plant populations, and to decrease the risk of large severe fires (Atzet and Martin 1992, Agee 1993, USDA 1995, Rogers 1996, Martin 1997). Tribes in the Klamath region used fire to promote the growth of acorns, berries, and plants, such as beargrass and hazel, that provide fiber used in traditional basket construction (USDA 1995, Taylor and Skinner 1998). Settlers and prospectors set fires to drive game, rid the forest of pests, and expose rock outcrops (Atzet and Martin 1992, Taylor and Skinner 1998).

Prior to the 1900's fires tended to be extensive and burn for many weeks (Agee 1993, USDA 1995, Taylor and Skinner 1998). This pattern helped maintain the open stand structure as described by historical visitors in diary and newspaper accounts of their travels (Volland and Dell 1981). More recent lightning caused fires in the Klamath area, such as the Siege of '87 Fires, Big Bar Complex, and the Dillon Creek Fire, have burned over large areas, suggesting that fires spread easily in these Douglas-fir (*Pseudotsuga menziezii*) dominated forests (Taylor and Skinner 1998).

Foresters and land mangers continue to use fire today as a way to reduce fuel accumulation. It is a principal tool in site preparation of clearcuts (Heinselman 1981, Smith et al. 1997). In the Dillon Creek watershed, harvested sites were either broadcast burned or excess slash from clearcutting was collected into burn piles. Broadcast burning not only eliminates potential fuel but can also provide a high-quality seedbed essential to successful seedling establishment.

Lightning is another important source of fire ignition in the Dillon drainage (USDA 1995). Dry lightning storms occur throughout the summer but are most frequent during the late summer months when drought in the region gives rise to highly flammable conditions during the hottest time of the year (Agee 1993, USDA 1995).

**Fire Regime**

The pre-European settlement fire regime of the Dillon Creek watershed was frequent fires of low to moderate severity with sporadic pockets experiencing stand replacement events. The mean fire return intervals for the drainage were between seven and 28 years at lower elevations and from 21 to 61 years in mixed conifer stands at higher elevations. In early years of suppression, fires like these, though common, were contained quickly; they seldom escaped initial attack by fire fighting personnel (USDA 1995).

Forest management practices in this past century, specifically the policy of total fire exclusion, have led to a change in the fire regime of the Dillon Creek watershed. Fire suppression has lengthened the time between fire events initiating a new regime of hot ground fires with larger stand replacement events (USDA 1995). The Dillon Creek Watershed Analysis (USDA 1995) indicates that longer fire return intervals correlate to trends in increased fire severity levels. Similarly, Atzet and Martin (1992) found in a natural disturbance study of the Klamath province that as the age of a forest increased (ie. longer fire return interval), so did fire severity. Both findings suggest that an essential environmental process may have been altered through fire suppression, leading to a shift in the natural disturbance system.

**Fire Suppression**

A major ecological consequence of fire suppression is not only increased fuel loads (Taylor and Skinner 1998), but also the development of more continuous and homogeneous fuels. Skinner (1995) found that forest openings have become smaller and more fragmented in a study of the spatial characteristics of three watersheds, including Dillon Creek watershed, in the Klamath Mountains. Dense stands of suppressed timber become widespread. Less fire resistant species have invaded the forest understory and moved into forest openings, reducing the number of natural structural breaks that can control fire spread (USDA 1995, Stuart 1998). The increased biomass may also result in more severe burning conditions (Martin 1997).

By the 1940's, the results of the fire exclusion policy were evident in the Dillon Creek watershed. Increased fuel loads, species composition changes, and stand structure shifts warned of a serious transformation in the ecology of the forest. Since 1910 there have been at least seven fires involving over 40 hectares within the Dillon Creek watershed (USDA. 1995).

In addition to fire exclusion, timber harvesting has lead to ecological changes in forest structure that have increased fire hazard. Current management practices, specifically clearcutting in the Douglas-fir/hardwood forests of northwestern California, produce early successional stands, dominated by sprouting hardwoods and shrubs. On drier sites, hardwoods may dominate the location for a substantial length of time. Clearcuts that undergo repeated intense fires may remain completely dominated by early seral, disturbance-adapted species if there are no close sources of Douglas-fir seed (Thornburgh 1982). The Dillon Creek Watershed Analysis (USDA 1995) suggests that the burning characteristics of brush species more than likely influenced the fire. On sites once occupied by Douglas-fir forests, grasses and shrubs may, in effect, inhibit succession back to the initial vegetation type (Mayer and Laudenslayer 1988). These failed plantations or man-made brush fields may perpetuate themselves because they burn more readily than the original timber stand.

**Study Objectives**

The relationship between natural fire behavior and silvicultural treatment has not been the subject of intense research (Weatherspoon and Skinner 1995). Managers do not fully understand the effect of silvicultural activities on fire severity. Some studies have shown that The purpose of this study was to examine the relationship between silviculture and fire effects following the Dillon Creek Fire and to investigate factors that may account for variations in fire severity. The study addressed these objectives with the following hypotheses: 1) clearcuts result in higher fire severity than uncut stands, 2) there are differences in fire severity in clearcuts based on site preparation, 3) fire severity differs among fuel types, 4) locations closer to clearcuts burn with higher fire severity, and 5) topography, specifically aspect, slope, and elevation, influences fire severity.

## STUDY AREA

The complex nature of the topographical features of the Klamath region and a historically frequent fire regime has resulted in a highly complex vegetative structure. Over 100 plant associations and at least 16 plant series have been identified (Atzet and Martin 1992). The vegetation of this region has also been altered by its long history of grazing, fire suppression, and logging such that the natural patterns of forest communities can often be difficult to distinguish (Sawyer et al. 1977). The zone includes forests with multiple aged cohorts and stands that commonly include all sizes of trees (Agee 1993).

Silvicultural activities in the watershed and surrounding landscape began in the 1950's (USDA 1995). Clearcutting first appeared on the southeastern and northeastern ridges of the watershed during the 1960's and continued until 1990. Sawtimber has been the most common product from these cuts (USDA 1995). Broadcast burning was a typical site preparation method, but about 25% of the clearcuts received no treatment at all. The harvesting activities occurred primarily in the Douglas-fir and Klamath mixed conifer vegetation types. Clearcuts were replanted primarily with Douglas-fir and ponderosa pine (*Pinus ponderosa*), but occasionally Port Orford-cedar (*Chamaecyparis lawsoniana*), incense-cedar (*Calocedrus decurrens*), and white fir (*Abies concolor*) were also included. Clearcuts generally contained smaller trees and a higher proportion of hardwoods, dense shrub, and dense grass habitat than did the study area outside the clearcuts.

## METHODS

### Sampling

Information gathered with Landsat satellite imagery, pre-and post-fire aerial photography, digital orthophoto quadrangles (DOQs), and ground observations was compiled using a geographical information system (GIS), ARC/INFO NT 7.2.1 (Environmental Systems Research Institute Inc. 1998). The Happy Camp and Ukonom Ranger Districts, Klamath National Forest and the Klamath Bioregional Assessment Study provided original data for the Dillon Creek watershed. Additional data was created from digital elevation models (DEM's). The compilation of data was reconfigured and amassed into a set of topographical and vegetative data significant to the analysis and study area and was statistically analyzed using NCSS 2000 (Hintze 1998).

The fire severity level was grouped into three categories based on the percentage of canopy kill: low (0-29%), moderate (30-69%), and high (70-100%). Klamath National Forest personnel distinguished the fire severity levels from aerial photography in early October 1994. In the case of trees, severity designations were made according to the percentage of upper and mid-story crown killed. For shrubs, the extent of kill in the canopy layer was measured and in grass habitat fire severity level was established based on the percentage of cover killed (USDA 1995).

Fuel models for the study area were derived from vegetation information provided by the Southern Oregon - Northern California (ORCA) Wildlife Habitat Map/Database Version 1.0a which is a modified version of the wildlife habitat relationship (WHR) classification system (Mayer and Laudenslayer 1988) based on computer classification of LANDSAT imagery (Fox et al. 1997). The five fuel models were based on physiognomic habitat type, WHR cover stage, and WHR size class. Fuel model descriptions (Table 1) loosely follow the standard 13 NFFL fuel model system developed by Rothermel (1983).

Table 1. Custom fuel model descriptions adapted from the NFFL fuel model system (Rothermel 1983).

| Fuel Model | Description |
|---|---|
| Grass | Includes all grass habitat types. Fire spread by fine fuels. |
| Woodland | All tree type habitat less than 39% crown closure and greater than 15 cm. DBH. Fire carried by understory shrubs and grasses. |
| Shrub | All shrub type habitat and tree habitat less than 15 cm. DBH. Presence of highly flammable species and personal accounts of high intensity fires throughout these areas (USDA 1995). Fires in this fuel type have a fast rate of spread. |
| Mixed Conifer | Greater than 15 cm. DBH mixed conifer, mixed conifer-hardwood, and mixed hardwood-conifer with canopy closure greater than 40%. Usually slow moving ground fires with occasional torching out of trees. |
| Mixed Hardwood | Greater than 15 cm. DBH mixed hardwood and mixed oak with canopy closure greater than 40%. Fires move faster than previous model and flare up when reach pockets of high fuel concentration. |

Clearcut polygons were digitized from the Bear Peak and Dillon Mountain USGS topographical quadrangles (7.5') with ARC/INFO. Fifty-one clearcut polygons were located within the Happy Camp and Ukonom Ranger Districts. Clearcuts ranged in size from 1 to 70 hectares with an average size of about 10 hectares. For purposes of this study, "clearcuts" included small patch clearcuts and some combined adjacent clearcuts, hence the extreme size variation. Adjacent clearcut stands were merged in the course of digitizing when the border between the stands was unclear. Merging only occurred when clearcuts were harvested within five years of each other, resulting in similar fuel types.

The distance between a sample point and its nearest clearcut was determined with the use of ARC/INFO. If a sample point was located inside a clearcut it was given a distance of zero. Albini (1979) stated that in large wildfires where there is sporadic torching of individual groups of trees, spotting distances might reach from two to three kilometers. It was assumed that beyond this distance, observations were most likely influenced by factors other than by fire in the nearest clearcut and so those located beyond 2500 meters (2.5 kilometers) were thrown out.

Thematic maps (or coverages) generated in the GIS showed fire severity level and forest stand activity (clearcut polygons). Site preparation method (broadcast burn or no treatment) was added as an attribute to the clearcut polygons. Stand activity information was obtained from the Region 5 Stand Record System (SRS) database provided by the Happy Camp and Ukonom Ranger Districts (USDA 1998). A digital elevational model (DEM) was used to generate aspect, slope, and elevation maps. The ORCAWildlife Habitat Map, which was displayed in a raster grid cell format (Fox et al. 1997), was converted into a polygon coverage and aggregated into five fuel model regions based on habitat characteristics presented in Table 1. Finally, over 20,000 random point coordinates were placed throughout the burn area to generate a point coverage map. These thematic maps were overlaid with the random point coverage to create a database where each point represented a single observation with attributes acquired from the thematic maps. Additionally, the distance in meters from each sample point to the nearest clearcut was added as an attribute. This database was imported into NCSS 2000 (Hintze 1998) for statistical analysis. The alpha level was 0.05 for all data analyses.

**Data Analysis**

To test the hypothesis that clearcuts resulted in higher fire severity than uncut stands, a two-way chi-squared test of independence was performed to discover if an association existed between fire severity and forest stand activity. The nature of the relationship between fire severity and stand activity was explained with the use of descriptive statistics.

Observations that occurred within clearcuts were further divided into two populations based on site preparation (broadcast burned and untreated) to test the hypothesis that there was an association between fire severity and site preparation. Again, a two-way chi-squared test of independence was used for the analysis.

The next analysis tested the hypothesis that fire severity was associated with fuel type. A two-way chi-squared test of independence was used in this instance. However, the fuel type variable had five classes, which made it difficult to explain the differences among fuel type classes based on inspection of descriptive statistics alone. Therefore, the data was subjected to unplanned tests of heterogeneity where the independence of selected subsets of data was evaluated. This process allowed us to see where significant differences in fuel type classes or groups of classes occurred. A simultaneous test procedure was used to test all possible subsets of data (Sokal and Rohlf 1981).

The subsequent analysis tested the hypothesis that locations closer to clearcuts burn with higher fire severity than do observations located farther away. Observations were grouped into three sample populations based on fire severity level. The dataset did not meet the assumptions of homoscedasticity (equal variances) and normality so a non-parametric Kruskal-Wallis analysis of variance on ranks (Kruskal-Wallis test) was used to compare the populations. NCSS 2000 has a pre-set limit to the total number of observations that can be used in a Kruskal-Wallis test (Hintze

1998) and so the total sample size including both populations was constrained to 1503 observations.

The Kruskal-Wallis test was also used to test the hypothesis that topography, specifically, aspect, slope, and elevation, influences fire severity. Observations were divided into three populations based on fire severity level. The variables measured were aspect, slope, and elevation. Three separate Kruskal-Wallis tests were performed using each topographic variable. Total sample size was 3801 observations for each analysis.

## RESULTS

A significant association was found between fire severity and stand activity (clearcut vs. uncut) ($P< 0.001$). Fire severity level was higher in clearcuts than in uncut stands. Almost half (49%) of the locations inside clearcuts were of high and moderate fire severity while less than a quarter (22.9%) of the locations outside clearcuts were of high and moderate severity (Figure 1). Furthermore, an association was found between fire severity and site preparation method ($P< 0.001$). Fire severity level was lower in clearcut stands that were treated (broadcast burned) than in clearcut stands that had not been treated. In treated clearcut stands, over half of the observations (52%) were low severity. However, in the untreated clearcuts fire severity was low for about 40% of the observations, suggesting that broadcast burning reduced overall fire severity (Figure 2).

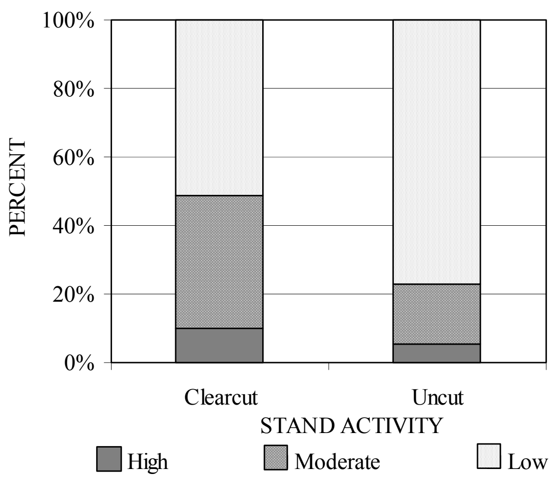



Figure 1. Distribution of fire severity levels in clearcut and uncut stands.

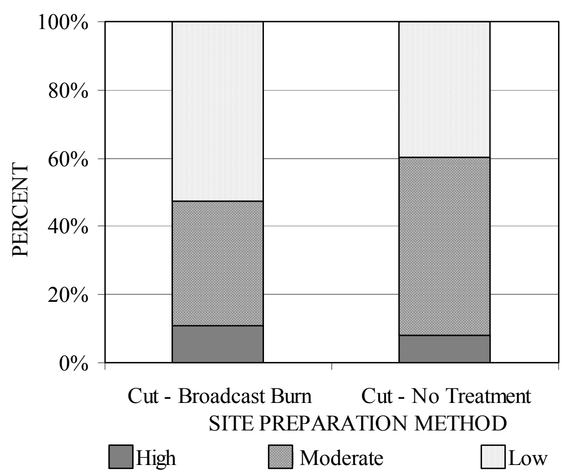



Figure 2. Distribution of fire severity levels in broadcast burned and untreated clearcuts.

Fire severity levels were also associated with fuel type ($P<0.001$). Three significantly different fuel type subsets were identified for the five different fuel types: grass, shrub-mixed hardwood-woodland, and mixed conifer. Figure 3 illustrates that grass had the highest percentage of high fire severity (25%), while mixed conifer had the least amount of high fire severity (6.1%). Shrub had the greatest amount of moderate fire severity (40.4%) and mixed conifer had the smallest amount (23.1%). Grass also had the highest level of high and moderate fire severity combined (57.5%). Shrub ranked second overall in percentage of high and moderate fire severity (49.2%) followed closely by mixed hardwood (47.3%) and then woodland (41.3%). Mixed conifer had the most low fire severity (70.8%)

Statistically significant differences (P< 0.002) among fire severity levels were found when the distances of sample points to their nearest clearcut were compared. The mean distance of locations with high fire severity level to the nearest clearcut was significantly less than the mean distance of locations with low fire severity level to the nearest clearcut. Locations closer to clearcuts showed higher fire severity levels than locations farther away (Figure 4).

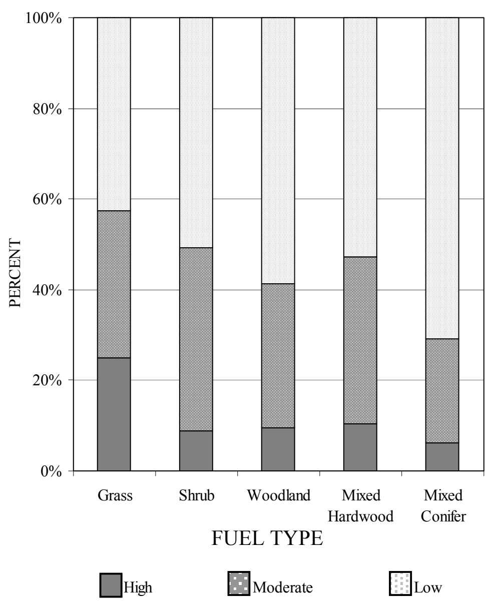



Figure 3. Distribution of fire severity levels among different fuel types.

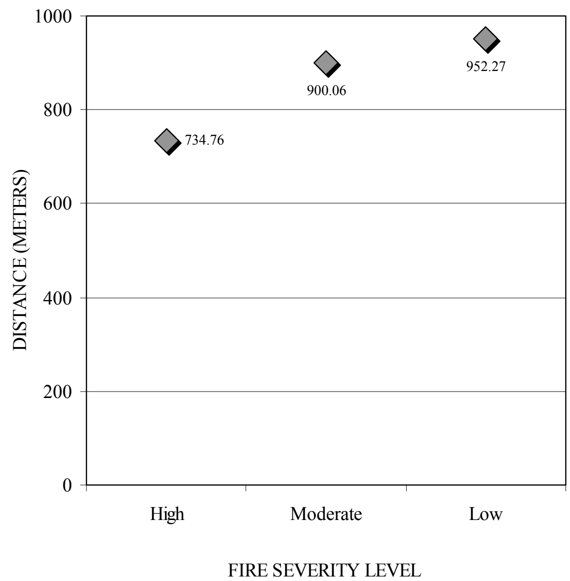
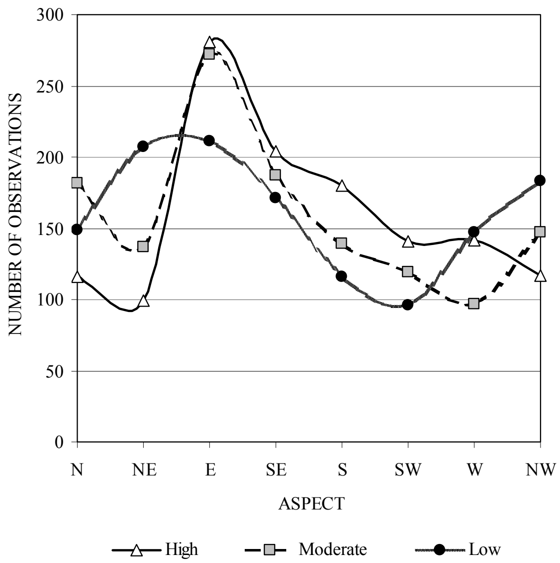



Figure 4. Average distance to nearest clearcut for different fire severity levels.

Results indicate that topography significantly affected fire severity level, but not always in the ways that were anticipated. Aspect differed significantly between fire severity levels (P<0.04). As expected, descriptive statistics showed that there were more observations of high and moderate severity than low severity on east, southeast, south, and southwest facing slopes. Alternatively, west, northwest, and northeast facing slopes had more observations of low fire severity, and north facing slopes had more observations of moderate and low fire severity (Figure 5). These results seem reasonable based on commonly recognized fire behavior principles and the findings of similar studies (Taylor and Skinner 1998).

The slope was statistically different among fire severity levels (P<0.001). However, contrary to what was expected, high fire severity was found on the least steep slopes, followed by moderate and low fire severity as slope increased (Figure 6). In contrast, we had reasoned that as slope increased, fire severity would also increase. One explanation for the disparity could be that clearcuts were located on less steep slopes, but were found in the first analysis to burn at high and moderate fire severity levels. The average slope of clearcuts was about 46 percent, which was the same as the average slope for high severity observation, also roughly 46 percent. This finding suggests that the fire severity on less steep slopes may have been tending towards high and moderate severity levels due to the presence of clearcuts.



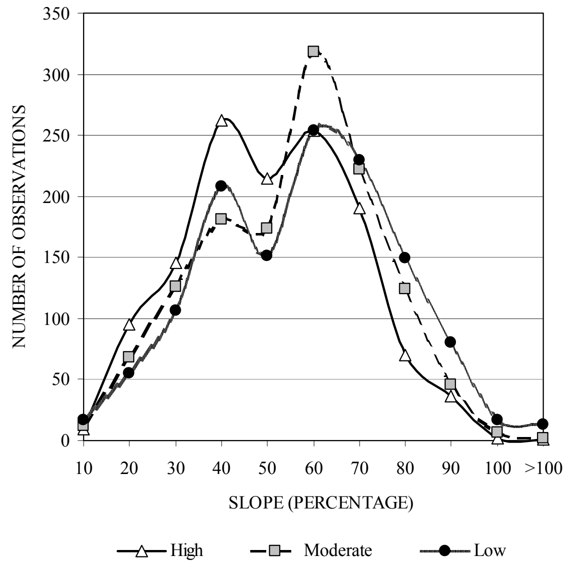




Figure 5. Number of observations for aspect by fire severity level.

Figure 6. Number of observations for slope by fire severity level.

Results for elevation were also different from what was expected. While the elevation differed depending upon fire severity level ($P<0.001$), high fire severity had the highest mean elevation, moderate fire severity had an intermediate mean elevation, and low fire severity had the lowest mean elevation. Average elevation of clearcuts (1072 meters) however, was higher than the average elevations of moderate (1048 meters) and low (1022 meters) fire severity levels, indicating that the presence of clearcuts again may have influenced the outcome (Figure 7).

## DISCUSSION

Results of this study indicate that fire severity levels are higher in clearcuts than uncut stands and that fire severity is inversely related to distance from a clearcut. Additionally, fuel types commonly found in clearcuts generated greater fire severity. The greater fire severity associated with clearcuts was due to the relatively higher proportion of flammable fuel types such as grass, shrub and hardwoods. This, in turn, may have influenced fire severity in neighboring stands. Thus, fuel characteristics have an impact on fire severity. Furthermore, the results suggest that the reduction of fuel loads through broadcast burning can mitigate severe fire damage.

Weatherspoon and Skinner (1995) described the relationship between the degree of damage in plantations and prior management activities in a study of the 1987 fires in the Hayfork Ranger District, Shasta Trinity National Forest. They found that fire damage to plantations was associated with the degree of fire damage in adjacent stands, grass and forb cover, elevation, and silvicultural activities, specifically site preparation methods. Similar to the results of this study, the degree of fire severity in plantations was found to be related to prior site treatment. Stands that were broadcast burned or machine piled suffered far less damage than units that were not treated (Weatherspoon and Skinner 1995).

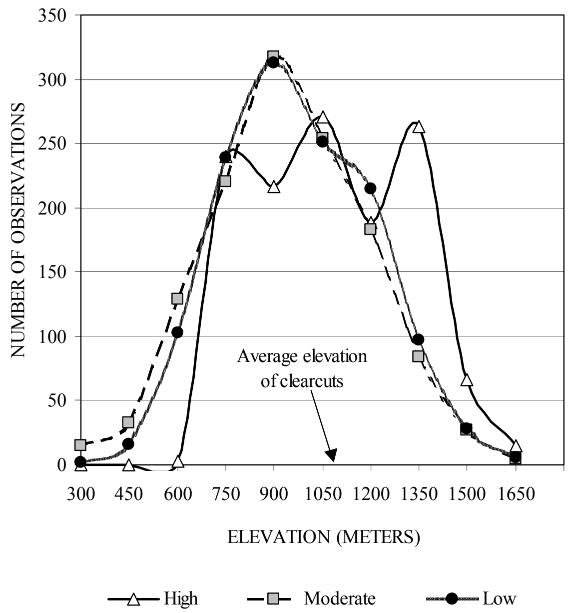



**Figure** 7. Number of observations for elevation by fire severity level.

Omi and Kalabokidis (1991) also realized the significance of fuel loading in a study of the North Fork Fire, one of the greater Yellowstone fires of 1988. They saw lower flammability in intensively managed areas than in adjacent fire suppressed mature stands. This phenomenon was attributed to the reduction of fuel on the managed units (Omi and Kalabokidis 1991).

Stand level climatic forces may also explain the increased fire severity found in clearcuts and adjacent stands. Countryman (1956) stated that many foresters have observed a difference in fire behavior between slash and uncut areas that may be due to climatic forces. Conversion of forests from closed mature stands to clearcuts causes changes in surface weather conditions resulting in a more dangerous fire climate with higher temperatures, lower humidity, and lower fuel moisture. He believed that this climatic shift was more important to understanding the effects that harvest activities have on fire intensities than simply the effects of increased slash fuel (Countryman 1956).

Another of Countryman's (1956) results may explain the tendency for increased fire severity levels in stands near clearcuts as was suggested by this research. He found fires in the open burn with greater energy and create strong convection columns, which loft burning embers into the neighboring forest (Countryman 1956). De Ronde et al. (1990) found that the edge of a plantation often experiences higher burn intensities than the interior because of the interactions of fuel type, fuel moisture, and wind. Fires create their own microclimate, which effectively spreads fire into surrounding forest.

## CONCLUSION

In recent years, the ecosystem approach to forest management has become more prevalent and management guidelines have attempted to be more accommodating to natural patterns and processes. In order to create a more ecologically friendly clearcut, managers have designed harvesting practices to mimic natural disturbance patterns across a landscape with smaller, patchy clearcuts. Managers are also recognizing the role of other ecosystem components. Logs, snags, and other coarse woody debris are a long-term source of organic matter, provide habitat for many organisms, and influence geomorphic processes (Franklin et al. 1997). Consequently, many current harvest plans require more biological material be left on-site post-harvest (Agee 1993, Kohm and Franklin 1997). However, this study has shown that clearcuts, regardless of treatment, increase fire severity. Considering this trend towards more sustainable silvicultural activities, expanding our knowledge about silvicultural practices that decrease severe fire effects is crucial to achieving multiple forest management objectives (Weatherspoon and Skinner 1995, Kohm and Franklin 1997).

Graham et al. (1999) believe that the best way to decrease hazardous fuel build up is through site specific silvicultural treatments. Forest types and ages react differently to different systems. Thus, no single approach should be applied to all stands. However, a silvicultural system that manages for tree density and composition seems to be essential (Graham et al. 1999). This relationship between forest health and silviculture demonstrates the need for managers to focus on a landscape approach to ecosystem management (Weatherspoon and Skinner 1995). The possibility that extreme fire in clearcuts will have a destructive ecological impact not only within the clearcut but also in adjacent uncut stands, establishes the importance of widespread fuels management. How management activities affect forest stands, their immediate surroundings, and natural processes can determine the quality of the timberland and landscape overall.

Research on the effects of harvest activities on natural processes is a positive step towards the overall goal of better forest health. The need to balance the requirements of timber, recreation, wildlife, aesthetics, and other forest resources with increased risk of fire, suggests the need for more studies such as this into the realm of fire behavior and silvicultural associations.

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## THE INFLUENCE OF FIRE SUPPRESSION ON VEGETATION, ENVIRONMENTAL QUALITY AND HUMAN HEALTH IN THE LOWER KLAMATH RIVER BASIN OF NORTHERN CALIFORNIA

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This paper examines the premise that fire suppression has significantly influenced the composition and density of forest vegetation throughout the forests of the Klamath River Basin. It draws from fire histories - both written and oral - fire risk assessment completed by the Forest

Service for the entire Basin, the considerable literature of fire studies conducted in the Basin during the past two decades, and what I like to call studies of the natural history of individual fire events which have been completed by the Klamath Forest Alliance and its allies. The paper offers the premise that fire suppression has not been equally effective across the landscapes of the Klamath River Basin. It offers the hypothesis and presents evidence that, in the more remote reaches of the steep and folded mountains of the lower Klamath Basin - the core Klamath Wildlands - fire suppression has not been effective and, as a result, vegetation and fire behavior are within the natural range of variability for these processes in this location. This suggests that the efficacy and impact on vegetation of fire suppression may be overestimated in other areas as well. It may be more valid scientifically to think of fire suppression effectiveness and consequent influences on vegetation as a continuum - from highly effective/deterministic influence on vegetation to ineffective/vegetation uninfluenced - rather than the current assumption that fire suppression/vegetation determination has been equally and highly effective across western forests.

Finally the paper turns from the impact of fire suppression on future vegetation composition and density to the impact of fire suppression activities themselves on Klamath Basin ecosystems – not only vegetation but also water quality, soil erosion, invasive species, stream sedimentation and fisheries. Evidence from the Hog Fire of 1977, the Yellow, Baldy and Glasgow Fires of 1987, the Dillon and Specimen fires of 1994 and the Big Bar Complex of 1999 will be examined to make the case that modern fire suppression activities IN THEMSELVES constitute a major degrading impact on the ecology and environmental quality of Klamath River Basin watersheds and one which is unnecessary and ineffective at putting large fires out. Ongoing studies by Anthony and Christine Ambrose of Citizens for Better Forestry of the Big Bar Complex will be used to make the case for a policy of minimum suppression or "loose herding" in Wilderness and other Backcountry areas.

## FIRE AND LANDSCAPE DYNAMICS IN WATERSHEDS OF THE KLAMATH MOUNTAINS

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Despite the great ecological importance of riparian environments, little information is available concerning their past fire history. Thus, a great deal of uncertainty exists about the interactions of fire and riparian environments. With the Mediterranean climate and the general pattern of frequent fires in most vegetation types, it is logical to assume that fires regularly affected many riparian areas of the Klamath Basin in the past. Fire return intervals (FRIs) developed from fire scars on stumps for sites adjacent to perennial streams in riparian reserves were found to have been approximately double the FRIs from nearby upland forest sites. However, the ranges of FRIs were very similar. It appears that FRIs in riparian reserves may be more variable than in adjacent uplands and tend to be longer. Riparian areas may have helped to enhance the spatial and temporal diversity of landscapes by acting as occasional barriers to many low- and moderate-intensity fires.

## FUELS TREATMENT ON PRIVATE LANDS: THE CASE OF LONG CANYON.

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It is commonly recognized that the expansion of homes into forested areas has created a potential for devastating loss of lives, dwellings, and forest resources. The East Fork Fire Management Plan was developed to address this potential in several settlements in the Covington mill area near Trinity Center in Trinity County. This community-based plan addresses fire safety and forest health opportunities for 300 rural residential parcels and adjacent forest land within the east fork of Stuart fork watershed. The planning process involved area residents, fire and forestry experts from CDF, USFS, Sierra Pacific Industries, and the private sector, and personnel from the Trinity county resource conservation district and the Trinity river conservation camp.

The plan contains recommendations that the community and individual landowners can follow to reduce the risk of losing their lives, homes and the landscape in which they desire to live. Recommendations to establish fuel breaks, reduce ladder fuels, and execute other management projects that reduce fire intensity will also help protect surrounding resource lands. It is anticipated that these projects will reduce the containment times of lower intensity fires and prevent them from moving into or out of settlements.

## COMMUNITY-BASED WILDFIRE MANAGEMENT: INTEGRATING SOCIAL AND ECOLOGICAL OBJECTIVES ON PUBLIC LANDS

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### ABSTRACT

A community-based approach to wildfire management in the U.S. has the potential to address persistent socioeconomic issues in forest communities while accomplishing fuels and fire management objectives in a cost-effective manner. In a community-based approach to managing fire, community expertise and labor is utilized in an ongoing set of integrated ecosystem management activities that reduces the threat of catastrophic fire. To realize the full benefits of this approach, capacity building at the community level will likely be needed in order for community-based businesses and groups to function as partners with government agencies. The case of a community-based approach to ecosystem management in northern California illustrates many of the components of community-based wildfire management as well as capacity-building needs and potential benefits. The emergency Congressional funding available for wildfire management in

2001 could be well invested in developing community-based approaches to wildfire management that yield environmental, social and economic profits.

## INTRODUCTION

During the fire season of 2000, 7.4 million acres of wildlands burned in the United States. Dramatic images of raging wildfires flashed across television screens nationwide. The cost of putting out the fires (suppression) exceeded $2 billion. The value of damages to natural resources, homes, and private property has not been totaled but was likely in the billions of dollars. The 2000 fires woke the policymakers in Washington DC to the "emergency" in the nation's forests. Congress approved $1.8 billion in FY2001 for a new National Fire Plan with a focus on "managing the impacts of wildfires on communities and the environment" (USDA/USDI 2000). Most of those appropriations are special, one-time emergency funds, and pressure is on the resource management agencies to show quick results. Treating wildfire exclusively as an "emergency," however, can exacerbate the socioeconomic problems faced by forest communities while failing to address the underlying reality of fire as an integral part of ecosystem processes.

While forest fire is generally viewed as a catastrophe requiring an emergency response, fire is actually a normal feature of many forest ecosystems. The 2000 fires occurred in areas where frequent fire has historically been a natural part of ecological processes. In recent years, however, fires have burned hotter over larger areas than in the past. The large fires of 2000 cannot be considered natural; they are the product of human intervention. More than five decades of effective fire suppression have resulted in an unprecedented build-up of small diameter fuels which contribute to the catastrophic nature of many present-day forest fires. Treating fire on an emergency basis will only perpetuate the problem when long-term investment is needed to address fire in a more comprehensive way.

A long-term approach to fuels and fire management requires landscape-level planning, diverse management activities in the field, and the development of technologies and markets for the products of fuels management. New public-private sector partnerships are needed to address the broad scope of tasks involved in managing wildfire in this way. Businesses, organizations, and individuals in forest communities can assist in fuels and fire management but may require investments in building their capacity to do so. Lessons applicable to capacity building for fire management can be learned from recent efforts to implement ecosystem management in the Pacific Northwest.

The special funding allocated to the National Fire Plan offers the opportunity to build the capacity to provide sustainable rural livelihoods in forest communities while reducing the threat of catastrophic fire for years to come. Local residents are particularly suited to assist in fire planning and management because they have knowledge of the area and transferable skills from years of living and working in the woods. Much of the work of managing public lands is currently contracted out to private firms. Surprisingly little of that work, however, is done by businesses located in small forest communities. Through a combination of local capacity-building and changes in agency policies, local communities will be able to do more of the long-term work involved in reducing the forest fuels and managing forest ecosystems. Moreover, value-added processing and marketing of the by-products of fuels management can not only create local jobs, but can also generate revenues for the government. When small diameter materials have some economic value, fuels can be treated over a larger area and the threat of big fires is reduced more quickly.

## WHY A COMMUNITY-BASED APPROACH TO WILDFIRE?

Community-based approaches to managing wildfire have the potential to be more cost effective, better for the environment, and better for local communities then current approaches to fire for a number of reasons described below.

Forest communities are most affected by forest fires, in terms of loss of property, lives and livelihoods and therefore have an ongoing interest in participating in wildfire management. Members of forest communities often have local knowledge that can help in planning management activities as well as fighting fires. Many local residents have knowledge of fire history and weather patterns as well as knowledge of resources that can help fight fires, such as water sources, water trucks, access points, and backwoods roads. Residents can identify valuable natural resources, cultural sites and property that should be protected in firefighting efforts. Community-based planning efforts can integrate this local knowledge and agency expertise. Many times, local residents provide continuity and historical understanding that cannot be provided by agency experts who are mobile or frequently transferred.

Forest communities contribute to the labor and businesses that can make fuels treatments economically viable. If a fire-influenced ecosystem is managed in a consistent, comprehensive way, forest communities are well situated to provide ecosystem management workers who are cost effective because they need not travel long distances and pay for lodging and food on the road. Moreover, local businesses can potentially process and market the by-products of ecosystem management with minimal transportation costs for raw materials. Together, efficient labor and local processing can turn some costly service contracts into revenue-generating product sales. The management of fire-prone ecosystems provides an opportunity to develop long-term stewardship relationships between forest communities and the forest that surround them that can replace formerly extractive relationships.

Residents of forest communities are currently struggling with how to make a living. They are suffering the dual social and economic impacts of reduced timber harvesting and the shrinkage of local Forest Service staff. The reduction in timber harvest levels in the 1990s has hit timber-dependent forest communities particularly hard. Many of them have people and businesses with skills that could assist in fuels management. Such communities often need capacity-building efforts to strengthen them to the point that they can be effective partners. The community-based approach to wildfire management can address two needs simultaneously – the socioeconomic decline in forest communities and the need to manage for fire in a consistent ongoing basis.

The need to incorporate local communities into fire management efforts is an issue that has been addressed in Southeast Asia as well as the United States (e.g. Makarabhirom, Ganz and Onprom 2000). While the ecology and causes of ignition are different in these two areas, the value of involving local expertise and capacity for on-going management is similar.

## EMERGENCY APPROACH TO FIRE MANAGEMENT VERSUS A COMMUNITY-BASED APPROACH

The National Fire Plan instructs federal agencies to “work directly with communities to ensure adequate protection” (USFS 2001). The Plan also notes nine operating principles including hazardous fuel reduction, collaborative stewardship, job creation, and applied research and technology transfer. It is not clear, however, how the agencies are supposed to achieve these multiple goals. A community-based approach to wildfire management builds on lessons learned from community forestry efforts and addresses each of these objectives.

Community forestry generally refers to institutional arrangements in which local communities have some share in decision-making and benefits and communities contribute labor and expertise related nearby forests to which they are culturally and/or economically connected. Community-based forestry in Trinity County and in federal forests elsewhere in the U.S. has come to mean: 1) community involvement in planning and decision-making through forums that encourage diverse local participation (i.e. that include protimber, proenvironment, and procommunity perspectives) (see Danks 2000), and 2) involvement of community members in the economic activities related to forest management. Local economic involvement in forest management includes contracts with local businesses and nonprofits for ecosystem management services, employment in local harvesting and processing of forest products, and direct employment with resource management agencies. Following on this conception of community forestry, a community-based approach to fire management involves communities as valuable participants in fire planning and prevention as well as economic opportunities related to the management of fire-prone ecosystems, processing of forest products, and fire readiness.

“Community” as used here refers to the residents of forest areas, who usually live in small, fairly isolated towns. Community does not refer to a local political unit as many forest communities in the West are unincorporated areas. Nor is community meant to exclude local residents who are government employees. Much of the expertise and organizational capacity that exists at the local level consists of residents who work at field offices of state and federal resource agencies. “Community-based” refers to both the local focus of attention and the relatively small scale of business operations and social interactions.

Table 1 contrasts the emergency approach that views wildfire as an accidental catastrophe and communities as helpless victims versus wildfire as a part of an ecosystem and communities as partners in managing a fire-influenced ecosystem. The text below it describes each box in greater detail. These approaches are presented as contrasting models for analytical purposes. Even with an active fuel treatment program, the capacity to respond to catastrophic fires will still be important to maintain. The challenge is to develop institutional arrangements that are able to meet both sets of needs.

Although ecologists and fire scientists understand the role of fire in the ecosystem, the institutional apparatus for fire management currently is organized to address fire as a catastrophe and has a strong focus on suppression. In contrast, a community-based approach to wildfire incorporates fire as part of ecosystem management. Planning and field activities integrate vegetation management with fuels reduction and fire fighting strategies. For example, vegetation treatments for enhancing old-growth characteristics (such as natural stand thinning from below or removal of invasive species) will be planned in a way that strategically breaks up fuels across the landscape and allows the introduction of prescribed fire. Shaded fuel breaks will be prioritized and laid out in a way that assists in fighting fires and mimics historical conditions to the extent possible.

Table 1. Contrasting Emergency and Community-Based Approaches to Wildfire.

| **Emergency Approach to Forest Fire** | **Community-Based Approach to Wildfire Management** |
|---|---|
| Fire as a catastrophe | Fire as part of ecosystem |
| Focus on suppression | Focus on integrated vegetation (fuels) management and fire fighting strategies |
| Resources allocated on an emergency basis<br>$$$$ suppression<br>$ pre-suppression | Resources allocated on an on-going basis<br>$ suppression<br>$$$$ fuels management |
| Outside expertise | Local knowledge |
| Centralized capacity to respond | Decentralized capacity to manage |
| Mobile, specialized crews<br>e.g. incident command teams<br>hotshot smoke jumpers<br>convict crews | Placed-based, multi-purpose, fire/fuels crews<br>e.g. brush disposal crews<br>ecosystem management technicians |
| Short-term, intense activity<br>(capital intensive, high risk) | Long-term activities and objectives<br>(good climate for private sector investment) |
| Communities as victims | Communities as partners |

To date, resources have been allocated to fire management largely on an emergency basis. Large sums are allocated to suppression when necessary, and little funding is available for ongoing presuppression activities. In a community-based approach to fire management, the opposite would be true. Resources would be allocated on an ongoing basis with the bulk of the budget in fuels management. Over time, less money will be needed on average for suppression.

Planning for and fighting large wildfires relies largely on non-local expertise. These "outside" experts use generalized expectations of fire and weather behavior, published maps, and satellite images among other sources in developing fire plans and managing active fires. The knowledge of community residents and local agency personnel who have lived through the last fires, know the roads and ridges, and know local resources available to plan for and fight fires is often excluded by current practices. Community-based fire management would integrate local knowledge with outside expertise.

Wildfire resources have been used to develop a sophisticated and effective centralized capacity to respond to emergency. Fires are fought by mobile, specialized crews from the incident command teams that manage large fires down to the hotshot smoke jumpers on the front lines and the convict crews mopping up afterwards. Even landscape rehabilitation (e.g. Burned Area Emergency Rehabilitation) after a fire is considered an emergency due to the potential for erosion and is usually done by outside crews.

It is clearly necessary to have a system that can efficiently move a large number of people to the site of an emergency and have them function well together when the need arises. However if all fire resources were devoted to this model, little would be available to reduce the risk of large fires. In a community-based approach, resources would be invested in a decentralized capacity to manage forests in a way that reduces the probability of catastrophic fire. In this allocation of resources, emphasis would be on the development of place based, multipurpose fire/fuels crews. Such crews, whether they be private contractors or public employees, could work on diverse vegetation management projects that integrate fuels reduction throughout a long working season. These crews would also be trained and available to put out fires where necessary and to assist in prescribed burning. Their knowledge of the landscape and prior participation in local planning efforts should make them particularly effective in fighting fires locally. The ability to mobilize large crews when necessary should of course be retained. New ways to integrate local knowledge and workers in fighting large fires, however, should be explored.

When fire is considered an emergency, fire management activities are short-term and intense. When fire is dealt with as part of ecosystem management, fuels and fire management are long-term, ongoing activities. Long-term commitments provide a better climate for private sector investment. Under those conditions, community-based businesses can invest in the training and equipment needed to play supporting role as partners with federal agencies in managing fire on public and private lands.

Communities are viewed primarily as the victims of catastrophic fire. During a large fire, forest communities are invaded by fire camps, are victims of smoke, and experience the losses of homes, pets, timber, scenery and economic activities. Beyond clearing a "defensible space" around their homes, there are limited roles for community members in the emergency approach to fire management. To prioritize National Fire Plan funding, federal agencies sought to identify the communities “at risk," particularly those in the urban-wildland interface where high property values are of greatest concern (Federal Register 2001). Labeling communities as “at risk” gives limited recognition to the organizations and businesses in forest communities could help agencies in addressing wildfire. In a community-based approach, communities are viewed as partners with agencies in managing fire-prone ecosystems.

## COMPONENTS OF COMMUNITY-BASED WILDFIRE MANAGEMENT : WHAT WOULD COMMUNITIES DO?

What parts of wildfire management are individuals businesses and organizations at the community level well suited to do? Community members are already carrying out key elements of wildfire management in the context of ecosystem management in fire-prone regions. Many of these activities are included in Table 2.

Table 2. Fire Management Activities in which Local Communities Can and Do Participate

| |
|---|
| On-Going Management of Fire and Fuels<br>fire planning / mapping<br>surveys – fuels, wildlife, erosion hazard, aquatic habitat, etc.<br>environmental analyses<br>fuels reduction in varied forms, for example:<br>ground fuels management<br>post-treatment burning<br>prescribed fire<br>fuel breaks, e.g. shaded fuel breaks<br>density management<br>fuels management in recreation areas (e.g. campgrounds)<br>monitoring<br>research |
| Complementary Value-Added Industry<br>small diameter wood products<br>primary and secondary processing (instead of just burning or chipping)<br>e.g. poles, flooring<br>value-added manufacturing<br>e.g. furniture, fixtures<br>non-timber forest products<br>e.g. morel mushrooms, mullein<br>marketing<br>web design / internet marketing |
| Fighting Fires<br>utilize local fire plans and knowledge<br>utilize local personnel, businesses, and resources |
| Post-Fire Rehabilitation:<br>erosion control of bare slopes<br>rehabilitation of roads/fire lines used in fighting fires<br>surveys / mapping<br>environmental analyses<br>replanting<br>salvage<br>monitoring |

Not all communities are prepared to engage in all of the activities listed above. In some cases capacity must be built with the aid of public sector investment. The most important changes needed, however, are in public sector policies and practices. In particular, if federal land management agencies solicit ecosystem and fire management services in packages that are appropriately scaled and offered regularly, the private sector in forest communities can itself invest in building the needed capacity.

## MODEL FOR DEVELOPING COMMUNITY-BASED APPROACH TO ECOSYSTEM MANAGEMENT

Lessons for what constitutes policies and practices that support a community-based approach to fire can be gleaned from recent experiences in the Pacific Northwest. In 1994, the Northwest Forest Plan, accompanied by the Economic Adjustment Initiative, transformed the land management regime and accompanying private sector businesses from an emphasis on timber production to ecosystem management in order to protect endangered old-growth species. These changes in land management objectives and practices were implemented with a special concern for the effect on timber-dependent communities. The efforts associated with the Northwest Forest Plan to increase the capacity in local communities to engage in ecosystem management provide insights into how the capacity for community-based wildfire management could be developed.

### Community-Based Ecosystem Management in Trinity County

Trinity County, CA is described below because it is a place within the Northwest Forest Plan area that exemplifies conditions in vulnerable forest communities in the U.S.. It is also a good example of the promise and challenges of agency-community partnerships to manage wildfire. In Trinity County, community-based organizations have worked with the Forest Service and other government agencies on a number of components of community-based fire management. These activities range from community-based fire planning to value added processing of the products of fuels management. This case shows the value of private sector involvement in fire/ecosystem management and the kind of capacity building needed in poor forest communities to achieve that goal. In addition, Trinity County was the site of several major fires in recent years. In 1999 the town of Lewiston lost 23 homes in an escaped prescribed fire and later that summer the Megram fire grew into a complex that burned 125,040 acres. Residents still talk of the "87 fires" when fires burned 91,000 acres adjacent to towns and smoke blocked the sun for weeks in the late summer of 1987. This fire history has created common ground among residents and agency personnel who experienced these traumatic fires and understand the need for fuels and fire management.

Trinity is a mountainous, rural county of approximately two million acres (810,000 hectares) and 13,000 people in northern California. There are about 18 communities within the County and their populations range from 30 to 3200. Most communities are fairly isolated with large tracts of forest land between them. The only local government is the Trinity County Board of Supervisors. There are no incorporated towns, no mayors, no town councils and no traffic lights. The rugged topography ranges from 600 to 10,000 feet in elevation and the predominant vegetation is mixed conifer forests and oak woodlands. The average fire return interval differs throughout the County with various studies reporting a range from three to twenty years (USFS 2000, Taylor and Skinner 1998).

The timber and recreation industries are the core sectors of the economy, making Trinity County one of the most forest dependent areas in the Pacific Northwest.1 More than 30 percent of employment in Trinity County was in the timber industry in the late 1980s (Greber 1994). Other than local commercial and support services (e.g. stores, schools, government services), there is relatively little economic activity, public or private, that is not directly related to the National Forests-related activities include logging, lumber mills, recreation, watershed management, fire management, tourism and reforestation. Local residents are economically connected to the forest not only through employment but also through some subsistence uses. Seventy percent of the homes in Trinity County are heated with wood (USDC Bureau of the Census 1993). Hunting and fishing are not only popular forms of recreation, but they also supplement the diet of many local residents. This close relationship with the surrounding forest means that many community members have a good knowledge of the terrain and experience in working in the woods that can increase the value of their participation in ecosystem and wildfire management.

Unfortunately, like many forest communities throughout the United States, Trinity County has relatively high poverty (19 percent) and high unemployment. For more than a decade, the annual unemployment rate in Trinity County has been about twice that of the state of California. Employment is highly seasonal in Trinity County, with the highest unemployment occurring during the winter months (Figure 1). Forest dependence, on both timber and recreation, contribute to this strong seasonality. These data suggest that the communities in Trinity County are in need of more livelihood options. There are many people with woods and wood products experience who are underemployed and could contribute to wildfire management.

The size and regularity of forest contracts makes a difference to small community-based forest-related businesses. There are three main ways that community members are employed directly in the management of national forests in Trinity County: as loggers, and their workers, who bid competitively to buy timber; and as contractors, and their workers, who bid competitively for paid contracts to do various tasks in the woods (e.g. treeplanting, surveys, rehabilitation, precommercial thinning), and as direct employees of the U.S. Forest Service. Trinity County businesses, however, received only seven percent of timber sales and field service contracts on the Trinity National Forest from 1991 to1996 (McDermott and Danks 1998). Analysis revealed that Trinity County businesses were most likely to win timber sales and contracts when they were packaged in small jobs (which require small crews and small amounts of capital) and were offered consistently year-to-year.

Unfortunately for forest communities, most timber sales and service contracts are packaged as large jobs with relatively short time frames which require large crews to complete the jobs on time. Despite the appearance of an open competitive market, this packaging constitutes a bias against forest communities where businesses are small and capital is limited. An emergency approach to fire management, with a focus on large-scale, short-term intense activities, will likely intensify the bias against local livelihoods. An ongoing program of fuels management, which seeks to incrementally treat fuels and restore ecosystem functions, can better offer opportunities to provide and package work in ways that are accessible to businesses in forest communities.

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[1] Normally the community--not the county--is the appropriate unit to analyze forest dependence in the U.S. even though more data are available at the county levels. However, the absence of significant agricultural, industrial (other than timber) or urban sectors in Trinity County makes it more like a forest dependent community than an economically diverse California county.

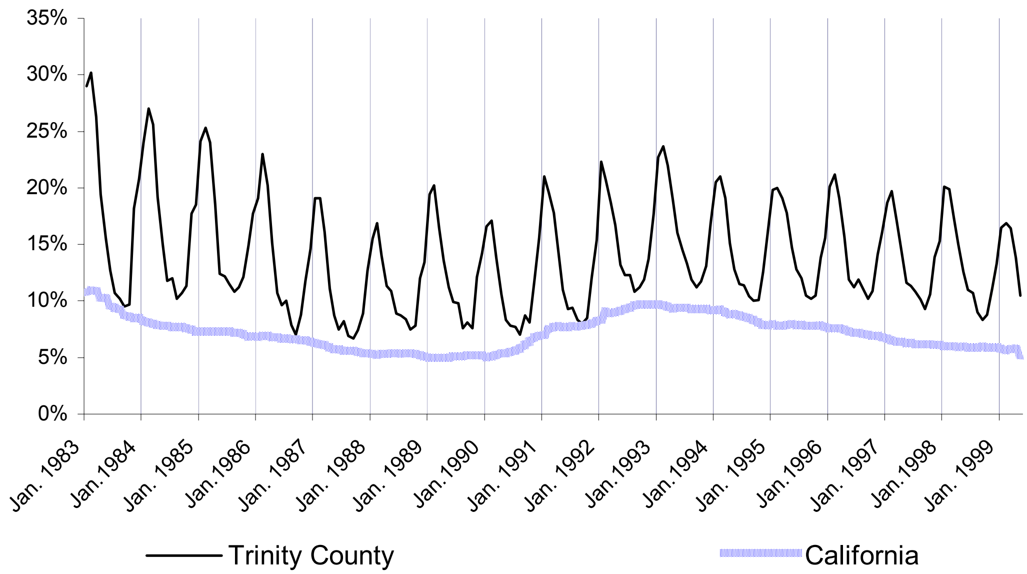


Figure 1. Monthly Unemployment Rates for Trinity County and California, 1983-1999

The highly seasonal unemployment, high poverty rates, and the strong historical dependence on timber extraction go hand-in-hand. There are many capable woods workers in the communities of Trinity County, but the lack of steady work has led to a precarious situation for families. Contracting practices that favor large businesses and require workers to travel long distances for short periods of time exacerbates the problem. While workers are away, they cannot participate in community and family life. They cannot help their children with homework, go to church, coach Little League, lead a scout troop, or serve on a community development committee.

Like the National Fire Plan, the Northwest Forest Plan included broad policy directives to work with communities in implementing ecosystem management. When the Northwest Forest Plan was announced, it was hoped that residents of forest communities could secure long season work year after year, doing the diverse tasks needed to steward national forests. Although the plan was criticized by the timber industry and environmentalists, Trinity County embraced the opportunity to implement ecosystem management in a way that would finally benefit forest communities. The Watershed Research and Training Center, located in the center of Trinity County, took the lead in capacity building efforts to enable forest communities to contribute to the ongoing sustainable management of nearby national forests.

The Watershed Center, in partnership with federal and local agencies, led a comprehensive set of programs to help prepare its community to engage in the new set of field, office and factory tasks involved in managing forest ecosystems for diverse benefits. The tasks of ecosystem management include a combination of field and information-based activities, such as data collection, data entry, mapping, surveys, inventory, planning, monitoring and research; designing, constructing, and maintaining trails, campsites and other recreational areas; marking, thinning, yarding, pruning and burning in dense natural stands and plantations; rehabilitating, closing and removing roads; and restoring streams and wildlife habitat.

The capacity-building efforts conducted by the Watershed Center and its partners to prepare people for this kind of work included: 1) an ecosystem management training program to diversify the skills of displaced timber workers and other unemployed residents, 2) advanced contractor training to bolster specialized field and business skills, 3) stewardship contracting program to help agencies design longterm contracts for ecologically beneficial forest work that was at a scale appropriate for local businesses, 4) a small diameter program to pilot harvesting and processing technologies that required limited capital and were ecologically appropriate, 5) assistance in developing private sector value-added processing and marketing of the products of ecosystem management. These efforts were enabled by the federal policies that encouraged agencies to work with communities and funding available to public agencies and the private sector to help forest communities adjust to changes in land management activities.

These capacity-building programs had multiple benefits. Forest communities had more and more diverse economic opportunities. Government agencies who could accomplish work more cost-effectively because community partners contribute pieces, like small diameter processing and marketing, that lowered government costs. The environment benefited because the forest finally received treatments that promoted healthier conditions and reduced the threat of a large, damaging fires.

The capacity-building efforts for ecosystem management in Trinity County are much the same as those needed for community-based wildfire management because fire is a main ecological force in the Trinity's forests and many of the ecosystem management activities, especially small diameter thinnings, fuelbreaks and prescribed fire, are essential parts of wildfire management. In addition, the mapping, inventorying, monitoring and other information-based field work of land management and planning are also necessary for wildfire management. Therefore, efforts to integrate wildfire management into ecosystem management and to develop capacity for a community-based approach to wildfire have already been piloted in Trinity County.

In additional to building capacity for implementing ecosystem management, local community-based organizations in Trinity County have collaborated on innovative community-based fire planning. This fire planning process used a participatory mapping approach to combine the knowledge of local residents and agency experts on fire hazards, fire-fighting resources, and special areas in need of protection (Everett, Sheen, and Doyas 2000). These data provide a foundation for the design and prioritization of wildfire management activities in the County.

Trinity County's ecosystem management activities demonstrate the potential benefits of a community-based approach to wildfire management. A community-based approach can help provide economic opportunity in small communities while accomplishing management activities. Involving the private sector in developing and implementing value-added processing and innovative stewardship contracting means some fuel treatments can be done because more cost-effectively. Reducing the costs of management not only saves taxpayers' money, it also helps the environment because more areas can be treated within the same limited budget. Achieving these benefits required both capacity-building efforts (which were conducted as joint public-private efforts) and changes in government policies to remove barriers to community participation.

## POLICY IN TRANSITION – AN OPENING FOR CHANGE

The new National Forest Plan prioritizes: fire-fighting, rehabilitation and restoration, hazardous fuel reduction, community assistance, and planning and analysis. The vast majority of the funding is still directed to the catastrophic model of fire, i.e. on firefighting readiness, suppression, and rehabilitation of burned areas. The National Fire Plan also represents a transition reflected by its focus on fuel reduction and communities. The need to retain fire suppression capabilities while building fire management capacity is not contradictory. These dual needs are so broad in scope that they require a public-private sector partnership, in particular, an agency-community partnership.

The way in which the National Fire Plan is implemented will have great impact on forest communities. If lawmakers and agencies only address fire as a catastrophic emergency, they will never invest in creating the institutional arrangements needed to reduce the severity of fire. With substantial new funding, an attentive Congress, and a new Administration to implement the Fire Plan, there is an unprecedented opportunity to invest in a new way of addressing fire that benefits both the environment and local communities.

## CONCLUSION

A short-term, emergency approach to wildfire addresses neither the underlying ecological problem nor persistent socioeconomic problems of forest communities. A community-based approach to wildfire management offers the opportunity to achieve multiple goals. Communities can play a bigger role than that of "victim". Community members can provide knowledge to create better fire plans and knowledgeable labor to implement those plans. The private sector can be contracted do much of the data gathering, project implementation and support work needed to manage fire as part of the ecosystem on federal lands. Community-based businesses can develop markets for by-products of fuels treatments that can make fuels management economically viable. For businesses and organizations in small forest communities to engage in these activities, the federal agencies need to consider scale and consistency of work opportunities. In addition, capacity-building can enhance individual skills and assist in the development of viable, local industries related to wildfire management. The policies and capacity-building efforts associated with the Northwest Forest Plan can provide examples of how the 2001 funding for the National Forest Plan can integrate social and ecological objectives on federal forest lands.

## ACKNOWLEDGMENTS

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## COMMUNITY PARTICIPATION IN FIRE MANAGEMENT PLANNING-A CASE EXAMPLE FROM TRINITY COUNTY, CA

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### ABSTRACT

The ecological, social and economic costs associated with wildfires are escalating in California. One still underutilized opportunity in efforts to address these complex problems is systematic involvement of rural community residents. They are often first responders in case of wildfire, they hold valuable local knowledge of place, fire history and fuel loading, and on a very personal level, they have the most to gain from participating in community level education, coordination, fuels reduction and other fire management efforts.

Wildfires are a recurring phenomenon in rural Trinity County in Northern California, but the intensity and scale of fires in 1987 and 1999 have catalyzed community organizations and state and federal resource management agencies into a systematic landscape level fire management planning and coordination effort lead by the Trinity County Fire Safe Council. In 1999/2000 the Fire Safe Council, using GIS technology and working through local Volunteer Fire Departments, initiated a participatory information gathering process with community members. They have worked to identify values at risk and site specific recommendations for pre-fire implementation activities such as fuels treatments, as well as capturing local knowledge of pertinent factors for emergency response. The experience gained may be of interest to other communities involved in landscape scale fire management planning.

**KEYWORDS:** community mapping, collaborative planning, fire management planning, landscape planning, public participation, GIS

## INTRODUCTION

Fire is a function of temperature, wind and fuels. Since people cannot control climate, reducing fuel loading through pre-fire treatments is the most promising area in which people may influence wildland fire behavior. (Agee, 1993; Weatherspoon and Skinner, 1996) Pre-fire treatments also can significantly benefit suppression efforts once a fire starts. (Agee et al., 2000). One of the underlying challenges of applying pre-fire treatments to the landscape is bringing together the land managers, often a mix of private owners and public agencies with different mandates, along with affected communities to decide which treatments to apply and where. The scale of the Summer, 2000 fires across the United States has focused national attention and is bringing new investment in fire management with an increasing emphasis in pre-fire treatment while maintaining fire suppression capabilities. As managers rush to implement programs, one important source of information, expertise and ground level support that could be drawn upon more than in the past are local communities, the people who live in the fire zone.

In November, 2000, the Trinity County Fire Safe Council in Northern California completed the first phase in an ongoing effort to work collaboratively with government agency and local citizen members to develop and implement a landscape scale fire management plan. In this paper we briefly report on the TFSC and the current status of this process.

## COMMUNITY INVOLVEMENT IN FIRE MANAGEMENT PLANNING ACROSS JURISDICTIONS

Local citizens are not normally involved in fire suppression planning or pre-fire decision-making processes. When a large wildfire burns, enormous emergency costs, often in the tens of millions of dollars are incurred for suppression. A large proportion of California wildlands are federally held public lands. On these lands, firefighting agencies go into a para-military attack mode. When a fire reaches a certain size and rate of spread or goes beyond local capacity for suppression, national strike teams are brought in from outside the area. They take over the "command central" of the fire suppression activities. While local line officers, *e.g*. U.S. Forest Service District Rangers are still in charge, in effect the "superior expertise" of the strike teams takes over. As rapid decisions are made regarding back-burning, bulldozing and other suppression activities, local citizens' knowledge, expertise and opinion is not typically factored into decisions. Yet, if site-specific information known to local residents (*e.g*. about weak bridges, narrow roads, locked gates and water sources on private land) were readily available, some fires might not escalate and resources could potentially be saved. Volunteer Fire Departments (VFDs) are first responders in emergencies including fire in many rural areas. Many VFDs are inadequately staffed, most have wish-lists of basic equipment for emergency response. It is in the interest of land managers and the public at large to have well staffed and supported VFDs and to maintain good communications with them. In operational terms, local site-specific knowledge and experience with the terrain, past fire behavior and locations for emergency fire lines, all could save lives, time and money in emergency situations.

Instead when a wildfire erupts under the current system, some local residents may gain short-term employment as fire fighters, or work as support activities staff providing food and facilities for large fire base-camps. Like a telescoped version of the historic timber and mining industries, suppression of catastrophic fire is yet another rapid boom and bust economic cycle for forest dependent communities – quick high earnings during and immediately after the fire, with years of lost forest resources to follow. Most would prefer to avoid the cycle and many agree with fire managers who advocate pre-fire vegetation treatments.

Here again, the potential value of citizen involvement in pre-fire management has not been fully recognized. Fire is oblivious to property and jurisdictional boundaries. It is up to private landowners to carry out fuels reduction around their homes and on forest parcels neighboring public lands. If they don't, the risk to public resources is increased. Industrial forestland owners carry out a range of fuels management and fire planning activities, sometimes, but not always in coordination with neighboring land management agencies. When a fire starts, whether on public or private land it can quickly travel to other ownerships.

## THE CALIFORNIA FIRE SAFE COUNCIL

In recognition of the need for coordination among a range of agencies, industries and communities to increase fire safety for communities, the California Fire Safe Council (CFSC) was formed in 1993. It meets quarterly and now has 50 members at the state level including such groups as State and Federal Resource and Emergency Response Agencies, the League of California Cities Fire Chiefs, the American Red Cross, Insurance and Realty Companies, Environmental Organizations and Utility Companies. The CFSC develops and distributes educational materials, evaluates legislation and policies pertaining to fire safety and supports over 60 local Fire Safe Councils that have emerged in communities around the state. The growing recognition of the institutional structure supporting community involvement in local fire management facilitates efforts to formalize cooperation at the local level among agencies and between agencies and communities, e.g. with Memoranda of Understanding on the types of joint activities that may be undertaken. However, while they share the common goal of improving fire safety, the community based Fire Safe Councils emerge from locally perceived needs for cooperation and vary in their structure, memberships and activities depending on their local circumstances.

## THE TRINITY COUNTY FIRE SAFE COUNCIL, CALIFORNIA

Trinity County is a rural county extending over two million mountainous acres (Figure 1). Fewer than 13,000 people live here. Over 75% of the land is managed by the federal government, primarily in the Shasta-Trinity and Six Rivers National Forests. The vegetation is predominantly mixed conifer forest and oak woodland (Sawyer and Keeler-Wolf, 1995) with fire as the dominant disturbance regime.

In the county, fear of catastrophic fire that could repeat or be worse than the 1987 and 1999 conflagrations is growing. In mid 1998, the Trinity County Board of Supervisors' Natural Resources Advisory Council appointed a sub-committee to address the issue of fire. This initiated the Trinity County Fire Safe Council (FSC) that has met on average monthly since. The FSC includes representatives from local Volunteer Fire Departments (VFD), non-governmental organizations (NGO's), the county, state and federal land and fire management agencies, and other community members. All have signed a Memorandum of Understanding (MOU) to cooperate on fire management planning (MOU, 1998).

The FSC has embarked on a landscape analysis and strategic planning process for fire management in the county. The first steps taken in 1999 and 2000 were to build local involvement and interest in fire management planning by seeking to systematically capture local knowledge about fire and to glean residents' and fire management specialists' recommendations for pre-fire treatments. The research objective involved was to develop and implement a method to capture local and regional expertise in fire management as effectively and efficiently for the local participants as possible. Participatory research and community mapping methods were adapted to achieve this goal. (Brokensha et al., 1980; Elwood and Leitner, 1998; Harris and Weiner, 1998; Obermeyer, 1998; Sieber, 1997) Two local NGO's, the Trinity County Resource Conservation District and the Watershed Research and Training Center, provided the team that led the effort. These FSC members, including the authors of this paper, found funding support from the USFS Pacific Southwest Research Station and the California Water Resources Control Board.

## COMMUNITY MAPPING AND PARTICIPATORY RESEARCH

The FSC team proceeded to work with community members in four steps: 1) to gather and develop a geographic information system (GIS) populated with all available spatial data for the county that were pertinent to fire; 2) to identify local knowledge and map data relevant for emergency response; 3) to work with local residents and professional experts to design a process for gathering community recommendations about fire management; 4) to implement that process including: gathering residents' perception of Values at Risk; collating their recommendations for pre-fire treatments to protect these values; and helping participants systematically prioritize among proposed activities.

### 1. Developing the GIS:

Data layers pertinent to fire management including e.g. topography, roads, hydrography, vegetation and past fire starts, were collated from a range of sources including the U.S. Forest Service, the Bureau of Land Management, the California Department of Forestry and Fire Protection and other data keepers. There had been no previous effort on this scale to integrate data sets for the county. Once these data had been compiled useful base maps for information gathering with community members and for future fire management modeling could be generated (See papers by P.Towle and K.Sheen in these proceedings).

**2. Identifying local knowledge and mapping emergency response data:**

From November 1999 on a series of 13 widely publicized community meetings were held in VFD halls throughout the county. The purpose of these meetings was to discuss the Fire Safe process with community members and raise the local level of awareness about issues of fire management ranging from needs of local VFDs to county, state and federal efforts. Further, the team hoped to identify local expertise in fire management that could be called upon to participate in later phases of the process and to gather site specific information not yet contained in existing GIS based map layers. In order to ensure comparability between meetings, the basic format for all meetings was the same, with two or more members of the FSC team participating in each.

At each meeting members of the FSC team presented an overview of the Fire Safe effort and then proceeded to gather participants around maps of the local terrain developed from the GIS. A computer with the GIS database was brought to each meeting so that existing information in addition to data on the maps could be accessed on request. Participants added missing information by marking reference points on the maps and explaining issues of concern which were written down. These data, of particular interest for local emergency response, included locating water sources, weak bridges, road maintenance needs, locked gates and similar information. After each meeting the FSC team entered the new data into the GIS database and maps reflecting the new input were sent back to meeting participants to verify that the new information was accurately reflected. Updated paper maps were left with VFD in each participating community so that new information might be added and included database updates on a regular basis. The GIS was shared with local land management agencies and emergency respondents e.g. VFDs. The number of community participants in these meetings was variable.

**3. Working with local residents and professional experts to design a process for gathering community recommendations about fire management:**

A two-day planning meeting involving representatives of agencies and groups participating in the Fire Safe Council was held in April, 2000 to develop an appropriate process for gathering community input across the county. The FSC team hoped that by bringing together locally and regionally recognized experts to contribute their ideas to the process, we would establish a credible process for all concerned.

At the meeting it was decided that in addition to the GIS and local emergency response data already gathered in previous meetings, the most important input from residents would be to identify and prioritize among key Values at Risk from wildfire in their local areas, and to make recommendations for protecting these values. Values at Risk identified by residents for example species habitat, prime recreation sites and so forth[2]. Recommendations might include identifying places in which to treat vegetation to reduce fire risk and hazard. However, even where the turn out

[2] Note this process varies somewhat from the approach taken by CDF in the California Fire Plan where Values at Risk are pre-identified and ranked by CDF staff and community meetings are held to evaluate these proposals (CDF, 1996: p 24).

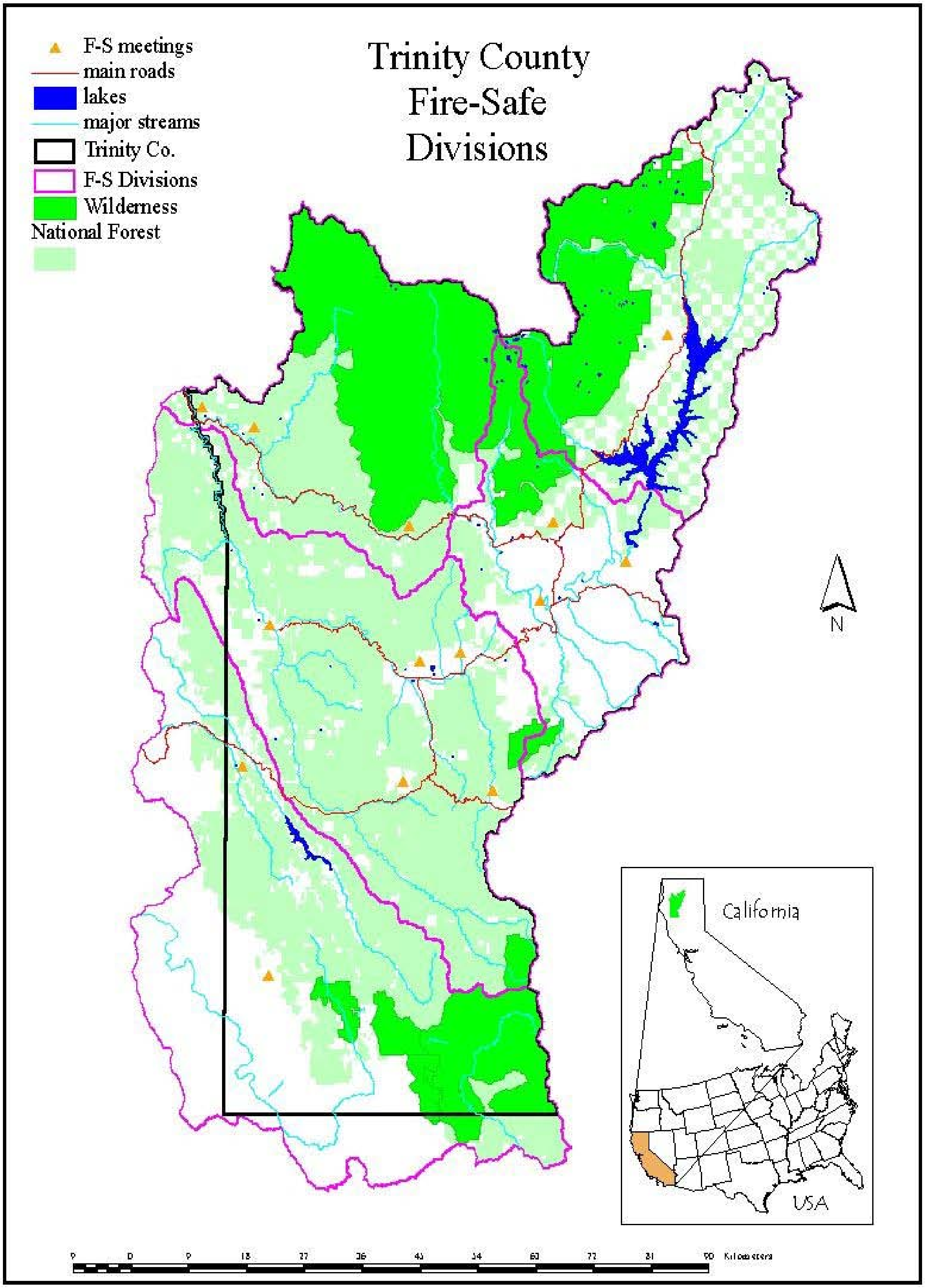


**Figure 1: Map of Trinity County in California**

was not large, it included a high proportion of VFD members and others with an active interest in fire management issues.

In order to make the best use of localized knowledge and staffing capability for meeting purposes, the county was divided into five parts. Evening and daytime meetings to maximize local attendance were to be held in central locations in each of these five areas, and discussion was to focus on the specific area in question.

**4. Community Meetings to identify Values at Risk and to identify and prioritize pre-fire treatments:**

As decided in the planning meeting, an evening and a day time community mapping meeting was held in each of the five areas of Trinity County in May 2000. Publicity to encourage broad participation was crucial. Everyone who had attended the earlier community meeting or who had been identified in the April meeting was sent a written invitation to attend and many people were also contacted directly by phone. In addition, the meetings were publicized in the local newspaper and several press releases about the fire planning process were published.

At the meetings people gathered around maps of their part of the county to discuss ideas in a lively give and take. As in the Emergency Response meetings described above, initial input on Values at Risk was captured on maps and in notes taken during the meetings as well as through on-location editing in the GIS system. In each case there were several community members, often life-long residents, who were immediately able to contribute ideas. The FSC team typically would sit down the following day with a smaller group of participants (often retired firemen, USFS staff or VFD members) to review and consolidate the data gathered earlier.

Once participants had identified which Values were at Risk from fire and where they were located, they next were asked to make recommendations for landscape vegetation treatments to protect values at risk. Recommendations might include, for example, fuels reduction work (thinning the forest from below, ladder fuels reduction, controlled burning) or shaded fuel break construction.

Finally, participants worked together to identify which projects should have highest priority. In an approach adapted from similar participatory prioritization methodologies (e.g. Margoluis and Salafsky, 1998), categories with which to evaluate proposals were defined and then ranked using a matrix approach. At each meeting, several categories with which to evaluate the importance or relative priority of proposed activities were presented and modified if participants desired (Table 1). Each category was discussed and defined in detail at the outset in each area meeting to ensure that all participants had a similar understanding of the valuation process. The resulting "scores" in the matrix were treated as indicating relative values among proposals. In order to avoid a false sense of quantitative valuation, all categories were weighted equally. The resulting prioritization matrices for each meeting were presented with a detailed description of the process applied and CD ROMs with the GIS data sets in a draft final report to the Fire Safe Council in January 2001 (Trinity County Fire Safe Council, 1999).

## RESULTS

Thirteen Community meetings were held at VFD Halls to capture emergency response data. Maps were created for each meeting and returned to participants for correction. They are now ready for further ground truthing and distribution. In addition, five community workshops were held involving over 200 people including a range of regional and local agency experts. At these meetings Values at Risk were identified and recommendations were made for pre-fire treatments to protect these values. In all 116 projects were proposed and prioritized.

A number of additional recommendations emerged from the community involvement process. Federal land managers were strongly encouraged to coordinate across jurisdictional lines on fire and road management policy. Trinity County was encouraged to identify community safety zones and escape routes in case of catastrophic fire and to keep water tenders and other equipment locally available. Strong support for VFDs was advocated. All fire managers were encouraged to take a landscape scale view of fire hazard and to coordinate treatments accordingly while identifying and focusing attention on critically important habitat for wildlife and on protecting old growth forests. They should pursue the joint outcomes of protecting key values from catastrophic fire, while allowing for reintroduction of low intensity fire, and providing an ongoing source of employment to the county workforce to carry out the fuels reduction work (Trinity County Fire Safe Council, 1999).

Figure 2: Participants Gather Around Maps at the North Lake Meeting, May 16, 2000 **(Photo by C. Fall).**

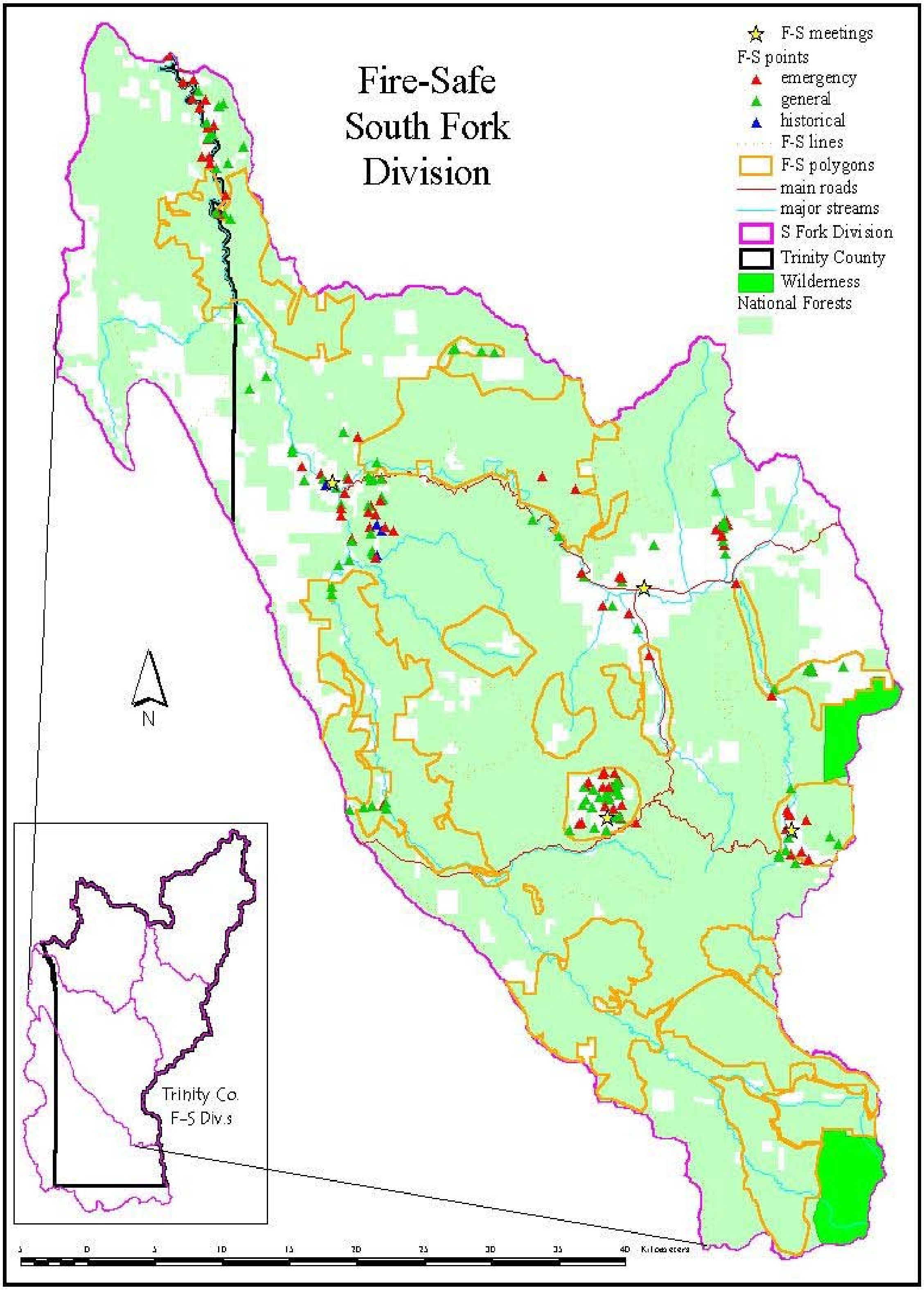


**Figure 3: Pre-Fire Treatment Recommendations Captured for the South Fork Area.**

**Table 1: Categories Used by Participants to Rank Recommended Projects**
(High, Medium or Low)

Community – areas most highly valued by community members

- ***High value e.g*. a community, a housing development or a grouping of several residences, a telecommunications translator, a community water supply, key travel corridors;**
- ***Low value* – no residences or infrastructure issues**
- **Public Safety** – a * was added to highlight urgent projects

Fuel Hazard – areas with high fuel loading, flammable vegetation

- ***High hazard* - dense, flammable vegetation e.g. thickets of second growth, untreated plantations, brush fields**
- *Low hazard* - open ground, areas previously thinned, no ladder fuels

Fire Risk – areas with a high likelihood of fire starting

- ***High risk* - high slope position and southwest aspect, past history of lightening strikes or high concentrations of human activity e.g. hunting camps.**
- *Low risk* - low slope position, little human activity, little past history of lightening strikes or fire

**Ecological Value –a measure of known ecological concerns in the landscape**

- *High value* - known habitat of threatened, endangered species or species for which U.S.F.S. survey and manage protocols apply[1]; notable stands of old growth vegetation, known nesting habitats of rare species
- *Low value* did not indicate lack of ecological value but rather no outstanding concerns for the particular area in question

Economic Value – a measure of known economic value of area resources

- *High value* - areas with private property values, power lines and/or plantations or other investments/resources at risk
- *Low Value* – no particular infrastructure or resource value

**Readiness – ability of landowners and managers to respond quickly**

- *High value* - ability of both private landowners and the U.S.F.S. to act immediately with community buy in on public or private land
- *Low value* - significant administrative work needed (e.g. NEPA) before activities could take place,

**Cost of Project – referred to overall economic cost of doing the work**

- *High cost* - due to inaccessible or steep terrain or large scale project
- *Low cost* - clearing defensible space around a residence, some types of controlled burn

**Recreation Value / Viewshed**

- *High value* - scenic highway designation; high recreational use area
- *Low value* – no particular value noted

**Land Allocation** – U.S.F.S. land allocations were included in the matrix to give a quick view of likely treatment opportunities and constraints on public lands as defined in the Northwest Forest Plan to protect the Northern Spotted Owl (e.g. Late Succession Reserve, Adaptive Management Area, Wilderness, Matrix).

## CONCLUSION

The recommendations have already provided a basis for Trinity County NGOs and VFDs seeking funding support for carrying out more fuels reduction work. A number of recommended projects are being implemented in 2001 (Baldwin, 2000). Further, there have been coordinated planning meetings between FSC members and the U.S. Forest Service. Other Fire Safe Council efforts are emerging in surrounding counties. The report has been distributed widely and has been a topic of discussion at national fire plan development meetings. The Trinity County FSC is currently involved in developing an overarching strategic plan for fire management in which the community recommendations will play a significant guiding role. Clearly there are many avenues for community involvement in fire management planning and implementation.

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## REHABILITATION AND MONITORING OF THE LOWDEN FIRE IN THE TRINITY RIVER WATERSHED

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This paper will discuss the physical and biological rehabilitation efforts undertaken to restore the Lowden Fire adjacent to the Trinity River immediately downstream of the Lewiston dam. The paper will describe the circumstances surrounding the prescribed burn that turned into a wildfire in early July 1999; the immediate effects of the catastrophic fire; the sensitivity of the landscape underlain with decomposed granitic soils; the short-term efforts undertaken to protect public safety and the water quality of the receiving waters; and the efforts to restore the landscape in sub-basins of the Trinity River using techniques developed in the adjacent watershed of Grass Valley Creek. The status of the restoration efforts will be discussed and current monitoring data will be provided. Particular attention will be placed on the importance of public outreach and community involvement in achieving the short-term and long-range goals of the rehabilitation program and the significance of catastrophic fire on the overall restoration of the Trinity River.

## FOLLOWING A MAJOR WILDFIRE--FUEL TREATMENT OPPORTUNITIES

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The Megram Fire burned over 50,585 ha (125,000 ac) on two National Forests (Six Rivers National Forest and Shasta-Trinity National Forest) in northwestern California during the summer and fall of 1999. Within a period of 73 days this fire burned through parts of the Trinity Alps Wilderness, a Late Successional Reserve, a Roadless Area, a Research Natural Area, an Indian Reservation, various Riparian Reserves, several plantations, along with general Forest land.

Adjacent community structures were not directly impacted, but smoke impacts were severe enough for both a state and federal state of emergency to be declared. The resulting tree mortality varied across the landscape from minor damage in previously treated shaded fuelbreaks to complete mortality in areas that had extensive blowdown related fuels from a windstorm that occurred over the winter of 1995-96. In several areas complete mortality stretches for miles across the landscape.

Now that the smoke has cleared, both short-term and long-term fuel treatment needs must be addressed. In the short-term, residual fuel from fireline construction and hazard trees along roads

present the greatest fuel and safety hazard. In the long-term, the standing dead component presents the greatest fuels hazard, especially when interspersed with a tremendous ingrowth of shrubs, grasses, hardwood sprouts, and conifer regeneration over the next 3-12 years. Opportunities for fuel treatments abound, but questions of priorities, environmental and political conflicts, cooperative ventures, research possibilities, and implementation restrictions and mitigations can make the process a daunting task.

This paper presents a process that moves us from existing guidance documents (i.e., the Land and Resource Management Plan, a Late Successional Reserve Assessment, and a Watershed Analysis) to potential landscape-level fuel treatment projects that can be further evaluated in environmental documents. By focusing on burn patterns across the landscape, the line officer's priority of community protection, and vegetative recovery patterns over time, a strategic, long-term fuel treatment program was developed for this area. As the infrastructure of building block treatments are created, the process will allow for "connecting the dots" on a landscape scale over an extended time frame.

## COMMUNITY PLANNING REGARDING FIRE ON THE SALMON RIVER

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The Salmon River is a 751 square Mile watershed located in the California portion of the Klamath River Basin. Private property accounts for only 1.3% of the Basin, with the publicly owned majority being under U. S. Forest Service management.

Since approximately 1911, the Forest Service has actively suppressed most fires occurring in the Basin. The suppression activities, along with resource management activities have created a landscape conducive to catastrophic wildfires capable of denuding large areas of our forested landscape.

The Salmon River Restoration Council (SRRC) has been involved in fire planning since 1994 when we started our Jobs in the Woods Program (JITW). The JITW Program is funded by the U. S. Fish and Wildlife Service and accomplishes fuels reduction activities on private properties in the Salmon River. The SRRC has also been working with the Forest Service to develop a basin-wide fire management strategy that will identify and prioritize areas where fuels reduction activities should occur.

The Salmon River Fire Safe Council (FSC) held its first meeting in December 2000. The mission of the FSC is to ".. help plan, monitor and implement the reinstatement of natural fire regimes in the Salmon River Ecosystem in a manner that protects life, property, improves forest health, and enhances the resources valued by its stakeholders." The FSC will be used for cooperative fire planning in the Salmon River Basin.

**FIRE ON THE SALMON RIVER**
**(POSTER)**

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The Salmon River area has experienced numerous wildfires since 1911. These fires have burned 44% of the Basin, while over 30% of the Salmon has burned since the mid 70s. Fire planning and fuels reduction activities need to be increased in order to begin reintroducing fire to its natural role in the Salmon River watershed.

# PART 7: COMMUNITY PERSPECTIVES ON THE RIVER AND ITS RESOURCES

## YUROK PERSPECTIVE OF TRINITY RIVER FISHERIES RESOURCES

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The Trinity River joins the Klamath River near Weitchpec, prior to flowing through the 44 mile Yurok Reservation and meeting the Pacific Ocean. The Yurok Tribe is the largest harvester of Klamath River Basin fisheries resources, which includes Trinity River chinook and coho salmon, steelhead, as well as lamprey and sturgeon. The existence of Yurok People has been intertwined with our fisheries resource since time immemorial. Our traditions, culture and religious ceremonies are intricately interwoven with the state of our natural resources. The construction of the Trinity Project, which extirpated anadromous fish from the Upper Trinity Basin as well as diverted up to 90 percent of the water from above Trinity Dam, has dramatically affected the health of the Klamath-Trinity Basin ecosystem, its fish populations, and subsequently directly affected the Yurok way of life. The Yurok Tribe unsuccessfully advocated for dam removal to be considered as an option for restoring the Trinity River, however we support the science that forms the foundation of the Record of Decision (ROD) recently signed by the Secretary of Interior. We look forward to the implementation of this ROD, so that our people can once again sustain themselves from the resources of a properly functioning Trinity River.

## DIVIDING THE HARVEST

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### ABSTRACT

The Klamath River fall chinook salmon are vital to the economies and culture of Northern California and Southern Oregon. In recent years, there have been many changes in the management of this important stock of fish. The reaffirmation of Tribal fishing rights have created new guidelines for the allocation of harvest. The reallocation of harvest combined with a harvest rate management policy designed to protect the spawning escapements, have increased restrictions on many segments of the fishing community.

This presentation will provide a basic overview of the history and development of Klamath River fall chinook management and allocation policies including the legal background and basis of Klamath River Tribal fishing rights, and the background and current principles of Harvest Rate Management.

## A BRIEF HISTORICAL PERSPECTIVE

### Indian Fishing

The Native People of the Klamath River Basin have depended on the salmon of the River since time immemorial. The awesome cyclical nature of the salmon's yearly migrations over the centuries influenced almost every aspect of their lives. Religion, lore, law, and technology all evolved from the Indians' relationship with the salmon and other fish of the Basin. The Supreme Court recognized the importance of salmon to Northwest Tribes such as these, when it concluded that access to the fisheries was "not much less necessary to the existence of the Indians than the air they breathed."

Such dependence on salmon required conservation measures to assure that the bounty would continue. Traditional fishing methods for salmon included the use of gill nets and dip nets made from Iris leaf fiber, spear fishing, and communal fish dams. Traditional fishing sites were, and to a great extent still are, considered privately owned. The right to fish at a particular site was transferable and governed by complex rules and laws. To ensure adequate subsistence for all, communal fish dams temporarily built at selected sites. Possibly the most advanced accomplishment of California Indians was the annual construction of the fish dam at Kepel. Several hundred people were involved in the construction, using log frames and a latticework of slats and poles to temporarily impede upstream migration. Every aspect of its construction and use were highly ritualized to ensure that the subsistence needs of all would be met and the salmon runs perpetuated.

Aboriginal fishing people faced the basic fishery management problems of today: how to cope with natural salmon population fluctuations and, how to control harvest while maintaining a viable economy. As evidence of their success, after thousands of years of harvest, when the first major immigration on non-Indians arrived at the Klamath in 1850 the River was "alive with the finny tribe."

The Indian people of the Basin signed treaties with the Government in 1852, but due to public pressure the treaties were never ratified. Instead, in 1855 the lower 20 miles of the River was set aside by Executive Order as the Klamath Indian Reservation. The administration of the Reservation was then severely disrupted by the flood of 1860-61.

Due to local feeling that the Reservation had been abandoned after the flood, Mrs.'s Richardson and Jones, two early settlers of Crescent City, started the first commercial fishery on the Klamath in 1876. They were evicted as trespassers on the Klamath Reservation by orders of the Federal Government in 1879. Amid a flurry of politics and confusion over the status of the Reservation, R. D. Hume of Oregon successfully challenged the ban on non-Indian fishing in the River. In a case known as "Forty-Eight Pounds of Rising Star Tea, Etc." The judge found that although the land was still the property of the Federal Government the Reservation had been abandoned after the flood. This decision, in 1888, allowed the unimpeded development of commercial fisheries on the Klamath and led a misinterpretation of the jurisdictional status of the Reservation and its fisheries for almost a century.

The commercial fisheries, while owned by non-Indians, primarily employed the resident Yurok people as fishermen and cannery workers. In the early years, the remoteness of the location and

attendant transportation problems kept the commercial efforts from expanding, but the fishery continued to provide a beneficial income for the People until the early 1930's.
On January 1, 1934, primarily due to efforts of the sport fishing community, all commercial fishing on the River, and use of Indian gill nets on the lower 20 miles, was banned by the State of California. Tribal commercial fishing rights were not to be reaffirmed until the late 1970's.

**The Ocean Fisheries**

Salmon fishing by non-Indians in California started in the early 1850's, coincidental with the massive inflow of miners into the "gold country". By the 1860's commercial fisheries were well established on the Sacramento system, and on the Eel River in Humboldt County. It was not until the early 1900's, with the proliferation of internal combustion engines, that serious salmon fishing started in open water. The ocean salmon troll fishery began in earnest in Monterey Bay; by 1910 there were 200 boats fishing out of that port (McEvoy, 1986).

The terminal fisheries in the rivers gradually gave way to the ocean fisheries in importance; by 1915 ocean harvests exceeded California terminal harvests, and the last cannery on the Sacramento closed in 1919. By 1923 the ocean troll fleet had expanded its fishing grounds north from Monterey to Crescent City. The fishery remained somewhat static until the mid-1940's when, with the end of the War, improved transportation, and a rebound in the salmon populations led to a dramatic expansion of effort. In 1935 the salmon fleet had consisted of 570 trollers, by 1947 that number had increased to 1,100. (McEvoy, 1986).

The ocean troll fisheries operated basically without restrictions through 1948. In 1848 the Pacific Marine Fisheries Commission (PMFC, not to be confused with PFMC) was formed by the Western States to: "promote the better utilization of fisheries…which are of mutual concern,…and to develop a joint program of protection and physical waste of such fisheries…"(Article I). This Compact led to more coordinated seasons and size limit considerations for the ocean troll fleet. The season for salmon fishing in the ocean was generally set to start May 1st of each year and run through September 30th. The salmon fishery flourished, and in the years between 1947 and 1970, "some one-half million to one million Chinook salmon" were landed annually off California (Bearss, 1983).

Under the new management regime of the Pacific Fishery Management Council, open fishing seasons began to change. Beginning in 1979, in the area known as the Klamath Management Zone (KMZ) off Northern California and Southern Oregon, seasons have become increasingly restrictive in order to reduce impacts on Klamath River origin chinook salmon. Commercial troll fishing in the KMZ, (from Point Delgada, north of Fort Bragg, to Cape Blanco near Port Orford) was completely prohibited during the 1985 season. Subsequent commercial seasons in the KMZ have been extremely limited, and allowed under limited quotas if at all.

**In River Recreational Fisheries**

Recreational fishing on the Klamath River depended on access. In the summer of 1894 the first through road, using a ferry at the Klamath, from Eureka to Crescent City was completed; with the advent of the automobile the area was ready for tourists. By the end of 1923 the new Redwood Highway, still bridge-less, was complete. The new highway included among its travelers the author Zane Grey, who stopped at the Klamath, and was fortunate enough to land a 57-pound salmon on

light tackle. Grey reported in a January 1924 article in Outdoor America, that it was "the most thrilling and fascinating place that I have ever seen." (Bearss, 1983)
In the mid-1920's several small canneries opened to cater to the hundreds of sportsmen lining the banks, and trolling the waters of the estuary. A fisherman's catch could be canned, including personalized labels, and saved for future use. The Bridge across the Klamath was finally completed in 1926, and in 1936 the California Chamber of Commerce reported that: "some 30,000 families vacationed that year in the Klamath-Trinity Basin, where they were served by eighteen private resorts and campgrounds, and another five operated by the U.S. Forest Service." (McEvoy, 1986)

In the mid-1950's recreational fishing in the Klamath had only increased in popularity, anglers in 1956 landed 15,000 fish in the estuary alone. In 1955 - 1956 from 1.200 up to 3,200 salmon per day were landed by sportsmen in the estuary (Bearss). Then, intensive logging initiated in the 1950's, and the construction of Dams and diversions on the system in the early 1960's, began to have serious impacts on the salmon populations. By the late 1970's the number of adult chinook taken by hook and line in the estuary dropped to a low of five to eight hundred fish per season.

The in-river recreational fishery is represented on the KFMC, and since 1986 has fished under a quota system based on annual predicted populations.

## TRIBAL AND NON-TRIBAL ALLOCATION

### Doctrine of Reserved Rights

People often mistakenly consider that "Indian Rights" are special rights that have been granted to Indian people by the United States Government. The fact is that these rights, such as Tribal fishing rights and the right to self-governance, are rights that the Indian People as sovereign nations had prior to conquest, and that they retained (Reserved Rights) when they gave up their land by Treaty or Agreement.

### Basics of Treaty Interpretation

The United States Constitution in Article VI, Section 2 states, "…and all Treaties made, or which shall be made, under the Authority of the United States, shall be the supreme Law of the Land; and the Judges in every State shall be bound thereby, any Thing in the Constitution or Laws of any State to the contrary notwithstanding."

In what is now Washington State, in the mid-1850', the Government negotiated treaties with the Tribes. "The principle purposes of the treaties were to extinguish Indian claims to the land and to allow a peaceful transition to occur between Indians and non-Indians in the area." The language reflected in most of these treaties with regard to the issue of Indian fishing rights stated in part: "The right of taking fish, at all the usual and accustomed grounds and stations, is further secured to said Indians in common with the citizens of the territory…" (Treaty of Medicine Creek, Art. 3, 10 Stat. 1132 (1855).

Under the treaties Tribes of the west gave up millions of acres of land in exchange for small reservations set aside for their exclusive use. While they gave up their land, they reserved their right to fish. "The treaties were 'not a grant of rights to the Indians, but a grant of rights from them, a reservation of those not granted.' United States v. Winans, 198 U.S. 371 (1905)." (Madson and Kross, 1988)

In 1871 the Government stopped signing Treaties, and moved to a process using formal Agreements. The only real difference was that while Treaties only had to be approved by the Senate, Agreements needed to be ratified by both houses of Congress. In addition, Reservations, such as the Hoopa Valley and Yurok Reservations, could also be created under statutory authority by Executive Order of the President. The Reservations in the Klamath Basin were created pursuant to a statute of March 3, 1853 authorizing the President to create Indian reservations in California "for Indian purposes".

The words "for Indian purposes" are important here, for as the Department of the Interior's Solicitor explained in 1993: "A specific, primary purpose for establishing the reservations was to secure to the Indians the access and right to fish without interference from others….the Indians' reserved fishing rights were of no less weight because they were created by executive orders pursuant to statutory authority rather than by treaty. Courts have uniformly rejected a 'treaty vs. non-treaty' distinction as a basis for treating Hoopa and Yurok fishing rights differently from the treaty-reserved fishing rights of tribes in other areas of the United States."

**Review of Local Fishing Rights Case Law**

After the flood of 1861, which left the Klamath Reservation decimated, the Forty-Eight Pounds of Rising Star Tea case, which found that the Reservation had been abandoned, and the allotment of lands to non-Indians; the State of California assumed it had jurisdiction over all fishing on the Klamath River. The State strictly controlled Indian fishing, and in closing the in-river commercial fishery in 1934 banned the use of gill nets in the lower 20 miles of the River even for subsistence fishing. The State's jurisdiction over Indian fishing was not challenged until 1969. In September of that year, Raymond Mattz, a Yurok fisherman, had his gill nets confiscated by the State from the banks of the lower River. Mattz contended that he was an enrolled member of the Yurok Tribe, fishing in "Indian Country", and that State law did not apply. He lost his case in two lower courts, but the Supreme Court, in Mattz v. Arnett, reversed the lower courts' decisions and found, in 1972, that the Act 1892 opening the Reservation to allotment and non-Indian settlement did not terminate the Reservation. The land within the Reservation boundaries was still "Indian Country." Based on that decision the First District Court of Appeals, in Arnett v. 5 Gill Nets (1975) found that the right of an Indian to fish on reservation was created by presidential executive order which was derived from a stature and thus not subject to state regulation;…"

The Bureau of Indian Affairs (BIA) took over management of the Indian fishery, and under regulations issued in 1977 reopened to lower 20 miles of the River to gill net fishing for subsistence and commercial harvest. The to public pressure, the BIA closed the Indian fishery in 1978 for "conservation" purposes. The closure, protested by the Indians, was effected by "strike force" of 35 Federal Special Agents supplemented by U.S. Park Service and BIA officers. The Conservation Moratorium on Indian commercial harvest remained in effect until completion of an EIS on the issue in 1987.

During the Conservation Moratorium in September of 1980, Walter McCovey, Jr., a Yurok fisherman, was charged with a felony violation of the California Fish and Game code: Mr. McCovey had been intercepted while attempting to sell salmon he had gill net harvested on the Reservation. Once again, the court found that the State lacked jurisdiction and held that the comprehensive federal regulation of Indian fishing rights preempted the State from criminally prosecuting Yurok fishers for the commercial sale of salmon harvested on the Reservation. (People v. McCovey, 36 Cal. 3d 517, 1984)

In 1987, with and allocation of approximately 30 percent of the allowable harvest under a Five Year Agreement with the Klamath Fishery Management Council, and with the completion of the EIS on commercial fishing, the Yurok Tribe opened the first uncontested commercial fishery in 54 years. Stock abundance predictions allowed for Indian commercial harvest in 1987, 1988, and 1989.

The Five Year Agreement instituted by the KFMC ended after 1991, and due to depressed salmon populations and predictable harsh closures on all fisheries, a new allocation agreement could not be reached.

Through the fall of 1993, according to the Department of the Interior, the PFMC ocean harvest regulations had failed to meet conservation requirements and was adversely affecting the Tribes' reservation fisheries. The Secretary of Commerce and the Secretary of the Interior met to coordinate regulations for the 1993 harvest and concurred that the Tribes were entitled to a 50 percent share of the available harvest. During the 1993 season setting process the PFMC recommended ocean harvests that would fail to meet the resource rights of the Tribes. The Secretary of Commerce suspended the PFMC's regulations, and under emergency regulations set a lower allowable harvest for ocean fisheries and allowed for a higher predicted in-river run and spawning escapement. Interior adjusted the Tribal allocation to near fifty percent. In October of 1993, the Department of the Interior's Solicitor issued a Memorandum (M-36979) concluding that: "…when the United States set aside what are today the Hoopa Valley and Yurok Reservations, it reserved for the Indians of the reservations a federally protected right to the fishery resource sufficient to support a moderate standard of living or 50% of the harvest of Klamath-Trinity basin salmon, whichever is less."

Ocean commercial fishermen alleged that the Secretaries of Commerce and Interior had violated the Magnuson Fishery Management and Conservation Act by reducing the allowable ocean harvest rate for 1993. The U.S. 9th Circuit Court of Appeals, in 1995, disagreed, finding that under the Magnuson Act Commerce may issue regulations affecting coastal fishing to protect against violations of "other applicable law." The Court concluded that the Secretary of Commerce "is a trustee of tribal interests as well as the administrator of the Magnuson Act; (and that he) properly considered the Tribes' fishing rights (as other applicable law) in issuing emergency regulations reducing ocean harvest limits of Klamath chinook."

## THE HARVEST MANAGERS

Salmon know no jurisdictional or political boundaries. They are hatched in the rivers, then emigrate downstream to the ocean, and spend the majority of their life freely feeding and growing in vast areas of the open ocean. Upon reaching adulthood, generally three or four years of age, they return to the river of origin and migrate upstream to spawn and die. During the course of their life they are subject to harvest by fishermen who are regulated by a variety of agencies, all of which must be carefully coordinated to prevent over harvest in any one area.

**Ocean Fisheries**

**The Pacific Fishery Management Council**

The Pacific Fishery Management Council (PFMC) and seven other regional councils were created by the Magnuson Fishery Conservation and Management Act in 1976 with the primary role of developing, monitoring and revising management plans for fisheries conducted within the 3-200 mile limit of the U.S. coast. The PFMC develops plans for ocean fisheries off California, Oregon, and Washington.

The Council is not a federal agency, but is a regional body funded through the Department of Commerce. It has (fourteen) voting members, including the Regional Director of the National Marine Fisheries Service, chief fishery officials of Oregon, Washington, California, Idaho, eight knowledgeable private citizens chosen by the Secretary of Commerce from lists submitted by each state governor, and since 1997, one new Tribal seat. Non-voting members include the Director of the Pacific Marine Fisheries Commission, the Regional Director of the U.S. Fish and Wildlife Service, and one representative each from the Alaska Governor's office, the U.S. Department of State, and the Pacific Area Commander of the U.S. Coast Guard; (From PFMC "Form and Function", 1988).

The PFMC has a professional staff headquartered in Portland, Oregon; a Scientific and Statistical Committee (SSC); and three separate Technical Teams including a Salmon Technical Team, and several citizens' advisory panels including a Salmon Advisory Sub-panel (SAS).
When the PFMC was formed in 1976, it recognized that the salmon resources off the Pacific Coast required immediate attention because of conservation and allocation problems. Consequently, the first fishery management plan (FMP) prepared by the Council dealt with commercial and recreational fisheries for chinook and coho salmon. Federal and complimentary State regulations implemented that plan in 1977.

The PFMC now has a basic "Framework Plan for Managing the Ocean Salmon Fisheries off the Coasts of Washington, Oregon and California". Certain principles of the Plan are fixed, such as a river's spawning escapement goal, in order to provide a long-term management system that cannot be altered without a plan amendment. Other elements are flexible, such as season regulations, and are determined before each season according to fixed guidelines and timeframes contained in the Framework Plan.

Under the Framework Plan the coast from the U.S. Canadian border to the U.S. Mexican border is divided into four major geographic management areas and separate FMPs have been adopted for principle stocks or stock groupings of salmon. Management Plans for chinook salmon are in place specifically for the: Central Valley, Klamath River, Northern California Coastal Stocks, Columbia River, and Washington Coastal stocks. Coho Plans regulate harvest of the California, Oregon, and Washington Coastal Stocks, and Columbia River and Puget Sound stocks.

**State Management**

While the Federal Government has regulatory jurisdiction over salmon fishing regulations from three miles to two hundred miles off the coast, the jurisdiction over the area from the shore out to three miles falls with the States. Thus, the States of Oregon and California have primary jurisdiction for regulations concerning near shore ocean commercial and recreational fisheries, but generally manage based on harvest levels stipulated by the PFMC. The California Department of

Fish and Game confirms their annual ocean commercial fishing regulations in April of each year subsequent to recommendations from the PFMC. The California Fish and Game Commission also meets in April meeting to establish proposed ocean recreational fishing regulations for the season.

**River Fisheries**
**Management of Klamath Basin Tribal Fisheries**

The State of California regulated all fishing in the Klamath River Basin, including Indian fishing, until 1977. From 1934 until 1977 the State had prohibited all Indian gill net fishing on the lower 20 miles of the River. State regulation of the Indian fisheries ended in 1977 after two court cases (Mattz v. Arnett and Arnett v. 5 Gill Nets). The two cases determined, first, that the old Klamath Indian Reservation had not been abandoned and that it was still "Indian Country", and as a consequence, the State of California did not have the jurisdiction to regulate Indian fishing on the Klamath.

Regulation of Indian fisheries on the Hoopa Valley Reservation, which at that time included what is now the Yurok Reservation, was taken over by the Bureau of Indian Affairs (BIA) in 1977. Through a 1978 Memorandum of Understanding between the Indian Affairs and Fish, Wildlife and Parks, the U.S. Fish and Wildlife Service (U.S.F.W.S.) provided yearly evaluations of the salmon runs into the River and monitored the Indian net harvest. The Hoopa Valley Tribe took over monitoring programs for their Tribal fisheries on the Trinity River portion of the Reservation in 1983. On the lower 43 miles of the Klamath River the U.S.F.W.S. continued monitoring the Yurok fishery until 1995 when the newly authorized Yurok Tribal Council, through their Fisheries Program, took over management of their fisheries on the Yurok Reservation.

Both Tribes now have full management authority over regulation of their fisheries. Harvest levels are set according to run predictions and allocation limits and regulations for quotas, closures, and gear are developed annually by the Tribes. Tribal regulations are reviewed by the Department of Interior to assure that the Trust Responsibility for the resource is being met.

**River Recreational Management**

The State of California, through the California Fish and Game Commission, retains full regulatory authority over the Klamath River recreational fishery. The Commission now convenes in early March of each year for a policy decision on the upcoming season's in-river recreational allocation. The expected harvest allocation is then forwarded to the KFMC and the PFMC for their consideration in setting ocean seasons.

**Cooperative Management**
**Klamath Fishery Management Council**

Due to predicted unprecedented closures of ocean fisheries in 1986, a Klamath Salmon Management Group (KSMG) was formed in 1985 under the PFMC to discuss Klamath River Fall chinook issues. This Group set its own precedent by bringing together, for the first time, Federal, State, Tribal, and commercial and recreational fishing representatives for the negotiation of management and allocation issues. After arduous negotiations they arrived at consensus recommendations to the PFMC for a new method of managing harvest to meet the River's spawning escapement goal, and an Agreement on how to divide the predicted harvestable salmon in 1986. It was this group which initiated the for the Klamath River its current form of management, known as Harvest Rate Management, and the first formal allocation of part of the harvest to Tribal fisheries.

Congress adopted the Klamath Basin Restoration Act (PL 99-552), in October of 1986. The Act created a new 11 member Klamath Fishery Management Council (KFMC) to supersede the original Management Group. The KFMC's advisory function is to make harvest management recommendations to the various management agencies including annual recommendations to the PFMC. All recommendations passed forward to agencies or to the PFMC must be with the consensus of all members.

## UNDERSTANDING HARVEST RATE MANAGEMENT INTRODUCTION: PROTECTING NATURAL STOCKS

### Salmon Life History

Salmon harvest management in general, is difficult due to the life cycle and migratory habits of the species. The chinook salmon of the Klamath Basin are an anadromous fish, that is they spawn in the fresh waters of the River, emigrate to the ocean in their first year, grow to maturity in the ocean, and return to their home River to spawn and die. These salmon generally mature to spawning age at three or four, and sometimes five years of age. There are some precocious individuals, generally males, who mature at age two and participate in the spawning migration. During their residence time in the ocean salmon are subject to harvest by commercial and recreational fisheries, and upon returning to the River at maturity they are harvested by in-river recreational fishermen and Tribal fisheries.

The Klamath River, as with other managed rivers, has populations of both natural spawning salmon and hatchery reared salmon. To protect the long-term genetic integrity of the chinook salmon, it is the natural component of the stock towards which conservation management is directed. One of the primary fishery management objectives of the PFMC's Framework Plan is to allow "Escapements of viable natural spawning of salmon…sufficient to maintain or restore the production of such stocks at optimum levels."

## HARVEST RATE MANAGEMENT

The ultimate goal of harvest management is to allow a defined number, or percentage, of a salmon population to escape harvest, and return to the river to spawn, in numbers sufficient to assure the future reproductive capacity of the species while allowing for future harvest. This management concept, which is termed "Maximum Sustainable Yield" (MSY), evolved though the need to protect the fish populations from over harvest. Technically, MSY is defined as "An average (yield) over a reasonable length of time of the largest catch that can be taken continuously from a stock without reducing its long-term reproductive potential."

Ideally, under the concept of MSY, one would know how many spawning fish a river system could support (the carrying capacity), and in addition to the reproductive capacity of the individual of the species, the survival rate of the offspring. Then one could simply calculate how many spawners were required (the spawning escapement), and what portion of the population could be harvested. The real biological and political world is not that simple.

In its early management of the Klamath River, based on data of past escapements, the PFMC set a goal for the number of adult fish escaping from the ocean to the River mouth to be 115,000 adult Fall chinook. This figure included both Trinity and Klamath stocks and hatchery and natural fish.

This "ocean escapement" goal policy rather than a "spawning escapement" goal was put in place because of the separate jurisdictional areas. The PFMC, under the Department of Commerce, regulated the ocean fisheries, but the Department of the Interior regulated the in-river Tribal fisheries. As a result, the final responsibility for the spawning escapement was left with Interior and the State of California who regulated the in-river recreational fishery. In addition to the disjointed management jurisdictions, there was a problem with determining the proper spawning escapement goal for the system. Having a fixed escapement goal is fine, if you know the carrying capacity of the system. In the case of the Klamath Basin, however, there had been radical changes since the 1960's in the number of stream miles available for spawning and in the River's flows and related suitable spawning and rearing habitat. The carrying capacity of the system was not defined.

In 1987, based on recommendations of the KFMC, the PFMC changed the spawning escapement goal for the Klamath Basin. Instead of having a fixed numerical ocean escapement goal they adopted a policy of "Harvest Rate Management." Under Harvest Rate Management, whether the overall stock populations are high or low, the management goal is to allow a fixed percentage of all salmon from each brood year to spawn. This management method provides two advantages. First, it allows the spawning escapement to fluctuate; in high population years the escapement would be larger than if the stock was fished down to a fixed numerical escapement, and in low years fisheries would not be closed to meet an escapement level that was not attainable. Second, having the wide range of escapements allowed under Harvest Rate Management will allow the eventual determination of the carrying capacity of the system. To protect the stock in years of very low abundance, an escapement "Floor" of 35,000 natural spawners was put in place.

Equally, or even more, important is the fact that the KFMC process committed all management agencies to the Harvest Rate management policy, so all agencies, Federal, State, or Tribal are managing to achieve the same stated overall harvest rate and escapement goals.

**Escapement Rate Goal**

Management of ocean salmon fisheries is complex. When fishing in the ocean, a troller or recreational fisherman's catch can include any one of the from two to five year old age class fish, and it will include salmon from other river systems. All of these components have different levels of vulnerability to the fishermen's efforts depending on size limits, age class strengths, relative population abundance, and seasonally fluctuating patterns of distribution throughout the fishing grounds. All of these parameters must be taken into account when designing regulations. Under Harvest Rate Management the ocean and river fisheries are managed to meet harvest rate combinations (total percent of harvest) that will allow approximately 33 percent of the potential natural adults from a given brood year to escape all fisheries and spawn.

To allow for the proper percentage of mature Klamath salmon to escape all ocean fisheries it has been calculated that each year ocean fisheries should restrict their take to approximately 20 percent of the four year old age class. Of course, ocean fisheries while harvesting at that .20 harvest rate in a "mixed stock fishery" will also catch two, three, and five year old Klamath salmon, and salmon from other systems. But, the .20 harvest rate on "fully vulnerable" four-year-olds, over the long term, is the current management goal.

In River, the Tribal and recreational fisheries only harvest mature Klamath salmon that have returned to the River to spawn. The only "mix" of the fish to be considered is whether they are hatchery or natural, or from the Klamath or Trinity side of the Basin. For harvest rate management purposes they are all considered "Klamath Fall Chinook" and the desired long-term harvest rate is .66 on the four-year-old component.

These combined harvest rates, .20 for ocean fisheries and .66 for river fisheries which over the long term will allow for the 33 percent escapement rate are termed "full fishing" and can only be applied when the resultant escapement of natural spawning fish is calculated to be greater than 35,000. If those combined harvest rates would result in an escapement of less than the 35,000 floor then they have to be modified downward to meet the escapement floor and ocean and river fisheries are restricted accordingly.

## ALLOCATION CALCULATIONS

The spawning escapement is the driving factor in Klamath Fall Chinook management. Each year the long-term allowable combined harvest rates are mathematically applied, using a "Harvest Rate Model" (HRM), to the predicted pre-season ocean stock abundance. This model then calculates what the natural and hatchery escapements would be under full fishing harvest rates. The resultant escapement is then fixed as the goal for that year. After the required escapement has been determined, the total allowable harvest is then known. The computer model is then used to determine the numerical value of each fishery's allocated harvest. The first division is between Tribal and non-tribal fisheries; each are allocated fifty percent of the available harvest. Then, based on prior negotiations, the in-river recreational allowable harvest is set as a percentage of the total non-tribal allocation. The end calculation results in the total number of Klamath salmon allocated for ocean harvest. Ocean fishermen, during the annual PFMC regulation process, then develop options for dividing the ocean allocation between Oregon and California commercial trollers and ocean recreational fisheries. Table 1. Shows the primary distribution of available harvest allocated in 1997.

| Tribal Share 50% of the total | Non-Tribal Share 50 Percent of the Total |
|---|---|
| Yurok Tribe 80 Percent | Ocean Commercial 71 Percent |
| Hoopa Valley 20 Percent | Ocean Recreational 14 Percent |
| | River Recreational 15 Percent |

### Tribal Process

After confirmation of the total allowable harvest the Tribes hold community meetings for Tribal Member input on regulations for time and area closures required adhere to harvest quotas. The Tribal Councils also make the determination as to whether there is sufficient harvest opportunity to consider commercial fisheries, or whether fishing should be limited to subsistence harvest.

### Post Season Estimates

### Harvest Estimates

The majority of the juvenile fish reared in hatcheries have microscopic size "Coded Wire Tags" (CWT) implanted in their snout prior to being released. They also have the small fatty adipose fin from their back clipped off, denoting them as CWT fish. When these marked fish are harvested, or return to the hatcheries as adults, the CWT's are extracted and decoded. The tags provide information on where they were reared and released, when they were released, what size they were, and how many were in the release group. Based on calculated ratios between the number of marked hatchery fish and unmarked and natural fish biologists can then determine the contribution of a stock of fish to the total harvest and estimate overall harvest impacts to specific stocks.

During the season the States of California and Oregon monitor the harvest of salmon. Port samplers examine a portion of all landed commercial and recreational caught fish and recover coded wire tags, length weight ratios of a portion of the catch, and harvest time and area information. This data is applied to the total sales receipts of the commercial catch and the total harvest estimates of the recreational fisheries. Post-season estimates of the total number of Klamath fall chinook harvested in the mixed-stock ocean fisheries can then be calculated. In the River the Hoopa Valley and Yurok Tribal fisheries staff monitor Tribal harvests. During subsistence only fisheries, nets are enumerated and sampled for CWT's, total harvests are calculated based on estimates or counts of total nets, and average catch per net for each area and net type. During commercial fisheries on the Yurok Reservation the total commercial harvest is counted and sampled at a single on Reservation buying station.

The California Department of Fish and Game monitor recreational fisheries in river. Samplers are stationed to conduct a "creel census" at key access points along the lower six miles of the River. Scale samples and CWT's are collected and total lower-river harvest is estimated. In the upper reaches of the River monitoring of the widely dispersed and often remote angler effort is cost prohibitive. Harvest estimates are based on a ratio with down river catches.
Scale samples are also taken from all in-river harvests and spawned carcasses to assist in estimating the age composition of the in-river run. This analysis provides for the calculation of how many three, four, and five-year-old fish escaped ocean fisheries.

**Harvest Escapement Estimates**

One of the unfortunate aspects of salmon management is that you don't know how you're doing until it's all over. Each year ocean fisheries start in the spring or early summer, the in-river fisheries reach maximum effort during late summer and fall, and the final runs of the fish to their natal streams and the hatcheries is not complete until late November or December. Finally, at that point in time, an estimate of what the total population of adult fish was for that year is compared to what was predicted. Based on hatchery returns, spawning ground surveys, and harvest data, the total distribution of the population to harvest sector, and natural and hatchery spawning components can be enumerated. The California Department of Fish and Game summarizes this information in a "Mega-Table" in January of each year.

## ANNUAL MANAGEMENT PROCESS

**Preseason Predictions**

To determine annual allowable harvests and the required spawning escapement biologists must first calculate the predicted pre-season ocean stock abundance. This is an estimate of how many Klamath chinook will be in the ocean prior to the commencement of any fishing. The Klamath River Technical Assistance Team (KRTAT) initially handles the task. Following receipt of the previous year's data on the age composition of the run, the Team runs a regression analysis on the two and three year components of the past year's run of fish. In essence, what they are doing is calculating how many three-year-old fish are left in the ocean based on how many of that brood's population came into the River as two-year-old fish, and how many fours are left in the ocean based on how many three-year-olds came in to spawn. These predictions are then sent to the PFMC's Salmon Technical Team for review and distribution to managers and the interested public.

In February of each year the California Department of Fish and Game holds a Salmon Informational Meeting to inform the public of the past year's management results, and the upcoming season's estimated populations and management concerns. The Klamath Fishery Management also usually meets during this time frame to begin developing options for harvest allocation and regulation recommendations to the PFMC.

The Department of the Interior, through the Tribes, confirms at the KFMC and PFMC level, that they will be putting in place regulations and quotas targeted at a harvest rate that will allow them 50 percent of the available harvest while protecting the escapement.

The California Fish and Game Commission informs the PFMC by early March what the targeted in-river recreational fishery harvest will be based on a percentage of the overall non-tribal allocation.

The PFMC meets for four days in the early part of March to develop options for ocean commercial and recreational fisheries based on the number of fish available. The options are sent out for public review and the PFMC meets again in early April to adopt recommended options for regulation of ocean fisheries, which they submit to the Department of Commerce for final approval.

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## HISTORY OF THE YUROK FISHERIES AND CURRENT CHALLENGES (TRIBAL VIEW PANEL)

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The Yurok Reservation extends from the Pacific Ocean to 44 miles upstream. The existence of Yurok People has been intertwined with our fisheries resource since time immemorial. Before the invasion of non-Indians to our territory, our people enjoyed the benefit of 100% of our natural resources. Prior to the early 1930s, we commercially fished on the reservation until the State of California illegally denied our fishing right, which in reality reallocated the harvest to non-tribal ocean fishermen. We were denied the right to fish traditionally for nearly 50 years, until the “fish wars” of the 1970s and 1980s, when our reserved right was reaffirmed. This was followed by litigation that led to the Supreme Court, and resulted in a reaffirmation of our right to 50% of the available harvest. Unfortunately, by the time our fishing right was reaffirmed, our fisheries resource had dramatically declined from poor land and water management practices. Today, we strive to work with the same groups that we once battled with regarding fish allocations, to restore the fisheries resource that is so important to us all. We now face new challenges to ensure that our people benefit from a meaningful right to Klamath Basin fisheries resources.

## ESA LISTINGS MISUNDERSTOOD BY THE PUBLIC

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### ABSTRACT

Recent Regulatory and Policy decisions have caused serious misunderstandings between State and Federal Agencies, Tribal members and Landowners within affected Counties. The primary cause is the prolific listing of species under the ESA without appropriate science to validate the

listings. For 127 years the Grange has been committed to the protection of the resources on our lands, streams and rivers.

To reduce misunderstandings several options are to be presented. Multiple listings under the ESA are evaluated as to their scientific basis. It is imperative that procedures for listing or delisting species under the ESA would include the utilization of the National Science Foundation for final determination.

Excessive clearing of riparian zones, agricultural chemical pollution and poor bank stabilization measures have led to degradation of the waters within the Klamath River Basin and have contributed to the negative impacts upon instream biological life forms and water quality. Successful water conservation programs that address all aspects, such as underground resources, riparian zones, agricultural usage and dams are addressed and evaluated. The role of regulatory agencies within this context are assessed as to future programs that affect all aspects of the Klamath River Basin and its recovery.

**CALIFORNIA STATE GRANGE WATER POLICY**

Since the formation of the California State Grange in 1873 to protect the great agricultural resources of California it has promoted protection of our most valuable resource in the ground, creeks, streams and rivers of this Great State… Water. Only one percent of the entire planet's water supply is fresh and every means possible for its protection should be implemented, for without water there is no life.

From 1885 to the present day the Grange has considered water resources to be inalienable rights of the State and that permission of State authorities is a prerequisite for the diversion of water resources by the Federal government. To further delineate our position, underground water has in the past and is still considered to be an integral part of the land. Under this tenet we have and continue to maintain that it is illegal to transport underground water. We also maintain that all waters should be held in trust for the populace, agriculture, power production, fish, mollusks and industry within the County of origin prior to one gallon being diverted for any other usage.

As to development of the water resources we continue to encourage the building of dams for flood control, water storage and agricultural usage. We have held and still hold that dams, water and hydroelectric power should be owned and operated by the people for the people. In this vain it is imperative that licensees of dams who meet all the necessary requirements will have first preference for renewal or re-licensing and not have those rights abrogated by State or Federal agencies.

The management of this valuable resource and the support of the State's Wild and Scenic Rivers Act was an important step for the Grange to assure high standards for water quality throughout the State. However, with the Federal government's intrusion into the State's control of these Wild and Scenic Rivers the Grange has urged the United States Secretary of the Interior to return control of the North Coast Rivers back to the State -- to no avail. We now demand the removal of all California coastal rivers from the Federal Wild and Scenic Rivers Act and the return of the State's and County of origin rights.

Programs for the conservation and replenishment of underground water resources are an important step for the future and the Grange supports such programs. Towards these goals we support the implementation of regulations requiring that tile drainage water returning into canals or streams of origin must be treated and its quality made equal to the quality of the water in the canals or streams from which it was taken.

There can be no doubt of the California Grange's position that to maintain agricultural production it is imperative that our most precious resource, water, must be protected for not only agriculture but for the people, power, forests, fish, animals and the beauty of this Great State of California. The inalienable rights of the people and the State afforded by the United States Constitution and the Bill of Rights must not be abrogated. Water is life and the Grange supports this tenet for without food and water…. there will be none.

**ESA LISTINGS MISUNDERSTOOD BY THE PUBLIC**

I am Dr. Richard Gierak and am Overseer of the Greenhorn Grange, Director of Interactive Citizens United and the President of New Frontiers Institute, Inc. I hold a Doctorate in the Healing Arts and have degrees in Biology and Chemistry. I am presenting this paper on behalf of the California State Grange, which represents tens of thousands of families in the rural, agricultural and ranching communities throughout California. In the seven Western States the Grange represents over 100,000 families and on the National Level hundreds of thousands of families.

For 127 years the California State Grange has been a steward of the natural resources that affect agriculture, grazing, and their associated environments. Consistent with that responsibility, the Grange has and continues to support the Wild and Scenic Rivers act as an important step to assure high standards for water quality. There is little disagreement when this act is appropriately applied. The same applies to the Endangered Species Act, the Clean Water Act, and a host of other acts. However, in regard to these other acts, serious misunderstandings and disagreements exist not only between landowners, tribal members and the various regulatory agencies charged with implementing them, but between the agencies themselves.

**I. SCIENCE**

It has become apparent that listings of threatened or endangered species is out of control due to the utilization of "junk science" which has awakened the public and aroused their mistrust of the government and confrontational anger. To be specific, let me state a few of the most blatant abuses as it relates to the coho salmon listing from San Jose, California to Roseburg, Oregon:

1. 1993 Report by NMFS in their Oceanic report states that the El Nino of 1983-1985 devastated the coho salmon population off the coast of California.

2. 1993 Calif. Dept. of Fish & Game rep, Dennis Maria, indicated that they do not have any accurate coho counts in the Middle Klamath for the past 20 years.

3. 1994 FEMAT pg V-30 states: Current scientific understanding of fish habitat relationship is inadequate to allow definition of specific habitat requirements for fish throughout their life cycle at the watershed level.

4. Report to Congress Prepared by NOAA, NMFS February 1998: pg 11 Conclusions “Many salmonid populations, which are declining due to a host of factors, are being preyed upon by pinnipeds." "Pinnipeds can have a significant negative impact on a salmonid population."

Analysis: By searching government documents from 1985 through 1998 the following excerpts reveal that the listing of coho salmon under the Endangered Species Act has no basis in Science. Primary causative factor in the decline of the coho salmon in Northern California Rivers can be directly attributed to Nature's whim: ie, floods, fires, drought and El Nino causing warmer water conditions in the Pacific. The major human activities to significantly destroy the coho salmon population in Northern California can be attributed to the Marine Mammal's Protection Act which has allowed this predator to devastate as many as 98% of the anadromous salmonids. Removal of 66% of the viable eggs and shipping them to other fisheries in the 80's has not assisted in a re-vitalization of the coho salmon in Northern California.

1985 LRP Ch5, pg6.Since Mt. Shasta Hatchery is on the Sacramento, which does not have coho salmon, the coho from this source may have been from another California stream, such as the Noyo River (Bob Corn personal communication)

1985 LRP Ch5, pg3. Iron Gate Hatchery states ".Annual goals for coho salmon call for collecting 500,000 eggs to enable rearing of 75,000 yearlings for mitigation.." Iron Gate coho were planted in the Salmon River in 1985. 450,000 and 850,000 surplus coho eggs were shipped to the Mad River Hatchery in 1986 and 1987, respectively. 1989-1990 Mid-Klamath Sub-Basin Spawning Ground Utilization Surveys indicate that prolonged drought during the past decade has been experienced in Northern California. This would certainly have a marked effect on achieving and maintaining "normal" instream flow regimes and related depth dependent water temperatures that might have a substantial impact on salmon.

Predation: Both El Nino and the recent drought have been cited as having an effect on the prey and predator species distribution. Threatened California sea lions were porking out on threatened salmon. Efforts to capture and relocate harbor seals exhibiting the same tendency have been unsuccessful in solving the problem. The LRP (Ch4, pages 37-39), states that estimates of mortality of anadromous salmonids from natural predators run as high as 98 percent (Fresh in Steward and Bjornn 1990) Yuroks traditionally harvested marine mammals (McEvoy 1987), but today many of these species are protected by the Marine Mammals Protection Act." In the typical logic of fisheries scientists, the report proceeds to ignore its own stated facts in favor of the politically correct.

1990-1991 According to Klamath National Forest Planner Jim Anderson, studies indicate that the largest contributions to sediment load in the Klamath Basin are from natural causes, including landslides and erosion after fire.

1991 Marine Fisheries Biologist in report to NMFS indicated floods of 1955 and 1964 on the Klamath River destroyed riparian habitat and salmon spawning beds by depositing from 10 to 30 feet of sediment and debris. 1991 "Coho were once abundant in the lower Klamath tributaries (Snyder 1931)". The exact status of wild coho populations in the lower river today is not known. U.S. Fish and Wildlife outmigrant studies 1990a indicate very few juvenile coho are present in the smaller Klamath tributaries.

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1994 FEMAT pg V-30 states: Current scientific understanding of fish habitat relationship is inadequate to allow definition of specific habitat requirements for fish throughout their life cycle at the watershed level. 1998 It is interesting to note that although the coho salmon spend over 95% of their life cycle in the oceans that said oceans are not part of "critical habitat". Another important factor in this diminution of coho salmon are the foreign fishing fleets trailing 15 to 20 mile long gill nets taking any species that happens to swim into them.

NOAA Technical Memo NMFS-NWFSC-28 March 1997 Working Group Included James Lecky of NMFS "In the 1994 Amendments to the MMPA, Congress directed that a scientific investigation be conducted to "determine whether Calif. sea lions and Pacific Harbor seals are having a negative impact on recovery of salmonid fishery stocks." "NMFS determined it did not have the resources nor was there sufficient time within a 1 year time frame" However, they reported the following: "The Calif. sea lion population has been increasing at an annual rate of about 5% since the mid-1970's. Harbor seal population have been increasing at a rate of about 5-7%." "Predation by Calif. sea lions and Pacific harbor seals may now constitute an additional factor in salmonid population decline and may affect recovery of depressed salmonid population.: Since passage of the MMPA in 1972 populations of Calif. sea lions and Pacific harbor seals have increased steadily in Washington, Oregon and California. These two pinniped populations are healthy and productive, and are not considered to be depressed, threatened or endangered."

Report to Congress Prepared by NOAA, NMFS February 1998: pg 11 Conclusions: "California Sea Lions and Pacific Harbor Seals are abundant, increasing, and widely distributed on the West Coast. Many salmonid populations, which are declining due to a host of factors, are being preyed upon by pinnipeds." "Pinnipeds can have a significant negative impact on a salmonid population." Status of Pinnipeds pg 2: "California sea lions, for example, are now found in increasing numbers in northern waters, in inland waters, and upriver in freshwater in many West Coast systems. They are also now found near man-made structures such as dams or fish passage facilities with increasing frequency".

Dr. John Palmisano, a former NMFS marine mammal biologist in Juneau, Alaska, taught fisheries and biology at U of Washington. He was also an environmental scientist for a consulting firm in Bellevue, WA. (503 645-5676)) 1997: pg2. "Coastal waters from Mexico all the way to Alaska have gradually warmed since the climate shift of the 1970s and the subsequent, periodic affects of El Nino." "It is estimated that 40 - 80 percent of estuarine habitat along the Pacific Northwest has been diminished or destroyed". "It is clearly not the perceived mismanagement of inland streams and rivers that has caused the recent degradation of the salmonid population".

The following quotes were obtained from the Los Angeles Times, Fri Oct. 23, 1998 by Marla Cone. National Research Council "It has come to our attention that the 25 member committee of the National Research Council in its report entitled, "Sustaining Marine Fisheries," has recommended immediate and substantial reductions in ocean fishing to rebuild marine ecosystems throughout the world that are so severely depleted they are in danger of collapsing. The total volume of fish being caught has reached or exceeded the maximum amount that can be sustained by the world's oceans, the scientists reported. About 84 million metric tons of fish and other seafood are caught each year in marine waters worldwide, worth about $3.5 billion a year in the United States alone. When it comes to individual fish stocks, 30% of the world's stocks have been overfished below the point where they can keep producing the current yield, and 44% are being fished at or near that point, according to the scientists, led by biologist Harold Mooney of Stanford University.

Terry Garcia, Assistant Secretary of Commerce According to Assistant Secretary of Commerce, Terry Garcia, who oversees ocean issues, the scientists' findings confirm the warnings that the federal government has long been issuing. "The world's oceans cannot sustain" the high demand for food, said Garcia, calling it "a very serious problem."

The scientists said they had "no silver bullet to offer," but advised governments in the short term to impose "substantial global reductions in fishing capacity."

Zeke Grader of the Pacific Coast Federation of Fisherman's Assns. stated, "In some fisheries there's just too many vessels and we're going to have to figure out ways...to retire them."

Warner Chabot of the West Coast chapter of the environmental group, Center for Marine Conservation, has stated "Fundamentally, we've still got too many boats chasing too few fish and political decisions preventing us from taking action on that. The fleet is much bigger and more sophisticated than the resource can accommodate." Chabot also said about 27 million tons of marine life are discarded each year. " When you consider that some 111 metric tons of marine life are caught each year and that 27 million tons are discarded due to archaic rules and regulations it would seem logical that rather than dumping overboard millions of tons of marine life should find a way to minimize the penalties and establish methods to reduce the bycatch waste. By not dumping the bycatch you could reduce the overall catch by 25% and still meet the present needs for food.

In direct contradiction to the above stated documents the National Marine Fisheries Service in 1997 listed the coho salmon as Threatened and attributed the decline to human activities at the watershed level and have instituted regulations which affect every landowner, agricultural activity, ranching activity and dam operation along streams and rivers in Northern California and in Southern Oregon.

The following data was supplied by the Iron Gate Hatchery located in Northern California: Appendix Table 3 Summary of Coho Salmon and Steelhead Trout runs :: Iron Gate Salmon & Steelhead hatchery. Iron Gate Hatchery phone number 530 475-0421 Coho Salmon. (See Graph)

| Year | Total |
|---|---|
| 1963-1964 | 180 |
| 1966-1967 | 4 |
| 1971-1972 | 147 |
| 1976-1977 | 1,757 |
| 1981-1982 | 997 |
| 1986-1987 | 1,025 |
| 1991-1992 | 764 |
| 1996-1997 | 4,097 |

**Conclusion:**

Based on the above data from the Iron Gate Hatchery it shows that from 1963 to 1997 there was an increase in coho salmon by a factor of 2,274%. It is apparent from these statistics that coho salmon in the Klamath River Basin has been on a steady increase over the last 34 years and that the listing of coho salmon in the Klamath River Basin has been based upon erroneous data and should be removed from the endangered or threatened listing under the Endangered Species Act.

To continue let me address the "spotted owl" listing as endangered under the ESA which claimed that they could only survive in "old growth forest" and that there were less than 2000 nesting pairs in 1990. The Fish and Wildlife Service in 1999 "now estimates that there are 3,500 known owl pairs - nearly double its first estimate. Moreover, there is evidence that the owls thrive in forest areas that have been harvested and replanted "

The National Center for Policy Analysis has published the following documentation from the U.S. Fish and Wildlife Service regarding the Spotted Owl.
http://www.public-policy.org/~ncpa/ea/eajf93/eajf93g.html

"The U.S. Fish and Wildlife Service declared the spotted owl an endangered species in 1990 and stopped logging over a wide area of the Northwest to protect it. But as more land is surveyed, the spotted owl appears to be less endangered than had been thought."

The Fish and Wildlife Service now estimates that there are 3,500 known owl pairs - nearly double its first estimate. Moreover, there is evidence that the owls thrive in forest areas that have been harvested and regrown " Meanwhile, the economic effects of the logging ban have been greater than predicted.

Proponents of the logging ban predicted that 2,300 jobs would be affected in three states. The Fish and Wildlife Service now projects that 32,100 jobs have been lost because of the ban. When privately owned woodlands are taken into account, industry groups and unions place the loss at close to 100,000 jobs.

Based upon the above information it is abundantly clear that the original listing of the Spotted Owl was based upon faulty data not only of their numbers but the habitat in which they thrive. In addition it is clear that the Economic Impact Report submitted in the listing process was also grossly underestimated. Therefore, I respectfully submit that the Spotted Owl be removed from the Endangered List and relieve the hardships which have been foisted upon the citizens within the affected areas by said listing.

To highlight the abuse of power within regulatory agencies, in 1997 Congress requested the data utilized for pending Clean Air Act regulations and the EPA refused to divulge their data. After new standards were adopted by Congress the EPA submitted their data which relied upon a single, feeble statistical survey purporting to associate premature death with air pollution. The report was hardly "independent" as the reviewing organization was half funded by the EPA.

The California State Grange supports the position of accurate science being utilized for the welfare of our natural resources and protection of the environment and its creatures. To avoid the predicament we are now in we suggest that all science submitted for any of the multitude of Federal agencies be submitted to the National Science Foundation or an equivalent non-political, scientific organization for review as to the data's accuracy, relevancy and integrity prior to any regulatory actions by said agencies.

## II. REGULATORY AND POLICY INFLUENCES

As we have already observed there is a serious lack of communication between Government Agencies and the general public which has led to serious reactions by the public. The California State Grange proposes the following programs to alleviate the problems of the past:

1. The formation of a coalition of representatives from State and County governments, FERC, NEPA, ESA, NMFS, PFMC, BLM, USFWS, and EPA to coordinate their efforts within the guidelines of State and Federal laws. These meetings should be open to interested parties and organizations.

2. Public awareness of impending regulations is the key to establishing rapport with the local affected populations and to this end we recommend all local newspapers and radio stations be requested to publish and air announcements of public meetings on specific issues. At such public forums a representative from all parties to the coalition should be present to answer questions and make succinct presentations. At such forums brochures, booklets and comment forms should be available to all participants. We also suggest that all citizens which may be affected by impending regulations be sent notices of these forums and include comment forms so that their voices may be heard.

3. Present comment periods are inadequate and should be extended to a minimum of 120 days. At such time all comments received must be read, evaluated and a summary report prepared for Congressional and public review.

4. Under the previous administration it was common practice that petitions for listing species was given paramount consideration while delisting petitions were rarely acted upon. This policy must revert to the will of Congress and all petitions, listing or delisting, must be given equal consideration within the guidelines set forth within the Endangered Species Act.

## III. REGULATORY AGENCIES ROLE

Over the last decade we have seen not only abuse of power by Federal Agencies with the utilization of "junk science" to validate their position, but, we have observed blanket regulations that affect not only those guilty of violations but primarily affect the innocent. There is nothing that will inflame the public more than being forced to obtain regulatory permission to peacefully coexist with nature on their privately owned properties. This is a flagrant violation of the fifth, tenth and fourteenth Amendments of the United States Constitution. The California State Grange proposes the following solution to this dilemma:

1. Discontinue blanket regulations that affect both the guilty and the innocent.

2. Employ a branch of law enforcement to patrol suspected areas of violation and issue citations to those who are polluting, degrading or destroying natural resources. Fines to be determined by the extent of damage foisted upon the area in addition to repair of the damage.

3. Any individual, group or corporation guilty of a second violation to suffer not only heavier fines and repairs but incarceration could be considered.

4. Any individual, group or corporation guilty of a third violation to suffer not only tripled fines and repair but incarceration would be mandatory.

### IV. CALIFORNIA STATE GRANGE'S POSITION

The California State Grange's position regarding the conservation and replenishment of underground water resources are an important step for the future. We also encourage the building of dams for flood control, water storage and agricultural usage.

There can be no doubt that the California State Grange in its attempt to maintain agricultural production, it is imperative that our most precious resource, water, must be protected for not only agriculture but for the people, power, forests, fish, animals and the beauty of this Great State of California. The inalienable rights of the people and the State afforded by the United States Constitution and the Bill of Rights must not be abrogated. The architects of the Constitution could not in their wildest imagination consider that private land would be taken for the preservation of fish, animals, trees, mountains, rivers or birds. Water is life, and the Grange supports this tenet, for without food and water ... there will be none.

## GUSSYFISH: LOOKING FOR HOME WHERE WE ALREADY LIVE

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If there is a goal that we all share, it is to take the best possible care of the landscapes we call home, and the natural and social systems that sustain us. We have tried many different ways to achieve this goal, often with little to show for it. Most of our human and financial resources have been devoted to litigious, legislative, and scientific efforts, and while some may argue that progress has been made, it could also be argued that these efforts have not helped us build common understanding between the various human communities that depend on the Klamath watershed. It is also unclear whether these efforts have helped form or strengthen bonds between human and nonhuman inhabitants of the region, bonds which, it will be argued, are necessary in order to ensure proper and long term stewardship of the region's resources.

The author attempts to chart out some new cultural territory where people come together as caretakers of their shared homes and landscapes. The presentation combines discussions of family, history, community, and habitat restoration in an effort to discover what it is that makes people feel like they belong to a place, what it is that helps us form bonds with the natural and human landscapes that surround us, bonds strong enough that we nurture and protect these landscapes as if they were our very own flesh and blood, which is exactly what they are.

## SOLVING THE KLAMATH BASIN'S ENVIRONMENTAL PROBLEMS: A FIRST STEP

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### Introduction

By now, you're probably aware of the situation in the Klamath Project. This project, authorized in 1905, has been shut down for the year. No irrigation deliveries to over 1,400 family farms and ranches. Reportedly, the water supplies will benefit three listed species. Time will tell whether the sacrifice of the families this year is worth the alleged benefit to these fish. Time will also tell whether this decision was the correct one from a biological, legal and moral standpoint.

As the daughter of a rancher forced to liquidate our cow herd last Monday because we couldn't afford to keep them, I have strong personal feelings about the decision. As the executive director of the Klamath Water Users Association, I have a more professional perspective. It's from this point of view that I will present our Associations' position on the situation and describe the steps we believe are necessary in the long run.

Let's begin with the facts. On April 6th the U.S. Fish and Wildlife Service, the National Marine Fisheries Service and the U.S. Bureau of Reclamation decided to utilize nearly all of the water supplies of the federal Klamath Irrigation Project for three listed fish species; the Lost River Sucker, the shortnose sucker and the coho salmon.

In a normal year, the families who farm and ranch over 230,000 acres in the Klamath Irrigation Project would receive roughly 500,000 acre-feet of water. This year, less than 10% of the farmland will receive any water at all. Two of the nation's most valued wildlife refuges will receive zero water. The federal agencies utilized all of the water that would have been available to us – incredibly; the U.S.F.W.S. and NMFS actually demanded 200,000 acre-feet more water than was physically available this year - as described in detail by acting Bureau Commissioner Bill McDonald in testimony to Congress last month.

These water supplies will be used to maintain an artificial level at Upper Klamath Lake, and to provide increased instream flows to the Klamath River.

The tragic social and economic, and environmental impacts of this decision are heartbreaking. Without irrigation water, and the ability to raise a crop, hundreds of farm and ranch families will not be able to support themselves. Many are now unable to pay their bills and to service their debts. Land, livestock, and equipment are being forfeited. Bankruptcy will be common.

These same impacts are happening to farm employees, and for the owners and employees of the agriculture related businesses. Long-term supply arrangements have been lost because of nonperformance. The base of our communities is being shattered. Demands for county social services are rising. Some people have already left. The irrigation districts will likely lay-off employees. Businesses will close. Enrollment in small school districts decline prematurely in a short period, and the closure of schools is quite possible. The children in those schools are facing the same anxiety as their parents. Farm fields will become fields of dust. Tremendous wind-borne soil erosion will occur, impairing land productivity and causing air pollution. Besides the farmland and the wildlife refuges, city parks, schoolyards, and cemeteries will go dry.

The long-term irreparable harm is overwhelming.

**Is This Tragedy Necessary?**

Some environmentalists and federal officials blame the drought. Clearly, they don't understand the Endangered Species Act or understand the Klamath Project, or even basic hydrology. We believe the drought is not to blame and the reality is far more tragic.

We often hear that there was just no choice but to shut down our farms and ranches. There is always a choice. But choices require innovation, leadership, and vision. These traits are sorely lacking in those officials responsible for implementing the ESA. The choice seems to have been made when some federal officials decided to create a scientific knot that could not be untied, by delay, and by ignoring less damaging alternatives.

I'll explain why we believe the science was suspect and how meaningful restoration actions for the species at risk were overlooked to justify taking water away from these families. For now the loss is ours. But, there will be survivors. And they will learn to become less trusting of the federal promise, and more aggressive in the pursuit of the justice. But, our loss is not the only one. The integrity of federal officials and the role of science in environmental protection will suffer tremendously. Of course, so will the fish and wildlife.

**General Background:**

Briefly, some background. The Klamath Project lies at the upper end of the 4,000 square mile Klamath River basin. Various streams, springs, and other tributaries flow into Upper Klamath Lake near Klamath Falls. Close by the City's limits, the lake's outlet is Link River, which eventually becomes Lake Ewauna and the Klamath River. After being joined by numerous tributaries in California, the Klamath River spills into the Pacific Ocean, over 220 miles from Klamath Falls.

With respect to the Klamath Irrigation Project, both the Oregon and California Legislatures enacted laws making state-owned land available for use in the Klamath Project. At the turn of the last century, the states ceded then-submerged land to the federal government for the specific purpose of having the land drained and reclaimed for irrigation use by homesteaders. The Oregon Legislature also authorized the raising and lowering of Upper Klamath Lake in connection with the Project, and allowed the use of the bed of Upper Klamath Lake for storage of water for irrigation.

In 1905, the federal government authorized the development of the Klamath Irrigation Project pursuant to the 1902 Reclamation Act. Reclamation also acquired, by purchase from private parties, water rights with earlier priorities for the benefit of the Klamath Project.

Thousands of people — family farmers and ranchers, their employees, and agriculture-related businesses — make a living directly from farming and ranching in the Klamath Project. In turn, their activities support the towns of Malin, Merrill, Bonanza, Tulelake, Newell, and Klamath Falls.

The total irrigated farmland of the Klamath Project includes about 230,000 acres. Most of this farmland is served from diversions from Upper Klamath Lake and points immediately below on the Klamath River. Another area is served via the Lost River and the two smaller reservoirs on the Lost River System – Clear Lake and Gerber Reservoirs. Farmland in the Klamath Project produces well over $100 million annually in direct revenue, and generates roughly $300 million in economic activity, supporting the farm families, farm workers, businesses and local communities. In addition, there are two national wildlife refuges in the Klamath Project area: Lower Klamath National Wildlife Refuge and Tulelake National Wildlife Refuge.

Klamath Project irrigation and refuges are, of course, only some of the many uses of water in the much-larger Klamath Basin. Upstream of Upper Klamath Lake, there is an estimated 200,000 acres of irrigated land and other uses that divert water. Downstream, on tributaries to the Klamath River in California, there are large areas of irrigated lands, particularly in the Shasta and Scott River Valleys, and an out-of-basin export to the Central Valley of California from the Trinity River of one million acre-feet of water per year.

Nevertheless, in the long history of the Klamath Project, the water supply has ordinarily been sufficient to meet all of these uses, and there have been only a few years when water shortage occurred to either Klamath Project irrigation or refuges. These shortages occurred late in the irrigation season when forecasted supplies did not fully materialize.

**Management of the List Species.**

For nearly a century, farmers, conservation groups and state and federal officials worked together. We worked our way through droughts, floods, and all of the problems that can occur in our 4,000 square mile basin. The situation began to change several years ago. In 1988 the Fish and Wildlife Service listed the Lost River and shortnose suckers under the ESA. Then in 1997, the National Marine Fisheries Service listed the coho salmon.

The Federal efforts to manage these species, particularly the suckers have always been suspect.

**The Suckers:**

In 1988, when the Fish and Wildlife Service listed the suckers, they claimed there were only a few thousand of them left. They also claimed these fish lived only in Upper Klamath Lake.

But the Service was wrong. Surveys completed after 1988 revealed there are literally hundreds of thousands of these fish living in Upper Klamath Lake and in lakes and streams all over the upper Klamath Basin. So either the earlier surveys were flawed, the data was manipulated, or these fish have recovered.

Now, the Service refuses to acknowledge this discrepancy. Instead, they note that thousands of suckers in Upper Klamath Lake died in the late 1990's. Credible fishery and lake scientists who have reviewed the data from these events believe these fish died because the lake was held to a higher than historic level. But incredibly, the Fish and Wildlife Service has required the lake to again be held to even higher levels. It simply chose the hypothesis regarding lake levels that damaged the Project, nothing more.

Doesn't this raise a number of troubling questions? First, which is it? Did the Service list a species with a population of several hundred thousand, or did they help to recover the species? Or did they pursue a management action - raising the levels of the lake - that has caused the death of thousands of these fish? They have had thirteen years to manage this species. Yet today, we're no closer to an answer to these questions, or to the recovery of either sucker species, than we were in 1988. Either way, their increasing lack of credibility on this matter further calls into question their management of the species.

If you doubt my point of view, listen to what fishery experts at Oregon State University wrote in their review of the Fish and Wildlife Service's 2001 biological opinion for the suckers. In a March 6th report, OSU stated that the Fish and Wildlife Service's plan contained "illogical conclusions", "inconsistent and contradictory statements", "factual inaccuracies", and "rampant speculation." They went on to state that the federal document was so flawed, it was difficult to review. The Fish and Wildlife Service will probably respond that it was their draft report. Does that matter? They have been working on these fish for over 13 years. To now be accused by a leading university of "rampant speculation", and "illogical conclusions", one month before release of their damaging biological opinion, throws into question all of their recommendations about this fish and what is needed to recover it – including lake levels.

That is not all. The Fish and The Service has also overlooked many of the real threats to these species, including one of the most obvious threats - the Sprague River Dam. This small dam prevents many of these fish from ever reaching 95% of their historic spawning grounds in the Sprague River. For years, farmers, conservation groups and others have called for its modification or removal. The Service has been a vocal proponent of the dam removal movement all over the country – as have many of you in this room. So why not remove this small dam? Not surprisingly, they have refused to consider modifying it even though their own justification to list these fish cited the dam as a principal reason for the suckers decline. It is also worth noting that OSU scientists say that a major step toward recovery occurred by elimination of the fisheries that snagged spawning adults in large numbers prior to the listing. We do not see that being acknowledged by the agencies.

**Coho Salmon:**
On the Klamath River, the National Marine Fisheries Service's (NMFS) effort to protect the coho salmon is equally bewildering. Although coho rely upon tributary rivers and streams for survival, NMFS is attempting to use the Klamath River as their primary habitat. They aren't willing to admit their embarrassing failures of lower basin "restoration" programs in the tributaries. But they are willing to sacrifice our family farms and ranches to protect the commercial fishermen – who unquestionably kill adult coho salmon each year. Rather than implement a comprehensive restoration program throughout the entire Klamath Basin for the coho, NMFS is focusing only on higher river flows – with the Klamath Project providing all of the water and hot water at that.

To realize how absurd this regulation really is, consider the Trinity River, where a million acre-feet of water are annually exported to California's Central Valley Project. Those water rights are junior to the Klamath Project. And the Trinity is more important to coho than water from the Upper Klamath Lake, because the Trinity is one of the coho's natural spawning rivers. Yet only thirty percent of the flow goes down the Trinity, as compared to one hundred percent on the Klamath. Where is the rationale from NMFS on this point? For years, the tribes and fishery groups have clamored for more water from the Trinity. Are they now calling for water from Upper Klamath Lake because they have lost the debate on the Trinity?

Remember, the nearest a coho salmon can theoretically come to the Klamath Project is over sixty miles away, below the Iron Gate hydroelectric facility on the Klamath River. Their actual use of that reach of the river is limited at best, poorly documented, and cannot be discerned from the NMFS Biological Opinion. By the Biological Opinion's admission, the species primarily occupies tributaries - there are over 100 tributaries in the lower Basin - and areas far down river.
To quote NMFS, "limited information exists regarding coho salmon abundance in the Klamath River Basin."

Coho numbers have unquestionably declined. But as the Yurok Tribe notes in their written testimony and attachments to Congress on March 21$^{st}$, many factors have contributed to the decline of the coho. This includes the construction of dams on the Klamath River in 1962 and on the Trinity in 1965. And "ocean over-harvesting, mining, logging, grazing…"

If the protection of the coho is so critical that the Klamath Project must be shut down this year, shouldn't society take every step necessary to protect these fish - including a one-year moratorium on all commercial and tribal fishing in the Klamath River when adult coho salmon are returning to spawn? Is it really about the coho? Or is it just about the Klamath Irrigation Project subsidizing the commercial harvest of a threatened species?

**The Real Problem: Process and Trust**
We understand that other interests put forward other arguments. Perhaps our most fundamental objection is process. We are, quite simply ignored. In upcoming months we hope there will be an open accounting of the way these decisions are made. Our water users do feel betrayed because they have been to the table. They have supported actions that were promoted with the promise of regulatory relief. The promises have not been kept. What do we tell them when the same agencies ask for still more?

**Stop Thief - Regulatory Discrimination:**

In the Klamath Basin, there is substantial water use outside the Project, including water use under rights junior to the Klamath Project. In fact, there is water rights permits that explicitly make other uses subordinate to the Klamath Project. Additionally, there are numerous diversions and uses of water by federal agencies outside the Klamath Project that diminish the amount of water in Upper Klamath Lake and the Klamath River. To our knowledge, most or all of these diversions have never been the subject of federal review. This is inequitable and inexcusable.

To be certain, it is a very dry year in the Klamath Basin. But presently it is within the range of droughts experienced in the past - droughts where we have provided for the needs of fish and wildlife, and farming. Droughts where water users have made sacrifices to make more with for fish and refuges. Droughts through which all interests endured. There is no evidence that past drought-year operations adequately meeting the needs of the Klamath Project have had any adverse effect on the listed species.

**The Hostage Crisis:**

Federal officials are holding the families who depend on the Klamath Project hostage for all of the Basin's environmental problems. They are doing this not because we caused all of the problems, but because we are an easy target. To accomplish this insulting act, they have been selective about science, hidden the processes established to ensure its accuracy, and exalted hypotheses over evidence. If history is any indication, they will squander their attempts to help these species. That is unacceptable to us. It should be to you as well.

**Steps for the Future:**

First, I recognize we'll disagree on many of the points I've raised today. Of course, history shows clearly that we also disagree on many issues related to the basin, and how to best restore its environment. But on that point, I would hope there is universal consensus. Our debate should be about how to best restore the environment. Toward that end, you'll find many farmers and ranchers in the Klamath Project who have good ideas, who care, and who are willing to work together. But we must first begin with credible science. To simply accept what is out there now is a disservice to those of us who live in the basin, and to the environment. Does anyone here really believe these species will recover without a renewed level of participation by all of us?

Second, we need to implement broad, comprehensive restoration actions that will address the basin's environmental problems. The federal agencies are not the answer here. They can provide funding, technical assistance on restoration projects and of course, we must have their approval. But they alone are not the answer. In the past, the tribes have put forward a number of good ideas for the Klamath River. We should look hard at their ideas, and actually implement the good ones.

Finally, we must work together. In the end, the innovation, the commitment, and the consensus starts with the people closest to the land. Our ties to this basin, to its history, and to its natural resources are things that outsiders will never understand. If we're not willing to work together, then there is no hope for this basin and its precious resources.

I believe we can. The basin must move forward together.

## COPING WITH COMPETITION: AN ECONOMIST'S VIEW OF CONTROVERSIES OVER WATER AND RELATED RESOURCES

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Fundamental changes in the economy over the past several decades have dramatically altered the competition for water and related resources in western states. The laws and institutions governing these resources often are slow to reflect the changes, however, and the resulting tension underlies many of the controversies over resource use and management. To understand the potential economic consequences of resource-management alternatives, one must understand the different types of competing demands for the resources and the forces that are causing some to grow faster than others. Those seeking to reduce the tension in an efficient and equitable manner must understand the ways in which these forces might intersect to create opportunities for win-win outcomes.

## KLAMATH BASIN WATERSHED EDUCATION PROGRAM (POSTER)

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OSU Klamath County Extension Office has been administering the Watershed Education Program in coordination with Oregon State University, U.S. Fish and Wildlife Service's Ecosystem Restoration Office, the Bureau of Reclamation, and local watershed working groups and advisory committees in Klamath County since 1998. Teacher education and landowner workshops are the focus of the program, and research-based information is used to provide education and outreach activities in Klamath County.

River clean-up activities, watershed workshops, public education, curriculum workshops and presentation of existing watershed education materials have grown large enough in the past 2 years to require more than 2 full-time staff positions with the Extension Office.

## SYSTEMIC LEARNING AND COMMUNICATION AMONG KLAMATH RIVER COMMUNITIES

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### ABSTRACT

Citizen groups dependent upon the Klamath River met in local communities to search for systemic or basin-wide actions while exchanging views via relational diagrams and meeting notes in 1993 and 1997. Mind maps identified issues whereas ActionGrams considered "leverages" or possible actions within the context of a river system. Groups corrected their diagrams and gave permission to exchange information with all other participating groups. We discovered that mind maps encouraged symptomatic thinking surrounding the issues whereas ActionGrams created conversations about possible actions among groups within the Klamath watershed. Participants commented that exchanging information among diverse groups along the Klamath River encouraged recognition of how they or their actions were connected with people and the other end of the river!

### INTRODUCTION

People that live within the Klamath River watershed are separated by mountains and a border dividing two states and federal jurisdictions, yet the river flows toward the ocean and fish return each year. Citizens grapple with natural resource issues while meeting with friends and neighbors, or during public hearings and forums. Listen carefully and you'll hear similar values expressed, often about conserving resources, livelihoods, and cultural, spiritual or historical relationships with the land, yet people seem to talk past each other by debating the conflict between components or applications within complex, adaptive river systems.

County Extension faculty sensed an opportunity to generate both *systemic* learning and communication among people and groups along the entire river. *Systemic* means seeing the river as a whole system with feedback loops, levels of complexity (hierarchy), and emergent properties of the system (functioning whole). Relational diagramming techniques were used as a way to learn and communicate the whole quickly and efficiently while clarifying thinking and assumptions associated with decision criteria and basin-wide management.

Citizen groups who meet regularly within local communities were invited by Extension faculty to participate in a series of learning sessions. Our purpose was to listen and record their comments and words along with relationships using either a mind map or ActionGram technique in 1993 and

1997, respectively. Our educational objective fostered an exchange of information and concerns between groups along with instruction on group process and systems thinking. Ranchers, Native Americans, recreational guides, fishers, and farmers were invited by Extension faculty from both Oregon and California to participate from the headwaters to the river mouth. Groups met during a two-week interval in 1993 and a single week in 1997. Recorded diagrams and notes were sent to each group for editing to ensure accuracy and to seek permission to exchange the information with all other collaborating groups.

This paper invites you to draw your own relational diagrams, to contrast typical mind maps (Buzan, 1980) and ActionGrams (William, *in review*) of complex systems such as rivers, and to consider our claim that this approach encouraged people to consider the Klamath River as a whole.

## RELATIONAL DIAGRAMS

Rivers are complex systems that adapt or change as a whole over time, yet "problem fixing" dominates our thinking and decision process. Relational diagrams encourage thinking in terms of function, feedback, interactions or loops, causality, and emergent properties of systems. We used mind maps and ActionGrams as learning tools to enhance open-ended discussion involving complex, adaptive systems among diverse participant groups dependent upon the Klamath River.

**Mind maps** capture key nouns, verbs, and multiple relationships between words as participants describe their stories. Similar ideas are clumped resulting in themes that can be prioritized for immediate inquiry while maintaining relationships between themes. Drawings often look like spider webs or strawberry plants. Participants were asked to describe their stories, often spiraling into issues and emotional concerns of the moment. Extension faculty recorded the stories in mind maps on flip chart paper to ensure accuracy from the point of view of the story-teller.

Draw your own mind map. Buzan (1980) suggests mapping chapter titles from a book or subheadings from a paper to gain insight about the author's intended arrangement of topics. He claims that mind mapping becomes a mental photo that improves information retention, and therefore exam scores.

Next, listen to a story or create your own. As the story unfolds, listen for key nouns (circles) and verbs (lines) including relationships between one or more nouns. Within moments, a mind map emerges on your paper that shows complex relationships, emotion, and individual factors comprising functional systems. Clumping similar ideas together offers opportunities to develop common themes for immediate inquiry while maintaining links between themes as you proceed from one topic to the next.

**ActionGrams** ask people to draw a system such as a river, consider components or factors, draw relationships between the factors or components, and look for leverage within the system; all within 10 minutes. Instructions are written on a wall for small groups to accomplish as attendees enter the meeting site. Uneasiness, nervous laughter, and bit of hesitation precedes drawing a squiggle representing a river followed by several people drawing components, relationships, and questioning what *leverage* means. Soon, someone asks "what is leverage?" By creating learning tension, participants in individual groups express readiness to learn the meaning and accomplish the task of describing *leverage* as the "point(s) in a system where the greatest impact, either positive or negative, might be expected" (Senge et al, 1994).

Time's up! Participants are asked to describe *leverages* within the system avoiding a verbal description of what we see in the diagram. Comments and discussion shifts immediately to possible actions, insights, and interactions.

Draw a system or ActionGram. Begin with a squiggle representing a river adding people, trees, fish, enterprises, eagles, towns, forests, oceans, recreation, and more. Add lines with arrows showing directional relations for primary functions or interactions. Soon, you'll notice loops that feedback internal control information within the system. Look for leverage(s) in the system. Since systems must balance, most loops stabilize the relationships and interactions to maintain a flexible equilibrium. Thus, ask yourself whether these loops balance or escalate? Escalation up or down occurs naturally or may be achieved when you wish to move the system to a new functional equilibrium. Time's up! Consider your leverages to see if they represent possible actions within a functional system?

Since natural resources act like or represent *complex adaptive systems* with hundreds or thousands of balancing loops that maintain the system at a functional equilibrium, the ActionGram encourages thinking as if the topic were a system (William, 2001). Current concerns about fish are a good example. Historical evidence suggests that fish populations were greater 200 yeas ago than today. Over time, many individual and interacting factors contributed to decline (negative escalation); no single factor caused decline in a complex adaptive system. Thus, escalation to a new level or equilibrium is unlikely unless numerous interacting and aggregating factors each contribute to a threshold that achieves a new dynamic equilibrium of increased fish populations over time. People nod affirmation while expressing both impatience to "do something" before extinction along with frustration about the "problem-fixing" mentality that dominates current thinking!! We claim that the ActionGram technique contributed to systemic thinking and action by diagramming the system and looking for *leverage(s)* or the multiple places in functional systems where the system may be impacted, either positively or negatively.

## EXPLORING TYPICAL DIAGRAMS

Consider your diagrams with the composites we made from the groups along the Klamath River (Fig. 1 and 2). What similarities exist; what differences? As you investigate the diagrams, what assumptions may require additional exploration? How might the differences be considered in search of over-arching goals or applications? And within group learning, how would these or other diagramming techniques contribute to systemic learning and decisions designed to improve the watershed as a whole?

## WHAT DID WE LEARN/RESULTS

Citizens representing diverse interests and concerns along the entire Klamath River identified water, fish, watersheds, and livelihoods as key issues. Group conversations moved from narrowly defined issues to considerations of the entire watershed. Both diagramming techniques and participatory involvement in learning empowered citizens to improve their understanding about complex systems with minimal instruction. Our purpose was to construct common knowledge

(Novak and Gowin, 1984). Knowledge construction shares information and knowing among diverse participants along with data from other sources while examining assumptions and relevance to the system or topic. This idea of building knowledge across group and agency platforms seems to focus inquiry on opportunities rather than playing the "blame game" or pointing the finger at someone else's problem!

Initially, mind maps were used as a way to encourage participants to express their concerns and emotions while quickly leading to themes for active discussion. As emotions shift toward investigation and making improvements, we circle common items into themes and automatically tackle one topic at a time while keeping others in mind until we've completed the system. The technique contributes to systemic inquiry and action, but several participants continued to "point the finger" or "play the blame game" when mind maps asked about concerns or issues.

During breakfast, a Klamath county resident asked, "what the drawing represented?" while we listened to their stories and suggestions. As their story was retold in loops, she expressed "disliking diagrams"! With four hours to ponder her comments while driving home, her concern was translated to disliking diagramming techniques that require lots of mental energy to learn. Our criteria for inventing the ActionGram suggested the technique must by fairly intuitive or natural to represent what people said and how they thought about complex systems such as natural resources. Thus, we claim that ActionGrams represent the way citizens think about complex systems.

ActionGrams ask people to draw a system, identify the components, draw the relationships, and look for leverage(s) or possible actions within the system. Loops emerge as relationships are drawn followed by alternatives that may fundamentally improve the system. As groups along the Klamath River drew their ActionGrams, we heard comments about connectivity, relationship, and the whole river or watershed; that people from one end of the river were connected and a part of the other end. Hearing these comments, we began to know that this was a powerful technique! Since then, ActionGrams begin most natural resource discussions and two university courses[1] facilitated by inter-collegiate faculty.

Lastly, we confirmed that groups along the Klamath River indeed have a multitude of ideas or possible actions to share with other citizens and stakeholders involved or responsible for functional river systems and basin-wide management of the resource. The experience of creating an ActionGram or mind map in a group of similar or mixed ideas and perceptions encourages communication while minimizing threat. Many resource problems occur because there is a level of perception that an issue or impact exists, when in reality the problem does not exist. However, if the perception is culturally or socially strong enough to influence management or regulatory action (regardless of scientific evidence), the perception itself becomes the issue.

Additionally, we discovered that exchanging notes recorded on flip charts and either mind maps or ActionGram drawings among participant groups confirmed our notion that communication and common action could be facilitated that related actions, issues, and leverages while respecting diversity and community values. We observed a lot more agreement between issues and suggested

[1] Two co-coached courses are offered by multiple faculty representing 3 or more colleges involving "Consensus and Natural Resource Issues" and "Systems Thinking and Practice." Students enter the classroom and immediately draw an ActionGram before instructors and the syllabus are introduced.

actions than differences. Drawings expressed a robust understanding of the complexity of river systems inhabited by humans along with thoughtful and sometimes creative "solutions" that merit consideration by everyone involved. Relational drawings encourage systemic thinking combined with systematic analysis.

## CONCLUSION AND SUMMARY

Both mind maps and ActionGrams provided a quick, easy, and fun way to focus systemic thinking and actions while offering a common framework for discussing facts, relationships, and leverage within complex systems that function as wholes. Inviting groups distanced between the headwaters and mouth of a river to share their drawings as a way to communicate and exclaim the connections using the ActionGram provided a reasonably neutral forum for inquiry and possible action among citizens residing along a river. We share the techniques and approach as a way to foster communication, learning, and respect among people who wish to exchange common interests and possible actions for the benefit of all organisms sharing a river and its many livelihoods. Perhaps drawing techniques like the ActionGram offer ways to explore basin-wide plans designed to improve adaptive systems like rivers over time.

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Figure 1. Composite mind map of key nouns, verbs, and relationships on issues or stories told by various groups of people dependent upon the Klamath River, 1993.


Figure 2. Composite ActionGram of Klamath River system including ideas about "leverages" or places within the river system where various groups dependent upon the river would expect greatest positive impact to improve the whole system.

## WETLANDS EDUCATION AND HABITAT ENHANCEMENT BY TULELAKE HIGH SCHOOL STUDENTS (POSTER)

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Students at Tulelake High School will be involved with wetlands education by collecting water quality data from locations throughout the Klamath basin (via DO, Hobotemps, pH, and observations). Students will participate in habitat enhancement by planting willows, observing organisms, and observing various land management strategies. Students will communicate their knowledge with brochures and various projects that are created to communicate their learning.

Session Objective: Students, teachers, and schools have a vital role in helping the public better understand our watershed, water quality, and the connections that life has to the precious resource. Communicating and being involved in monitoring and restoration are activities that can be done people of all ages. Students will share their observations, data, and activities.

## RESOURCES AND PEOPLE (RAP) CAMP (POSTER)

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Resources and People (RAP) Camp is a program for high school students and educators (K-12) that promotes critical thinking and informed natural resource decision-making. It is held annually at a campsite in the Cascades between Klamath Falls and Medford. RAP Camp is the result of many community-based partnerships that include the Forest Service, Bureau of Land Management, Klamath Basin ERO Office, along with other agencies, private organizations and volunteers. RAP Camp strives to present participants with an unbiased, informed view of current natural resource management practices through hands-on activities in the field and a land management planning exercise. Topics covered during the week include forestry, watershed, riparian, wildlife, fisheries, range, botany, fire ecology, archeology and recreation/wilderness. Students are given many career ideas, encouraged to stay in school and have the opportunity to experience interaction with others from differing backgrounds (rural/urban and cultural). Teachers write lesson plans for their classrooms, receive a wealth of material and "hands-on" ideas plus 3 hours of continuing education credit from Southern Oregon University.

## CELEBRATING THE BIODIVERSITY OF UPPER KLAMATH BASIN AND WATERSHED RESTORATION ACTIVITIES (POSTER)

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The Klamath Basin Ecosystem Restoration Office, located in Klamath Falls, Oregon was established in 1993 as a cooperative program to focus on coordination, long-range planning, on-the-ground restoration and outreach and education in the Klamath River watershed. Our display will show the uniqueness of Upper Klamath Basin's biodiversity, offer historical perspectives, and highlight watershed restoration programs and activities.

## SRRC- COMMUNITY RESTORATION PROGRAM (POSTER)

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The SRRC Community Based Restoration Program entitled the Salmon River Community Restoration Program is described, including the activities and results from our annually held series of Cooperative Ecosystem Awareness Workshops and Volunteer Restoration Training Workdays that the SRRC has held in the Salmon River since 1993. The SRRC has held over 250 events involving 5,000 volunteer person days.

# THE KLAMATH RIVER BASIN CONSERVATION AREA RESTORATION PROGRAM: WATERSHED RESTORATION BASED ON PARTNERSHIPS BETWEEN STAKEHOLDERS (PAPER AND POSTER)

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The Klamath River Basin Conservation Area Restoration Program is a federally funded 20-year program to restore habitat for anadromous fish in the Klamath River Basin. The Congressional Act that established the program in 1986 specified that restoration be guided by a 16-member Klamath River Basin Fisheries Task Force made up of representatives of state agencies, federal agencies, four Native American tribes, and local stakeholders. The stakeholders now represented include five county governments, and commercial and sport fishermen. The Task Force has adopted a bottom-up approach to habitat restoration, emphasizing local input and initiatives. In 1992 it began funding locally-designed watershed groups within each sub-basin of the Klamath where anadromous fish are present. These groups act as partners in planning as well as carrying out habitat restoration. The Task Force annually distributes about $600,000 of federal funds to its partners (agencies, non-profit organizations, tribes, and individuals) for projects that address restoration needs including: 1) habitat restoration such as riparian planting, cattle exclusion fencing, bank stabilization, and irrigation conservation, 2) education of restoration needs and activities, 3) sub-basin planning and coordination, and 4) monitoring and research.

# PART 8: FEDERAL ENERGY REGULATORY COMISSION RELICENSING

## FERC RELICENSING AND THE ECONOMIC VALUATION OF NON-MARKET RESOURCES

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Relicensing the hydroelectric dams along the Klamath River will depend, in part, on the costs and benefits that are expected to accrue. While some costs and benefits can be estimated and projected, albeit imperfectly (for example, the revenue generated by a kilowatt-hour of electricity), environmental costs and benefits (including water quality, aesthetics, cultural values, species survival, ecosystem health, and non-fee-based recreation) must also be considered. The question is how can a market value be estimated for the non-market environmental "goods" to allow the full (social) costs and benefits of the project to be considered in the relicensing decision?

Economists have developed several methods for estimating economic value when market prices do not exist. Among these, the contingent valuation method (CVM) has been used most frequently. CVM uses surveys to determine the public's willingness to pay (WTP) to enjoy an environmental benefit (or avoid an environmental cost) or the price the public would be willing to accept (WTA) for the loss of an environmental benefit (or the imposition of an environmental cost).

This paper considers the use of CVM to help quantify the environmental costs and benefits associated with the upcoming relicensing decision.

## POWER-DROUGHT PLANNING FOR FARMERS, A WIN-WIN APPROACH TOWARD RENEGOTIATING LONG TERM POWER CONTRACTS

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In 2006, the Bureau of Reclamation's preferential rate power contract (with Pacificorp) will expire and potentially expose 300,000 acres of Upper Klamath Basin irrigated land too much higher electrical rates. If irrigators are to receive decent power rates in our future we must explore all avenues toward providing ecosystem benefit for preferential treatment. A potential concept involves irrigators offering to idle 10% percent of their farmland during drought years in exchange for beneficial power rates. This type of approach benefits participating irrigators and the environment within a watershed and encompasses all water rights priority dates thereby allowing governments to plan dry year instream flow augmentation throughout a River Basin.

# PART 9: PROGRAMMATIC RESPONSES AND WATERSHED ASSESSMENT

## NORTH COAST WATERSHED ASSESSMENT PROGRAM: THE BENEFITS OF AN INTERAGENCY, COLLABORATIVE APPROACH

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The California Resources Agency and CalEpa have successfully established and funded an interagency watershed program for the north coast. Its goals are to: 1) develop baseline information about watershed conditions, processes and uses on the north coast; 2) guide salmonid restoration programs; 3) foster collaborative watershed stewardship efforts among agencies, private sector and non-profits; and 4) improve regulatory and permitting processes. Existing information about instream, riparian and watershed conditions and processes will be compiled and analyzed and new data will be developed to assess landslide hazards and sediment transport, fish habitat, water quality, and historic and current land use influences. These assessments will be linked to identify limiting factors for fish protection, to recommend fish habitat trend monitoring, and to provide guidance for cumulative effects analyses for future management activities. Data and findings will be peer reviewed, available for public comments, and made available on-line and on CD through the Institute for Fisheries Resources KRIS tool. In order to implement the program, an interagency team will first meet with local groups, landowners, and agencies within a basin to identify stakeholder concerns, existing assessments, studies, and data, and opportunities for collaboration. Our initial scoping of the Gualala and Redwood is providing critical direction for ways to work successfully with landowners to implement the program, including: 1) identifying landowners who are willing to share their data, 2) developing options for optimizing communication and minimizing access requests; 3) information needs for ongoing planning and restoration efforts; 4) opportunities for helping with local assessments; and 5) ways to ensure that all participating agency programs use and agree on the findings. While we have estimated that it will take about seven years to implement assessment methods on 6.5 million acres of state and private lands, we want to work closely with federal agencies to integrate assessment efforts in mixed ownership basins and watersheds. We plan to begin assessment activities in the Scott and Shasta Rivers in the second year of the program.

## CALIFORNIA HABITAT RESTORATION PROJECT DATABASE: AN OVERVIEW OF CALIFORNIA KLAMATH BASIN DATA

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## ABSTRACT

The California Habitat Restoration Project Database (CHRPD) is an ongoing effort to compile stream habitat restoration data and make this information widely available. The CHRPD will ultimately contain records for all restoration projects completed in California for which data can be obtained. Data in the CHRPD are useful for summarizing and studying restoration efforts at a variety of levels, from local to statewide. The California portion of the Klamath Basin is used here to demonstrate the possibilities for regional assessment of restoration project data.


## INTRODUCTION

Planning the restoration and management of California's anadromous streams requires the ability to evaluate the successes and failures of past restoration efforts. Without a comprehensive, statewide stream habitat restoration project dataset, this kind of evaluation is difficult at best. There has until recently been no such dataset available; the CHRPD was initiated in 1999 to fill this need. The CHRPD is a cooperative effort involving the Pacific States Marine Fisheries Commission (PSMFC) and the California Department of Fish and Game (CDFG), with funding from the National Marine Fisheries Service (NMFS). In addition to serving as a repository for information about California habitat restoration projects, the CHRPD features a geographical component, with each project georeferenced. Widespread distribution of CHRPD data will assist restoration planners, policy makers, researchers and educators in analyzing and evaluating past trends, as well as making informed decisions regarding restoring streams and watersheds in the future.

The CHRPD aims to capture as many types of data about restoration projects in as consistent a manner as possible. Great variability exists in the availability of data for different projects, as well as in the quality and consistency of the data that is available. The standard project data collected, though, can be stated simply as who, what, when, where, why and how. Within these general categories are many detailed observations about the projects, maintained in a database structure that has the flexibility to accommodate varied levels of data quality and consistency.

A key component of restoration planning is the cost of the work to be done, so a special focus of the CHRPD is capturing cost data in as much detail as possible. Again, flexibility in the database structure is crucial, because cost data availability and quality are especially variable. Also, it is important to be confident about the data that are present in the database, to ensure that calculations and analyses of cost data are as accurate and precise as possible.

Based on data in the CHRPD, a set of summaries of restoration projects in the California portion of the Klamath Basin has been compiled.

## DATABASE METHODS

### Data Sources

All data currently in the CHRPD are from the CDFG's Fisheries Restoration Grants Program; these data include all stream habitat restoration projects completed since 1981 and funded through the CDFG. Expansion of the database to include restoration projects completed by other agencies and organizations in California is now underway.

**Database Structure and Data Categories**

The CHRPD is composed of a relational database, maintained in Access 2000, with each project georeferenced. The database structure is based on the StreamNet Data Exchange Format (www.streamnet.org), with new tables added to accommodate specific needs for data collection in California. The StreamNet database format includes the following data categories: project beginning and ending dates, purpose, project location, goals and treatment details, monitoring, project participants and both their work and financial input, land ownership, and species affected by the project. New data categories added for California data include: watershed planning recommendations (for watershed survey projects only), project funding proposals and appropriations, final report data (including whether the project goals were met), detailed budget information, and rates charged for specific budget items. The specific fields in each of these categories are described in Table 1 and a schematic of the database structure (not the actual table relationships) is shown in Figure 1.

**Georeferencing**

Projects are located geographically by marking the measures of their position along a stream; points have one measure and lines have two, one at the beginning and one at the end of their reach. Their locations can then be stored in a database table as coordinates along streams; the only data needed are the unique ID of the streams and the projects' distances from the mouths of their streams. These database tables can easily be converted to shapefiles for geographical analysis. In the case of projects that did not take place on streams (for example, road or upslope work) or projects whose streams do not yet exist in the streams coverage, their locations are mapped by heads-up digitizing directly into shapefiles. Polygons are also heads-up digitized and stored in shapefiles.

The process of georeferencing instream projects requires a GIS layer containing statewide routed hydrography. Routed hydrography makes it possible to treat an entire stream as a single entity, rather than a series of segments broken up by the stream's tributaries. As a result, it is possible to locate projects at specific locations along the stream, with reference to the entire stream length. Currently, the CHRPD is using 1:100,000 routed hydrography, but will take advantage of 1:24,000 hydrography once a complete layer is available for California.

**Reference Files**

In the case of the CDFG Fisheries Restoration Grants Program data, documents for each project have been stored in folders. In order to keep track of all of this supporting documentation, each folder is assigned a unique reference ID. The reference ID thus refers to a collection of documents; because there are a large number of documents for each project, it would be impractical to assign unique numbers to each. As project files have been examined, they have been left in their original order in their boxes. The boxes are loosely organized by date of contract initiation, and in some cases there is no discernible order. Each file has been assigned a reference ID, though, so it is now possible to use the database to rapidly locate a particular paper file.

## DATA QUALITY

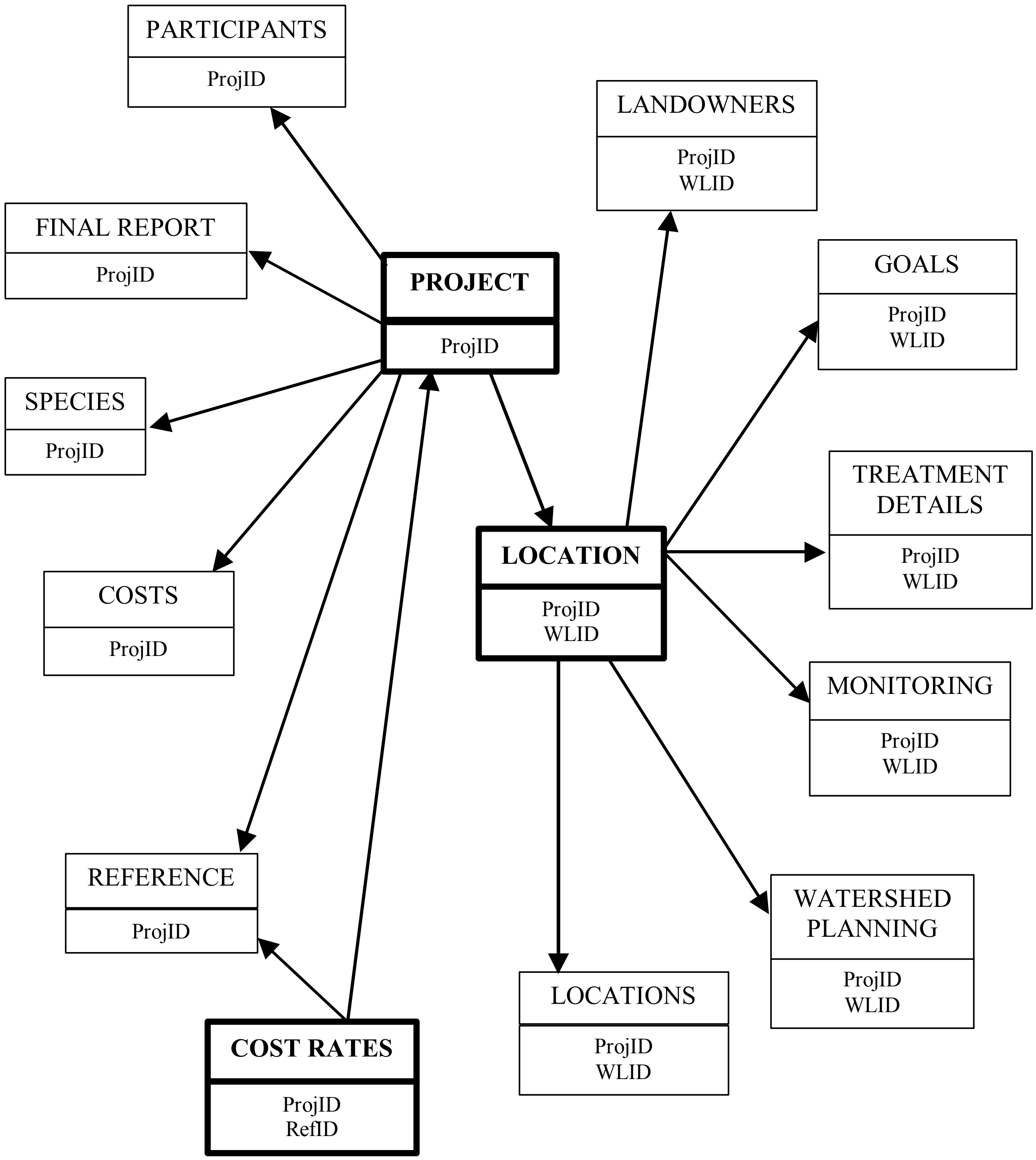
The amount and quality of data that have been extracted from the database and paper files maintained by the CDFG Fisheries Restoration Grants Program vary widely. Both quantity and quality are dependent on contractor reporting, which is in turn dependent on CDFG requirements and enforcement of these requirements. The enforcement of minimum reporting requirements has

Table 1. Data types in the CHRPD. Based on StreamNet database structure (www.streamnet.org) with California-specific changes.

| | |
|---|---|
| General Project Information | • Project name<br>• Data compilation date<br>• Source person for data<br>• Source agency for data<br>• Frequency data are to be updated<br>• Primary subbasin (4th field hydrologic unit)<br>• Status of project (planned, ongoing, completed)<br>• Bibliographic information supporting data<br>• Whether entire project is anonymous<br>• First year of work on project<br>• Last year of work on project<br>• Purpose of project<br>• Limiting factors addressed by the project<br>• Time frame for which results are expected<br>• Analysis of the project (things that facilitated, complicated or would help the project)<br>• Whether a final report is on file<br>• Whether the project goals were modified, and if so, how<br>• Comments (general) |
| Target Species Information | • Species name<br>• Whether species is a target species or a secondarily affected species (negative or positive)<br>• Species run<br>• Species subrun<br>• Species rearing type (natural or hatchery) |
| Participant Information | • Participant name (may be many)<br>• Whether participant wants to remain anonymous<br>• Year(s) of participation for each participant<br>• Project number used by the participant (for CDFG-funded projects, this is the contract number)<br>• Name of program that participant operated under (for CDFG-funded projects, this is the name of the funding source)<br>• Role of participant (funder, on-ground implementor, or both)<br>• Whether participant is the primary coordinator for the project<br>• Dollar amount of cash, in-kind support, labor, equipment, materials and total amount spent by each participant<br>• Dollar amount of money requested by participant in project proposal and amount appropriated by funding agency (for funder participants only)<br>• Contact person for each participant (name, title, address, phone, fax, email, comments |

| | |
|---|---|
| | • Comments |
| Location-specific Information | • Site names<br>• General work type category at each site (instream, riparian, upland, wetland, road work)<br>• Site type<br>• Spatial type (code for how project location is georeferenced: stream point or reach, nonstream point, nonstream arc, or polygon)<br>• Land cover<br>• Land use<br>• Goals for each work type, location<br>• Details and quantity of work done at each location (also which work and how much was done by each participant)<br>• Land ownership at each project location, including owner name, percent of project area owned, owner type (government, private, tribe, etc.), and contact for each owner<br>• Recommendations for work to be done at specific sites based on watershed planning survey (for watershed survey projects only)<br>• Comments |
| Monitoring Data | • Monitoring methods (if any)<br>• Monitoring objectives<br>• Whether control data were collected<br>• Whether monitoring data are available<br>• Types of data collected<br>• Comments |
| Cost Information | • Costs of each item in the budget, including quantity and units<br>• Items divided into personnel, materials, operating, and overhead categories<br>• Both projected and actual budgets can be captured<br>• Rates charged for various items can be recorded (in a table that also has the capacity to hold rate data from sources other than project documentation, such as restoration planning manuals or research papers) and then used to calculate average rates for these items |

Figure 1. CHRPD general structure.




This is a schematic of the database structure and does not represent the actual relationships between tables.
General data categories are in capital letters.
The names of the fields linking the categories are listed below the category name:
ProjID is a unique identifier for each project
WLID is a unique identifier for each work type and location within a project
RefID is a unique identifier for each reference from which project data have been collected.

and enforcement of these requirements. The enforcement of minimum reporting requirements has improved dramatically over the years, so there are more data available for more recently completed projects. In addition, data quality is dependent on CDFG record keeping: the amount of paper documentation saved and the care with which data is entered into the database.

While all data categories suffer from occasional missing data, location data are profoundly affected by the manner in which the project was reported. For example, when a contract was granted to do work in several different locations, these locations are sometimes divided into several different projects (each with a separate ProjID). In other cases, though, these same locations are left in a single project (one ProjID and a WLID for each discrete work type and location). There has been little consistency in how projects are divided by CDFG and contractors for purposes of budgeting: one contract may have five budgets for five locations or only one budget for five locations. As a result, decisions about how to break up projects in the CHRPD have been made based on the need to capture as much cost data as possible. This means that if five budgets are reported within a single contract, the contract is entered into the database as five projects, but if five locations are given in a single budget, the contract is entered as one project with five WLIDs. One important result of this system is that to obtain counts of projects completed, the total number of projects (ProjIDs) is less reliable than the total number of locations within each project (WLID and ProjID).

The project location data are also affected by the presence and quality of maps accompanying the contractors' reports. Some representation of the project location must be present in the file in order for the project to be digitized. How the project is digitized is entirely dependent on the way the contractor chose to represent it on a map. For example, a project involving the placement of five instream structures might be represented as five points along the stream by one contractor. It might be represented by a different contractor as a single line along the segment of stream containing the structures. Project locations are digitized with the greatest detail possible given the contractors' maps.

Also greatly affected by the quantity and quality of project documentation and reporting is our ability to capture detailed project cost data in the CHRPD. Reporting of cost data varies widely between projects, depending especially on the contractor, but also on when the project was done and whether all project documents have been saved in the files. In order to calculate average amounts spent on specific items for specific types of projects, it is very important to capture as many detailed cost data as possible. Unfortunately, many projects only have a projected budget on file, so the actual amounts spent are unknown. Of the projects that have any budget at all, 60% have projected budgets and only 45% have actual budgets. Furthermore, most budgets, projected or actual, are not itemized in great detail. Most often, when a budget has been itemized at all, it is divided only into personnel, materials, operating and overhead categories, without listing specific items within each category. Ideally, budgets list each separate item with the quantity and units purchased and the cost.

Many projects involve multiple funding sources, but the CDFG records often only include the money used from the CDFG grant. In most cases, it is impossible to determine whether the project used funding from other sources in addition to CDFG. In some cases, though, the final report states that additional funding was used but does not provide the amount. Only in rare cases are the additional funding amounts described. If in-kind contributions and funds from other sources are not reported, the total amount spent for the project listed in the database will be a gross underestimate of the true total spent.

## RESTORATION PROJECTS IN THE LOWER KLAMATH BASIN

The data being captured in the CHRPD lend themselves to many different kinds of analysis. The following figures are a few examples of the possible uses of CHRPD data, meant to demonstrate potential database applications. It is important to note that the CHRPD is by no means complete, and that these maps are based only on CDFG Fisheries Restoration Grants data from 1981 to 1999. Approximately 75% of the CDFG dataset has been entered into the CHRPD.

One potential use of restoration project data involves comparisons across the entire state, as demonstrated in Figure 2 by a map summarizing the total amounts spent on restoration projects in California basins ($4^{th}$ field hydrologic units). This type of summary is especially valuable in determining statewide priorities for restoration project development and funding. A similar analysis can be carried out at the regional level, as in the map showing total numbers of projects in each planning watershed in the California portion of the Klamath Basin (Figure 3).

The database can also be used to compare locations where restoration work has been done to other relevant geographical distributions; for example, Figure 4 shows the distribution of steelhead trout in California Klamath streams overlaid with restoration work sites. This map makes it possible to see where work has been done in relation to where the species are that the work was meant to benefit. Please note that the steelhead distribution data used here is draft only and is not intended to represent the current distribution of the species, only to serve as an example of the possible uses for restoration project data. Figure 5 displays restoration work sites coded to represent the different types of work done, allowing an analysis of the distribution patterns of different work types. This map will be especially useful when paired with data from watershed planning projects, so that recommended restoration sites can be overlaid with sites where work has already been done.

Finally, in evaluating patterns of restoration work, it is also interesting to look at the characteristics of the land on which the work is being carried out. For example, the different types of land ownership of restoration sites in the various hydrologic units in the California portion of the Klamath Basin can be compared (Figure 6).

## CONCLUSION

The maps presented in this paper are only a few examples of the many ways to represent CHRPD data. These data are very important for evaluating past anadromous habitat restoration projects and planning future work. By maintaining consistency with other fisheries data collection efforts in California and the Pacific Northwest, it will be possible to combine CHRPD data with related data such as fish distributions, anadromous habitat distributions, or land management patterns. The primary method of ensuring consistency between fisheries databases in California lies in the GIS component of these databases. If all data is tied to standardized California hydrography, then it is relatively simple to relate these data to each other, permitting detailed studies of many issues of concern to fisheries management.

Figure 2. Amounts spent on restoration projects in California by basin.

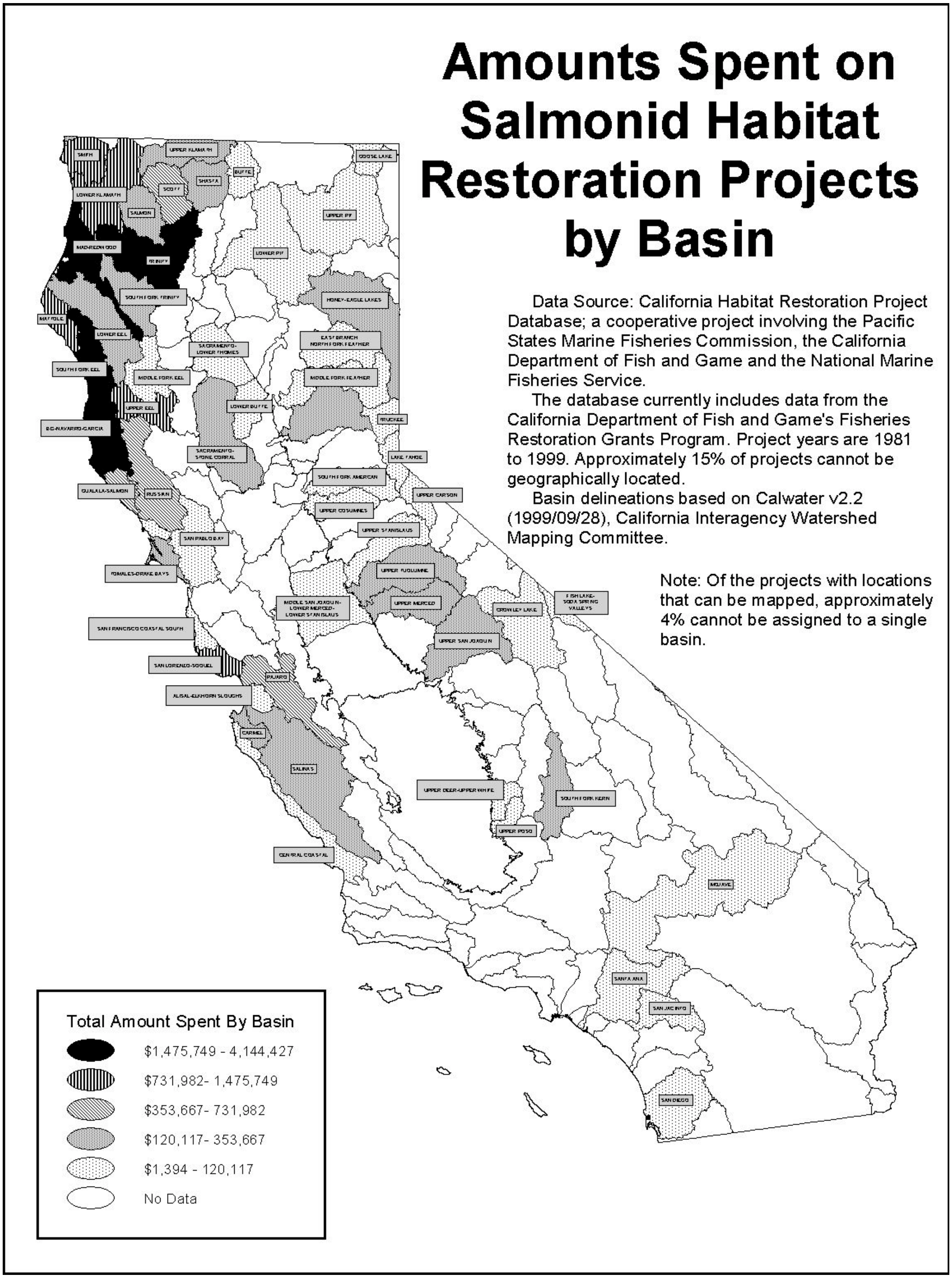


Figure 3. Total number of restoration projects in each of the watersheds that make up the Lower Klamath Basin.

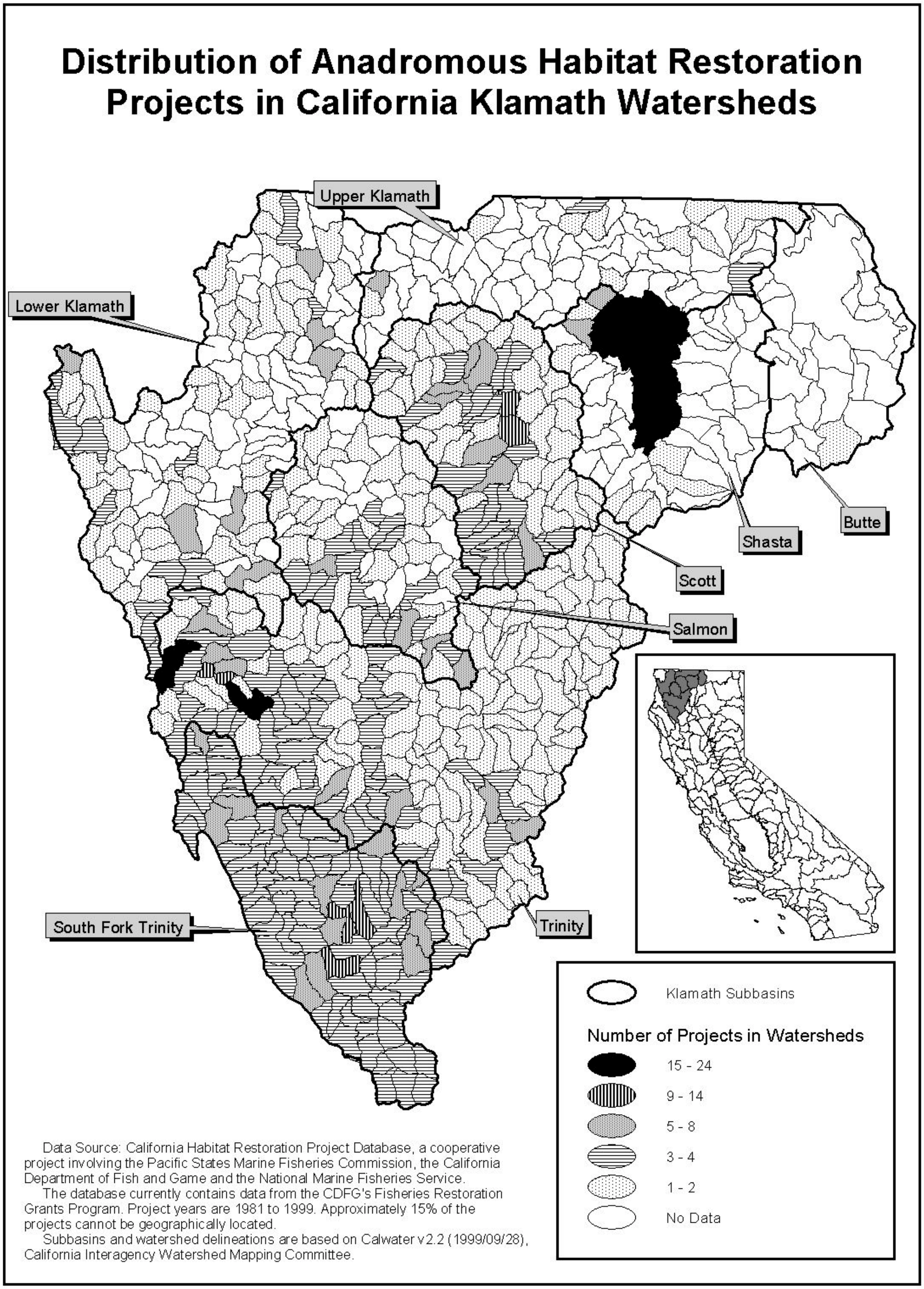


Figure 4. Restoration sites in relation to steelhead distribution.

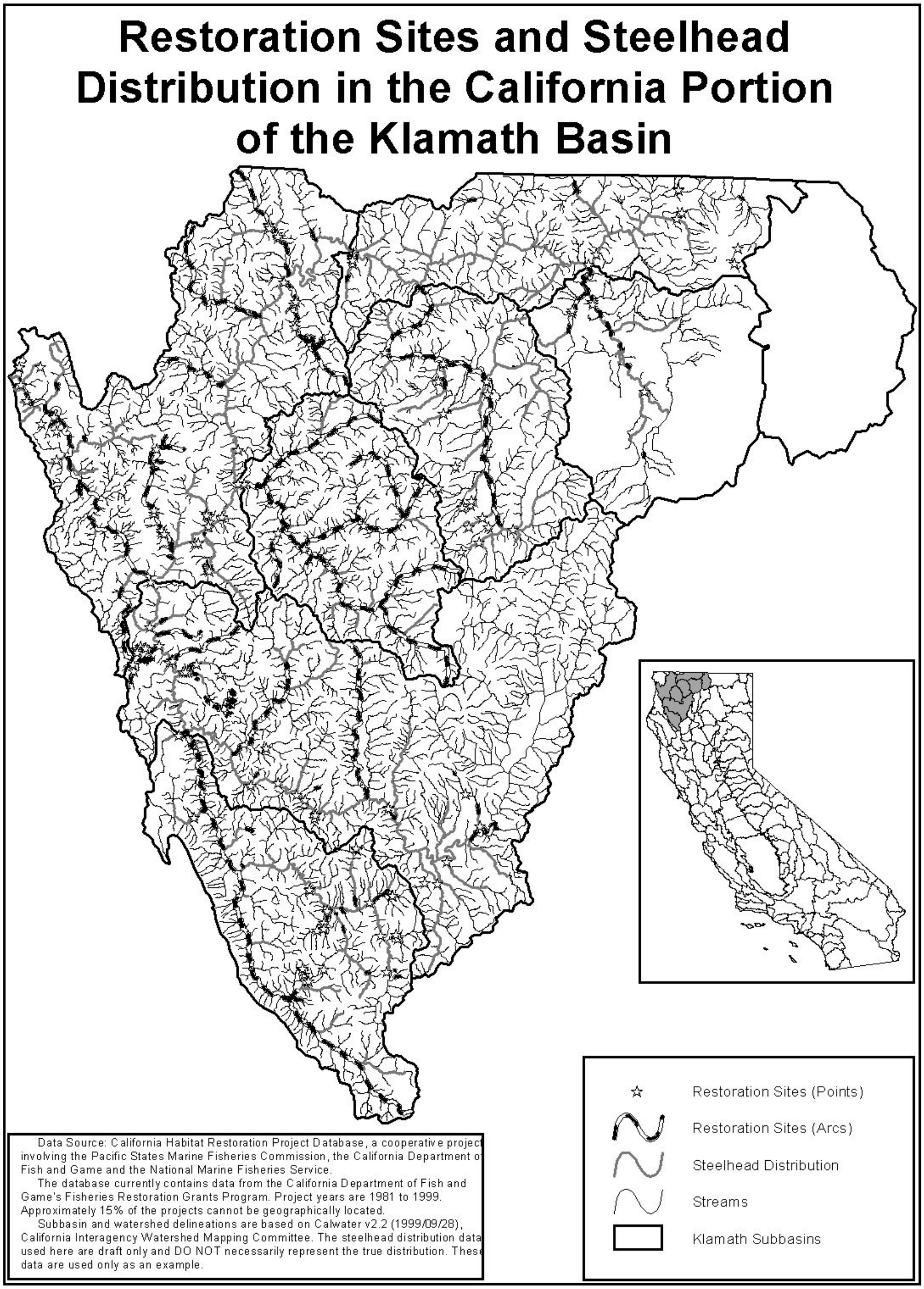


Figure 5. Distribution of restoration work sites, coded by work type.

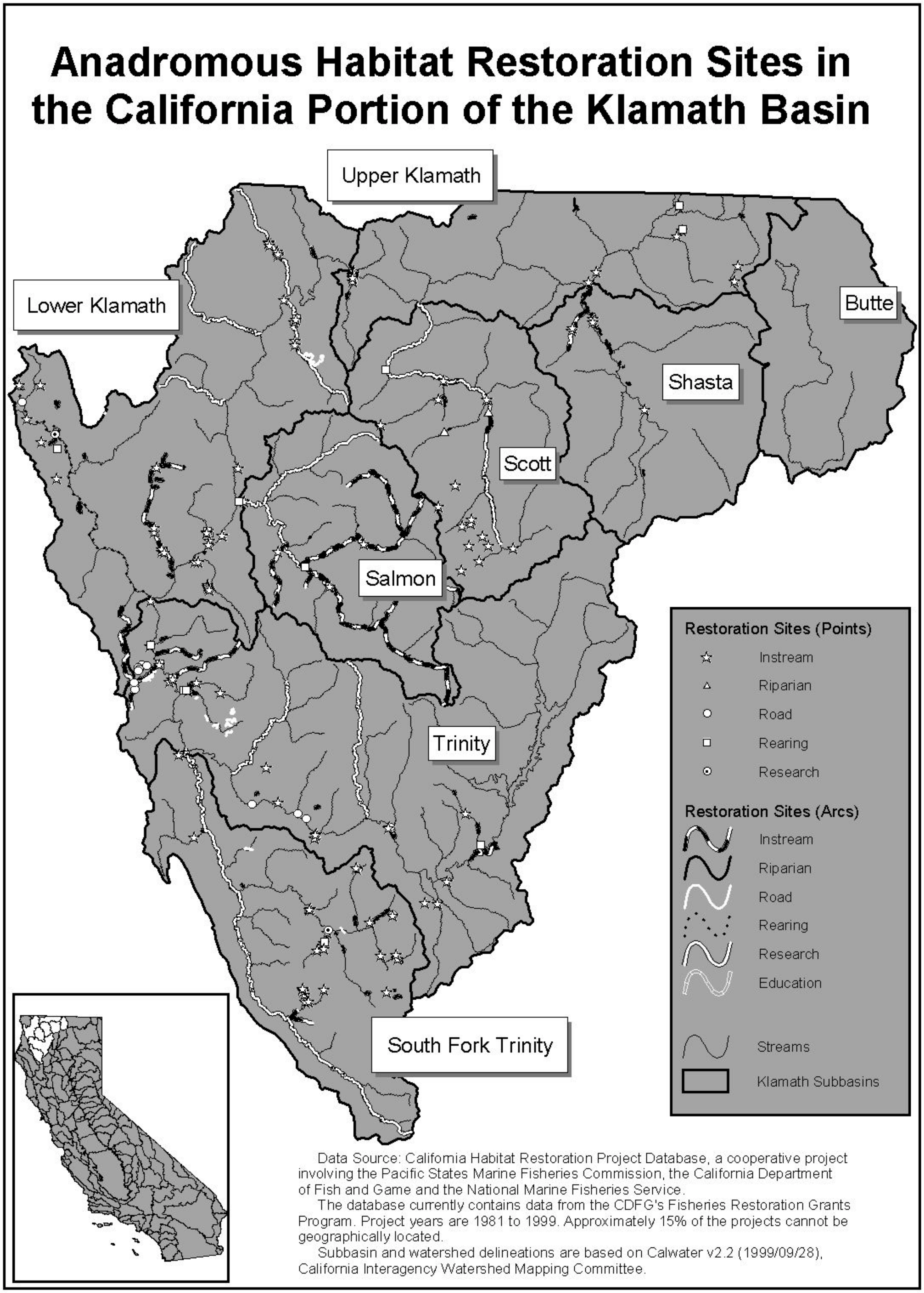
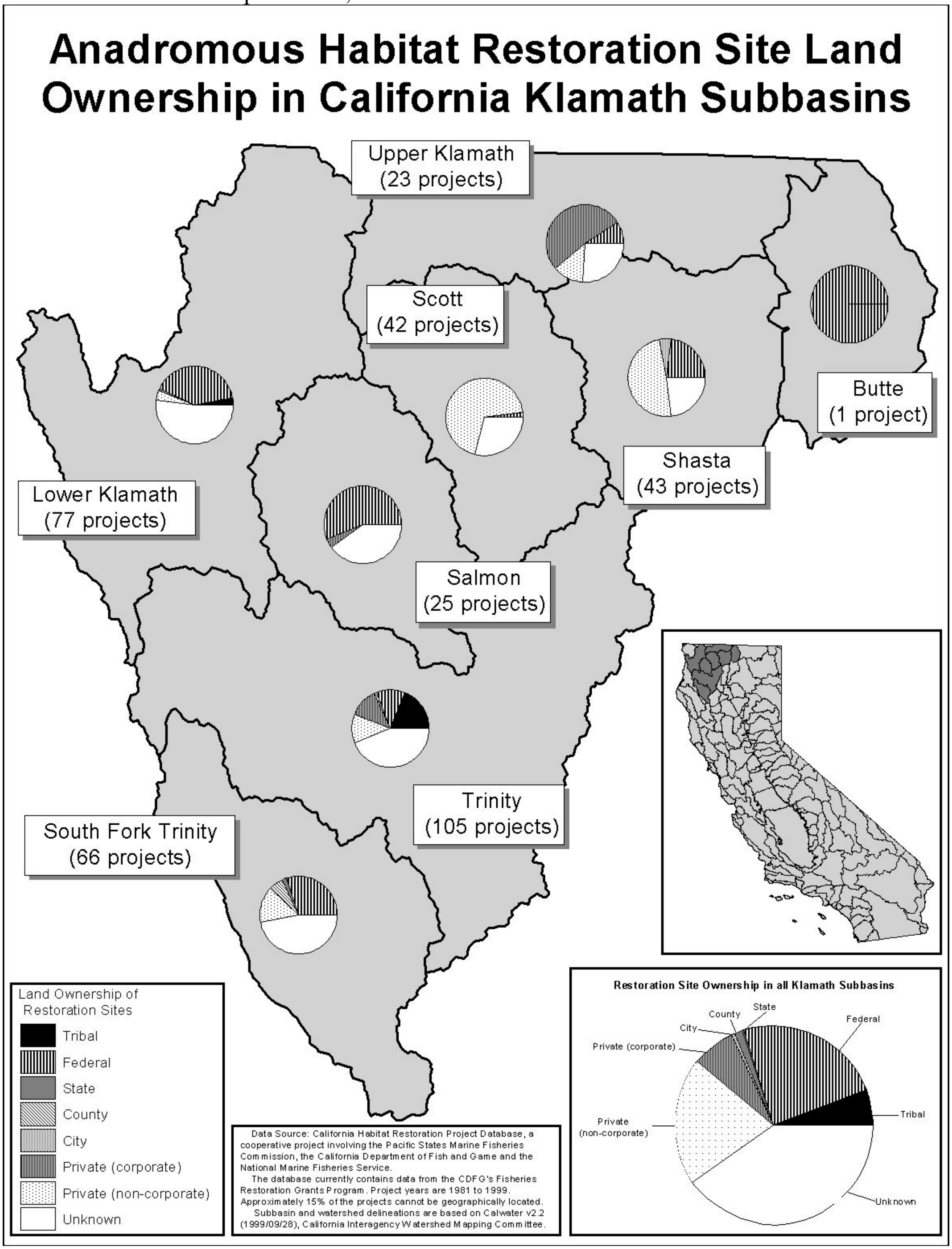


Figure 6. Summary of land ownership of restoration sites. Ownership figures refer only to the sites at which work was performed, not to the rest of the land in the basin.



The CHRPD is currently seeking new sources of habitat restoration project data, expanding the focus of the database beyond projects funded by the CDFG. The goal of the CHRPD is to include all restoration projects completed in the state of California between 1981 and the present, and to update the data yearly so that the database remains current. A comprehensive database of California habitat restoration projects is a powerful tool for studying restoration efforts in the state and applying knowledge of past work to a better understanding of what needs to be accomplished in the future and how best to effect this change.

### KLAMATH BASIN COORDINATED MONITORING GROUP (POSTER)

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Multiple agencies are currently monitoring water quality throughout the Klamath Basin. Although each monitoring program fulfills an agency/organization specific need, the discrete programs do not necessarily compliment one another. In an effort to leverage a basin-wide water quality monitoring program from these individual efforts, the Klamath Basin Coordinated Monitoring Group was formed in March 2001. The objective of this group is to identify individual monitoring efforts, parameters of interest, sampling frequency, field methods, resources, etc., and to use this information to coordinate Klamath River monitoring efforts from Link Dam to the Pacific Ocean, including the Shasta, Scott, and Salmon tributaries.

Three categories of monitoring are included: water temperature loggers, logging water quality probes, and grab samples. A primary goal of the group is to define baseline protocols and quality assurance measures to provide consistent, high quality data from all programs. Further, careful planning and scheduling will allow the multiple efforts to collect grab samples on the same date throughout the area of interest, thereby providing a synoptic representation of water quality throughout the 2001 field season. Participants in this process include multiple federal and state agencies (including but not limited to USFS, USFWS, CDF, DFG, USBR), as well as several Native American Tribes and PacifiCorp.

### A GLOBAL PERSPECTIVE ON THE BIODIVERSITY OF THE KLAMATH-SISKIYOU ECOREGION

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The Klamath-Siskiyou ecoregion of northwest California and southwest Oregon is renowned for its extraordinary biodiversity. Despite this recognition and the growing interest in the region's biological significance, the global importance and status of this ecoregion is underappreciated by the public, resource managers, and decision makers. We reviewed the conservation importance and status of this ecoregion relative to that of 30 temperate coniferous forest ecoregions in the us and Canada and also compared the results to a related global comparison of diverse forest ecoregions. The Klamath-Siskiyou is among the world's most outstanding temperate coniferous forests. We identified a total of 2,377 species for six terrestrial taxa. Levels of endemism were particularly pronounced for mollusks (60% of the taxa) and plants (8%). The combined freshwater portions of the ecoregion also had a continentally significant levels of endemism (42% of fish; 60% of mollusk) and richness. However, the biodiversity of this ecoregion was considered endangered based on numbers of species (154) with federal or state listing status, numbers of globally-imperiled plant communities (10), extensive loss of high conservation value forests such as old-growth and oak woodlands, and extent of habitat fragmentation evident in aquatic and terrestrial ecoregions. Increased attention to completion of a representative network of protected areas combined with active restoration of ecological processes (i.e. fire) and improved land management on federal and non-federal ownerships is essential for maintaining the ecoregion's globally outstanding biodiversity values.

## FAILURE ANALYSIS: THE MONITORING IMPERATIVE

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Most industries have well-developed systems for detecting and finding the root causes of significant failures. The findings enable adaptations that promote continual improvement toward coherent specifications of success. In natural resource management, failure detection and analysis often fails: failures are undetected, obscured, considered debatable, and not aggregated to scales where adaptive changes can be institutionalized to promote cumulative improvements in outcomes. A variety of challenges must be overcome to achieve effective failure detection and analysis in natural resource management. Without this, monitoring results will remain mostly moot, the same sets of mistakes will chronically recur, and adaptive improvements will be elusive.

## KLAMATH RESOURCE INFORMATION SYSTEM (KRIS) PROVIDES TECHNOLOGICAL SUPPORT FOR THE CALIFORNIA RESOURCES AGENCY NORTH COAST WATERSHED ASSESSMENT PROGRAM (POSTER)

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**William Kier**

The Klamath Resource Information System [KRIS] is a custom software program that was originally designed for assessing fishery restoration and water quality in the Klamath and Trinity River. KRIS integrates datasets, charts, graphs, photographs, and bibliographic resources into a free Windows compatable database. Each KRIS project also has a companion ArcView electronic map element. The North Coast Watershed Assessment Program (NCWAP) is a California Resources Agency initiative begun in July 2000 which will cover 22 northern California basins over three years. The California Department of Forestry and the National Fish and Wildlife Foundation are funding a project to provide the KRIS technology for support of this effort through the Institute for Fisheries Resources (IFR). IFR is the non-profit research branch of the Pacific Coast Federation of Fishermens Associations, the commercial salmon trollers group. IFR staff have completed a KRIS project for the Noyo River basin in November 2000 and projects for the Big River and Ten Mile River are under construction. In other basins, IFR staff will support NCWAP watershed analysts as they use KRIS systems to generate charts and capture annotated photos. A subset of this information, and spatial data from the KRIS Map project, will then be excerpted for use in watershed assessments. Call (916) 227-2652 for a free copy of KRIS Noyo or see krisweb.com.

## POSITION ADVOCACY BY SCIENTISTS RISKS SCIENCE CREDIBILITY AND MAY BE UNETHICAL

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Because the public debate about complex natural resource issues is so contentious, research scientists are increasingly being asked to bring science information to the decision process. The science they bring often enlightens the debate, possibly reduces polarization and probably improves the estimates of likely consequences and risks for the various decision alternatives being considered. A scientist should proactively deliver science information to the decision process so it can be fully considered, and in a manner that will make it hard to ignore. When the scientists slip into a role of advocating any particular outcome, however, especially if they portray their advocacy as science, they risk their personal scientific credibility and they risk diminishing the science contribution to the decision process.

## FOREST SERVICE AND BUREAU OF LAND MANAGEMENT UNIFIED WATERSHED MANAGEMENT, UPPER KLAMATH BASIN

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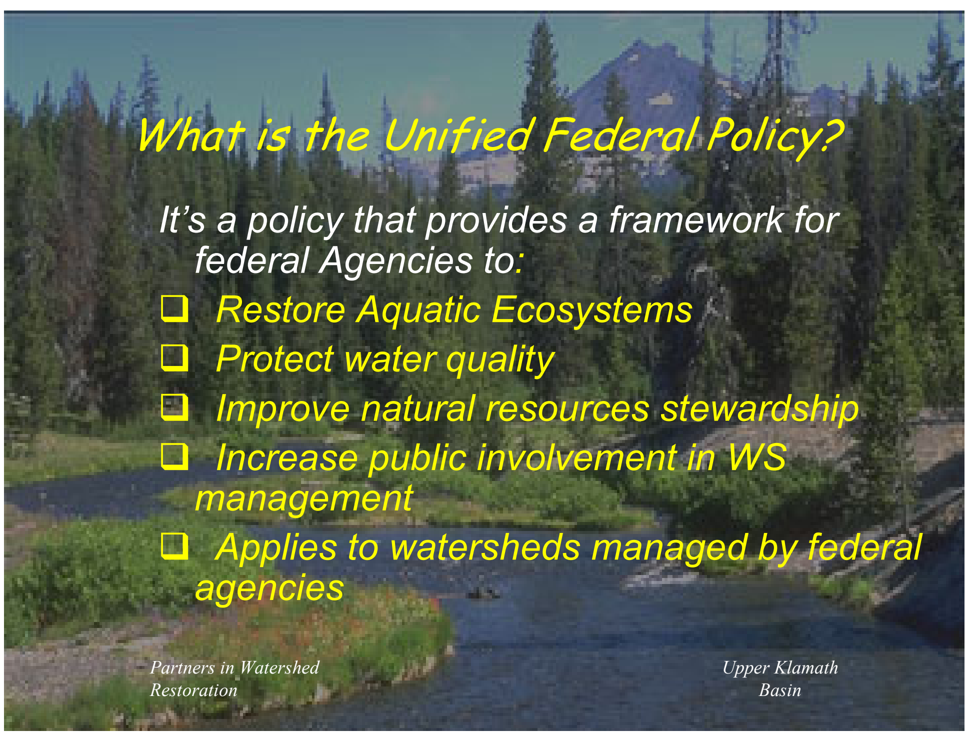
As part of the President's Clean Water Action Plan it is proposed that the Federal Departments of Agriculture and Interior work together, in concert with States, local governments, and the Tribes to implement a Unified Federal Policy for watershed and resource management planning and implementation. The USDA Forest Service, Winema and Fremont National Forests and the USDI Bureau of Land Management, Lakeview District have begun to implement a collaborative, unified approach to watershed management. The primary goal of this effort is to accelerate Federal progress toward achieving the objectives of the Clean Water Act. A cost-effective watershed approach will be used in resource planning and project implementation to prevent and reduce pollution of surface and ground waters resulting from Federal land and resource management, and to protect and restore watersheds. Currently, the Forest Service and Bureau of Land Management are working together to establish a unified approach to watershed management by coordinating water quality monitoring and assessments, soils inventories, water rights adjudication, and fish and wildlife management. Joint agency participation is demonstrated by participation in the TMDL process, in membership in the Klamath Basin Provincial Advisory Committee, on local Watershed Councils, and collaborative watershed assessments.

**Paper presented in reduced sized images of PowerPoint slides below. To view full sized slides using Microsoft PowerPoint (.ppt file), click here. To view full sized slides using Adobe Acrobat Reader (.pdf file), click here.**


A Unified Federal Policy For
Watershed Restoration
Upper Klamath Basin
Oregon
USDA
DEQ
Partners in Watershed
Restoration
Upper Klamath
Basin


What is the Unified Federal Policy?
It's a policy that provides a framework for federal Agencies to:
❑ Restore Aquatic Ecosystems
❑ Protect water quality
❑ Improve natural resources stewardship
❑ Increase public involvement in WS management
❑ Applies to watersheds managed by federal agencies
Partners in Watershed
Restoration
Upper Klamath
Basin

## *Federal Agencies*
## *Federal Unified Policy Goals*

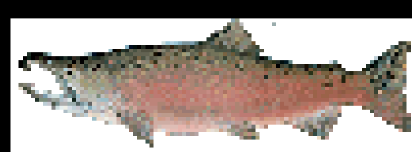
- *Use a watershed approach to prevent and reduce pollution of surface and ground waters on Federal Lands*
- *Accomplish this in a unified, cost-effective manner*

*Partners in Watershed Restoration*

*Basin*

## *Federal Agencies*
### *Federal Unified Policy Guiding Principles*

- ❑ *Use consistent and scientific approaches to assess, protect and restore watersheds*
- ❑ *Prioritize watersheds and funding to accelerate improvements in water quality, aquatic habitat, and watershed conditions*
- ❑ *Use watershed assessments to guide planning and management*



## Federal Agencies
### Federal Unified Policy Guiding Principles

- Work with States, Tribes, local governments, private landowners, and stakeholders
- Meet Clean Water Act responsibilities
- Ensure federal land and resource management is consistent with State, Tribal, and local government water quality management

## Federal Agencies
### Unified Federal Policy Objectives

1. Develop consistent procedures for delineating, assessing, and classifying watersheds.
2. We will use a watershed management approach when protecting and restoring watersheds.
3. Improve compliance with water quality requirements under the Clean Water Act
4. Enhance cooperation with Federal, State, Tribal, local government agencies, and stakeholders

## *Federal Agencies*
### *Watershed Management Approach*

A. *We will identify priority watersheds based on factors that include:*

1. *The percentage of the watershed under Federal management;*
2. *Issues the Federal agencies identify, including possible adverse effects on surface and ground water quality;*
3. *Water quality impairment, impacts to aquatic resources, and/or changes to flow regime;*
4. *Watershed Assessments*
5. *Vulnerability of the watershed to degradation; and*
6. *Substantive public interest*

## *Accomplishments*

*Spencer Creek Watershed Analysis*

- *Cooperative effort between DOI Bureau of Land Management and USDA Forest Service*
- *Identified watershed restoration opportunities*
- *Helped define management direction for Spencer Creek*

*Partners in Watershed Restoration*

*Upper Klamath Basin*


Accomplishments
BLM/Forest Service
Cooperative Roads
Study
• Cooperative effort between DOI Bureau of Land Management and USDA Forest Service
• Research study designed to quantify sedimentation from roads
• Will provide site specific information for environmental analysis
USDA
U.S. DEPARTMENT OF THE INTERIOR
MARCH 3, 1849


Accomplishments
BLM/Forest Service
GIS Core Data
• Identified watershed GIS needs across agencies
• Cooperative effort between DOI Bureau of Land Management and USDA Forest Service
• Goal is for seamless, consistent coverage across jointly managed watersheds
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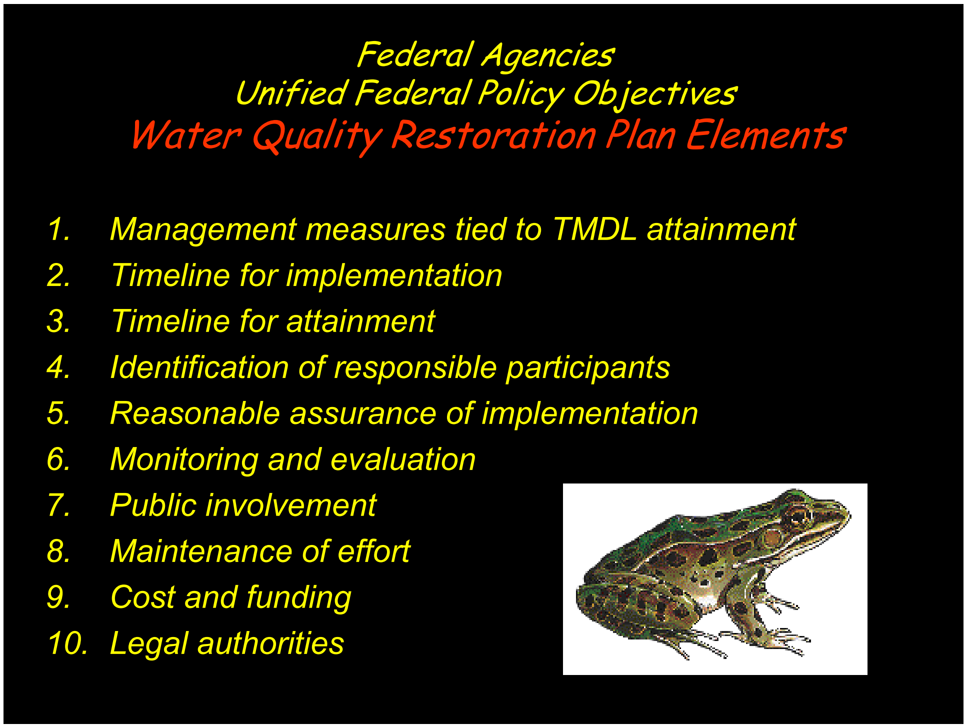
Accomplishments
Total Maximum Daily Load Allocation (TMDL)
• Forest Service, BLM, State, Tribal and private landowner interests involved
• Goal for Federal Agencies is compliance with Clean Water Act on Federal lands
Klamath Tribes
USDA
DEQ
Partners in Watershed Restoration
Upper Klamath Basin


Accomplishments
Water Quality Restoration and Management Plans
• BLM and Forest Service
• Water quality monitoring
DEQ
USDA
Partners in Watershed Restoration
Upper Klamath Basin


Federal Agencies
Unified Federal Policy Objectives
Water Quality Restoration Plan Elements
1. Management measures tied to TMDL attainment
2. Timeline for implementation
3. Timeline for attainment
4. Identification of responsible participants
5. Reasonable assurance of implementation
6. Monitoring and evaluation
7. Public involvement
8. Maintenance of effort
9. Cost and funding
10. Legal authorities


Accomplishments
Watershed Councils
• Supported by both Federal and State agencies in Oregon
• Goal for Federal Agencies is compliance with Clean Water Act on Federal lands
• Establish partnerships for restoration
DEQ
USDA
U.S. DEPARTMENT OF THE INTERIOR
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Upper Klamath Basin


Accomplishments
Maintain and Develop Partnerships
• Fish and Wildlife Service
• Oregon Watershed Enhancement Board
• Sustainable Yield Unit
• Nature Conservancy
• U.S. Timberlands
• Ducks Unlimited/ Trout Unlimited
• Rogue Community College
• Oregon Fish and Wildlife Department
DEQ
USDA
U.S. DEPARTMENT OF THE INTERIOR
MARCH 3, 1849
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Upper Klamath Basin

## ONGOING COOPERATIVE WATERSHED ASSESSMENT IN SPENCER CREEK

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Spencer Creek drains approximately 54,000 acres (84 $mi^2$) of mixed conifer forest in the eastern Cascades, and is tributary to the Klamath River below Keno, Oregon. Streams within the watershed are included on the 1998 Oregon 303(d) list due to high water temperatures, excessive sedimentation, and other water quality concerns. Spencer Creek and its tributaries are important spawning habitat for redband trout. For these two reasons and others it is designated a Tier 1 key watershed under the Northwest Forest Plan.

A watershed analysis/coordinated resource management plan (CRMP) was written for the watershed in 1995. Under the CRMP framework, private-federal resource inventory projects have been initiated. These include (1) generation of high quality hydrologic network maps and attribute tables; (2) a comprehensive inventory of the road network, with emphasis on sediment production potential and road-stream interactions; and (3) calibration of sediment delivery models to local physiographic and climatic characteristics.

Ongoing private-federal and interagency coordination will help ensure that these projects maintain a watershed-based (rather than ownership-based) approach while still meeting the needs of all landowners. The products of these efforts will be used to (1) develop TMDLs; (2) determine how to most effectively restore and maintain aquatic habitat; and (3) update the CRMP.

## FRACTAL ANALYSIS WATERSHED PROJECT (PAPER AND POSTER)

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Using readily available data, can an objective, quantitative method for determining a subwatershed's health be established for use in targeting areas in need of restoration?

The Oregon Institute of Technology GIS Service Center is conducting a watershed analysis with data from the Upper Klamath River Basin in order to develop a protocol for identifying riparian restoration sites. The purpose of this project is to create a model for predicting a subwatershed's perennial stream length from knowledge of the subwatershed's area and its moisture regime. Such a model could be used to differentiate between a normally functioning subwatershed and one whose hydrologic function is unbalanced, and hence is in need of restoration efforts.

## ECOSYSTEM RESTORATION OFFICE BASELINE BIOASSESSMENT FOR THE UPPER KLAMATH BASIN

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**Don R. Frei,**
**Kathleen A. Sale,**
**Dennis V. Rourk**

The Ecosystem Restoration Office (ERO) Baseline Bioassessment was initiated in 1998 to acquire baseline habitat information in the Upper Klamath Basin (UKB). The purpose of this bioassessment was to enable (1) the evaluation of change over time for habitat restoration activities and (2) provide a reference to determine key areas to focus watershed restoration. Baseline information obtained since 1998 includes extensive sampling of benthic macroinvertebrates (rapid bioassessment) and selected water quality and physical characteristics acquired from flights in 1998 and 1999 of the major rivers, marshes, creeks, and sites where ERO is involved in habitat restoration and enhancement. This paper will describe the baseline bioassessment program and discuss the results of the data acquired in 1999 in the Sprague and Sycan Rivers.

# PART 10: MODELING APPLICATIONS FOR BASIN RESEARCH AND MANAGEMENT

**LANDSCAPE ASSESSMENT ANALYSIS AND TEMPERATURE MODELING FOR RIVERS IN THE KLAMATH LAKE DRAINAGE (MODELING WORKSHOP)**

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A Landscape Assessment for the Klamath Lake Drainage was recently developed as part of Total Maximum Daily Load (TMDL) activities for temperature. The presentation will include discussions about techniques used to:
1) collect, develop and analyze remote-sensed and Graphical Information System (GIS) data in order to create high resolution data sets (~1:5K), 2) verify these data sets with ground level data, and 3) develop network scale temperature simulations (modeling) using the developed high resolution data sets.

**ADVANCES IN INTEGRATED FISH HABITAT MODELING USING TWO-DIMENSIONAL HYDRAULICS (MODELING WORKSHOP)**

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Utilization of spatially explicit three-dimensional channel topographies in conjunction with two-dimensional hydraulic modeling and substrate/cover mapping provides new opportunities for fish habitat modeling. This paper describes the conceptual development and application of a chinook fry habitat model. The model is based on the integration of three-dimensional channel topographies including substrate and cover mapping with two-dimensional hydraulic solutions. The model explicitly incorporates a distance to escape cover component in addition to depth, velocity, and substrate characteristics at a location in the river channel. This paper describes the conceptual model formulation, requisite computational steps, model outputs, and assumptions. Modeling

results are compared to known chinook fry utilization at several flow rates and river reaches as part of model validation.

## THE SYSTEMS IMPACT ASSESSMENT MODEL (SIAM) DEVELOPMENT AND APPLICATION (PAPER AND POSTER)

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The Systems Impact Assessment Model (SIAM) for the Klamath River is a decision support system covering important water quantity, water quality, and fish production components in the mainstem Klamath from Upper Klamath Lake to the ocean. Meant to address a variety of "what-if" questions, SIAM helps uncover the variety of spatial and temporal impacts associated with an array of water management options. It has been proven useful in understanding the magnitude and frequency of events believed to be constraints to the successful recovery of anadromous fish in the Klamath, and continues to be developed to address practical recovery objectives. Principal outputs from the model include predictions of mean daily flow and reservoir storage levels, mean daily water temperature and dissolved oxygen, weekly habitat value and fish mortality, annual fall chinook production, and a set of indicators of ecological health. Model outputs include a variety of tabular and graphical displays, including several useful synthetic metrics. The model, including 39-year database of historic flow conditions, is freely available for use by those interested in system understanding and planning.

## KLAMATH PROJECT OPERATION SIMULATION MODEL (MODELING WORSHOP)

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KPSIM (**K**lamath **P**roject Operation **Si**mulation **M**odel) is a model of the regulatory facilities of the Klamath Project. It simulates the operations of Upper Klamath Lake (UKL), Gerber Reservoir, and Clear Lake to test a range of deliveries to the Klamath Project in concert with a range of Klamath River flow targets below Iron Gate Dam and target minimum UKL lake levels.

The model has been in active use since 1997 in the formulation and analysis of a broad range of operational alternatives for studies related to annual operating plans, biological assessments, long-term operating plans, the water supply initiative, and a variety of other analyses.

The object of this presentation is to discuss how KPSIM is used in these studies – how the results are used and what the human role is in interpreting these results for a broad audience. Of particular concern will be how development of model capabilities follows stakeholder interests and how a common understanding of model limitations is critical to stakeholder satisfaction with results.

## INDIVIDUAL-BASED MODELS FOR RIVER FISHERIES MANAGEMENT

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There are many limitations of habitat-based methods for instream flow assessment: observed habitat "preference" cannot be assumed equal to habitat quality, factors other than habitat typically limit fish populations, effects of flow variation cannot be assessed, and there is no way to determine how much habitat is needed for different life stages. Individual-based models (IBMs) are designed to overcome these limitations by modeling fish instead of just habitat.Our trout IBM simulates habitat in two-dimensional cells as it varies with flow, temperature, and turbidity; and how fish select their habitat, feed and grow, die of various causes, and reproduce. The model trout select habitat to provide good tradeoffs between growth and mortality risk; growth is a function of habitat conditions and competition among trout. Simulation of spawning and redds allows model runs of many years. Recent progress ncludes (1) software with graphical interfaces allowing behavior of model fish to be observed and tested; (2) validation of how model fish select habitat; (3) long-term simulation of population-level effects of instream flow, seasonal flow patterns, and turbidity; and

(4) use of the IBM to test PHABSIM. The trout IBM is easily adapted to new sites and species. We are also developing an IBM for chinook salmon. More information is at http://math.humboldt.edu/~simsys/ .

## LEWISTON RESERVOIR MODELING
## (MODELING WORKSHOP)

**Kamman, Greg**
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A series of temperature models were used to evaluate proposed flow alternatives as part of the Trinity River Mainstem Fishery Restoration EIS/EIR. These models include: the Bureau of Reclamation's reservoir temperature model (RTM) of Trinity Lake; Trinity County's temperature model of Lewiston Reservoir (BETTER); and the us Fish and Wildlife Service's model of the mainstem Trinity River below Lewiston Reservoir (SNTEMP). The Lewiston Reservoir model (BETTER) is a two-dimensional model operating on a one-day time-step. This presentation will focus on how and why the BETTER model was used in conjunction with other temperature models to evaluate proposed Trinity River restoration flow alternatives. Because CVP diversions and river releases are made from Lewiston Reservoir, this presentation will also explain how the BETTER model was used to identify and evaluate alternate reservoir management operations (in addition to revised flow schedules) that could further benefit thermal conditions and fishery habitat in the mainstem Trinity River.

## BASINS: A DECISION FRAMEWORK STRUCTURE FOR MANAGING AQUATIC RESOURCES IN THE UPPER KLAMATH BASIN
## (MODELING WORKSHOP)

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EPA's Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) model has been adopted across the United States for managing water quantity/quality issues for a variety of interests, including the analysis of point and nonpoint source management alternatives. BASINS is based on a Geographical Information System (GIS) format that allows for the easy exchange/substitution of spatial data, i.e., changing of landuse patterns. Within BASINS are a suite of currently adopted water quality models including NPSM (HSPF), TOXIROUTE, and QUAL2E. This format allows for a comprehensive assessment of downstream water quantity/quality issues in terms of upstream nutrient loading. The modular format of the model is appropriate for the eventual replacement/exchange of current algorithms with newer ones as they are developed. Fate and transport calculations for both point and non-point sources can be accommodated within this framework.

An examination of the capabilities and limitations of the BASINS modeling framework will be discussed as well as initial results from a pilot study being conducted in the upper Sprague River.

## MODELING WILD ANIMALS IS A DIFFERENT KIND OF BEAST (MODELING WORKSHOP)

**Williams, John G.**
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This talk reflects the view that "(T)he value of modeling in fields like biology has not been to make precise predictions, but rather to provide clear caricatures of nature against which to test and expand experiences" (Walters 1986, p. 45). The objective of instream flow modeling, however, is typically to make predictions upon which flow criteria can be based. Most instream flow models combine hydraulic or hydrodynamic models with biological models to make such predictions. I will challenge this procedure first by pointing out that no such model has been successfully validated at the field scale, using the failed example of Guay et al. (2000) as an illustration. Secondly, I will note the argument of Ludwig (1994) that "effective management models cannot be realistic," so that if predictions truly are the objective, then models with relatively few parameters should be used. The experience with population models used for fisheries management should make us cautious, however; Schnute and Richards (2001) have coined the term "fishmatic" to denote the inevitable uncertainty associated with the apparently impeccable arithmetic of these models. Thirdly, I will argue, using Railsback's IBM (EPRI 2000) as one example, that models are very useful, but we need to think about and use them differently than has been the normal practice.

# PART 11: GEOGRAPHIC INFORMATION SYSTEMS AS A MANAGEMENT TOOL

## USING DYNAMIC SEGMENTATION IN A VECTOR GIS TO DISPLAY, MODEL AND ANALYZE FISH RANGE AND DISTRIBUTION, HABITAT CONDITION, SPAWNING AND RESTORATION ACTIVITIES EVENT DATA (POSTER)

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These map compositions demonstrate how "dynamic segmentation" can be used to display fish range and distribution, habitat condition data, chinook spawning monitoring, and restoration and enhancement activities relative to the stream channel they occur in. These data sets contain records from multiple years and dynamic segmentation offers tools for displaying and analyzing these data both spatially and temporally, within and among these various data sets.

Dynamic Segmentation associates multiple and diverse sets of attributes, referred to as "events", to any portion of a linear feature, referred to as a "route", utilizing relational database technology to make the associations.

Development and use of a common stream route system by multiple agencies and resource interest groups creates the opportunity for any variety of stream-related "event" data to be collected and referenced to that common stream network. This possibility offers tremendous opportunities for data sharing, large extent analysis and landscape modeling among disparate agencies and interest groups.

## GIS USE IN RESOURCE MANAGEMENT: A MAP PRESENTATION DEMONSTRATING CULTURAL AND ENVIRONMENTAL FACTORS MANAGED PER THE HOOPA VALLEY TRIBAL COUNCIL'S FOREST MANAGEMENT PLAN (POSTER)

**Emery, Gary**
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The Hoopa Valley Tribal Council has adopted a guideline for management of cultural and natural resources on the Hoopa Valley Indian Reservation. This is the Forest Management Plan (FMP). The purpose of this Plan is to fulfill obligations for statutory, administrative and regulatory requirements related to forest management such as the listing of the spotted owl and coho salmon under the Endangered Species Act of 1973 of the spotted owl and coho salmon. An additional purpose of this document is to provide an opportunity for informing the Tribal membership about their forests resources, and provide the Tribal Council with alternative management strategies to assess.

The GIS process that created the maps presented here accounted for 25 separate FMP defined factors. Each was accounted for as part of a set order of priority. Arc Macro Language (AML) programming drives the creation of the GIS coverage that is the source of these maps. The AML uses overlay analytical tools to create a layered product. The AML was written so that the evaluation process could be repeated as needed to take advantage of the dynamic nature of much of the base layer evaluated.

## GIS AS A TOOL FOR COLLABORATIVE PLANNING IN THE SCOTT RIVER WATERSHED (POSTER)

**Finke**, **Carlin M.**
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Geographical information systems (GIS) are increasingly recognized as tools to assist in the decision-making process. Spatially identifying critical factors allows planners to analyze complex factors affecting watershed health and to be better able to prioritize the restoration needs of their watershed. A visual display of the data, even without additional analysis, can have a tremendous effect on understanding complex relationships.

Working with the Scott River Watershed Council, graduate student researchers from Humboldt State University are compiling spatial data to be used for collaborative watershed planning. using community-mapping methods, local knowledge of the residents and scientists of the Scott River watershed is being captured and mapped. The resulting GIS layers will provide a database of factors limiting watershed health and another of restoration projects.

This information, compiled with GIS data from other sources, provides the community with the tools for analysis and modeling, lessening its dependence on agencies. Though full access to the GIS information is still limited due to the technical literacy required to run the software, the Scott River Watershed Council has facilitated greater community access to all types of information in order to enable greater participation and understanding in the collaborative planning process.

## THERE AIN'T NO SUCH THING AS A FREE GIS (WITH ALL DUE RESPECT TO THE ECONOMIC AXIOM - TANSTAAFL) (GIS WORKSHOP)

**Martischang, Michael F.**

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Geographic information systems (GIS) represent one of the most effective tools that governmental organizations and individuals alike can apply to the complex and continuous task of storing, managing, monitoring, analyzing, and presenting data about the landscape. Rapid and complimentary advances in both software and hardware technologies, accompanied by steadily declining prices for these technologies, have moved GIS from the domain of high-end market, large-scale military/political/business strategic planning to the diverse consumer market of individuals, small interest groups and non-military agencies at all levels of government. When supplied with *"good"* data that is *skillfully* and *appropriately* manipulated, a GIS can offer land managers just what the slick glossy marketing materials promise: unprecedented insights to both spatial and tabular data that can be flexibly used to supply insightful *information* to the full range of decision making needs any individual or organization might have.

Managers of GIS staff and facilities generally fund and support the "tangible" asset portion of a GIS and under-fund and support the "intangible gray-matter" assets it requires to build, operate and maintain a useful GIS. This panel discussion seeks to present some of the "intangible gray-matter" issues for consideration by managers of GIS functions within their particular organization. Observations and opinions are from a GIS coordinator of nine years experience and responsible for providing spatial and tabular data support to over 50 end-users across a 1 million acre area of interest within an federal government agency attempting to implement both national and agency-wide GIS and information management standards. By elevating managers' awareness of the staffing and expertise needs necessary to fulfill the "marketed expectations" of a GIS, they could be better equipped to make budget and staffing decisions that would lend invaluable support to the most important GIS asset – talent.

## USING GIS TO UNDERSTAND THE RESOURCE MANAGEMENT DECISION MAKING PROCESS (GIS WORKSHOP)

**Salmon River Restoration Council (SRRC),**
**Villeponteaux, Jim**
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The Salmon River is a 751 square Mile watershed located in the California portion of the Klamath River Basin. Private property accounts for only 1.3% of the Basin, with the publicly owned majority being under U. S. Forest Service management. The watershed is forested with steep mountain canyons and a highly diverse ecosystem. Due mainly to the large federal management influence, there are prolific GIS data available for the entire watershed. This GIS information is used extensively in the resource management decision-making process.

The Salmon River Restoration Council (SRRC) has been working cooperatively with the Forest Service since 1992. The SRRC has received advanced GIS equipment and training funding from ESRI, Trimble and HP. This equipment has enabled us to engage in meaningful dialog with managing agencies regarding data accuracy, data gaps and analysis of interpretation. Our technical capabilities have allowed us to be more efficient interpreters of resource management issues to the public, which in turn increases awareness and builds ownership in their watershed.

Our cooperative planning efforts using GIS have included a vegetation layer accuracy assessment, road sediment source production assessments, fire management planning and the Salmon River subbasin restoration strategy.

## CREATING AN INTERACTIVE ONLINE DATA REPOSITORY FOR THE KLAMATH BASIN:
## ESTABLISHING A PROTOTYPE KLAMATH WEB GIS

**Steinberg, Steven J.**
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The Klamath Basin is managed across multiple jurisdictions, many located in remote locations. Access to, and distribution of, up-to-date information for the basin is an ongoing concern for a wide range of interested parties including scientists, planners, and members of the public. This paper examines a recently implemented, Internet accessible, data repository for the Klamath Basin. Using freely available Internet tools, the Klamath River Restoration Interactive Map provides online access to a variety of data sources using interactive mapping technology. The technical goals of this data repository are to: 1) provide a universally accessible, web-based interface that provides users with the ability to interactively view and query data within the Klamath River Province and; 2) provide users with the ability to download specific data layers for use in their own mapping and analysis applications and; 3) demonstrate the value of an interactive online data repository as a tool for a wide range of users without the traditional pitfalls associated with locating and accessing a variety of data sources.

The Klamath webGIS and other projects are available at Humboldt State University's Advanced Spatial Analysis Facility web site: http://humboldt.edu/~asaf

**DEVELOPING A GIS DATA BASE FOR UPPER KLAMATH AND AGENCY LAKES' MARSHES**
**(POSTER)**

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**Brian Peck**
U.S.D.I. Bureau of Reclamation, Klamath Basin Area Office, 6600 Washburn Way, Klamath Falls, OR 97603
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A geographic information system data base was prepared for the seven marshes that occur on the outer margins of Upper Klamath and Agency Lakes. The data base was prepared by the manual photo interpretation of 9X9 inch 1:12,000 scale color infrared aerial photographs. The 9X9 inch photographs were supplemented with 35 mm color infrared photographs.

The purpose of this project was to develop base line data on the marsh plants that occur in the seven marshes and to use that information on modeling the effects of possible drawdowns on endangered suckers.

# APPENDIX A

**Daily Schedules of Presentations**

# SCHEDULE OF PRESENTATIONS

## MONDAY, MAY 21

| | WORKSHOPS with Individual Presentations |
|---|---|
| Time | Room: Founders 111 |
| 8:00am | ***Geographic Information Systems As A Management Tool*** |
| | Interagency Migration of Aquatic Data to Routed Hydrography-- *Best, D.; Lamphear, D.*<br><br>The Use of GIS by Grassroots Watershed Councils to Understand Decision Making Process--*Villeponteaux, J.*<br><br>The Use of GIS to Support Community Based Decision Making Process--*Towle. P.*<br><br>GIS Use in the Trinity County Resource Conservation District--*Sheen, K.*<br><br>There Ain't No Such Thing As a Free GIS (With All Due Respect to the Economic Axiom - TANSTAAFL-- *Martischang, M.* |
| 12:0Opm | **LUNCH** |

| | |
|---|---|
| | **Room: Founders 111** |
| | ***MODELING AND ITS ROLE IN THE KLAMATH BASIN*** |
| 1:00pm | Introduction and Role of Modeling, *Deas, M.* |
| 1:10pm | ***Session 1: Planning Models*** |
| | A) Klamath Project Operation Simulation Model – *Parker, N*<br>B) BASINS: A Decision Framework Structure for Managing Aquatic Resources in the Upper Klamath Basin –*Ritter, J* .<br>C) MODSIM/SIAM –*Bartholow, J.* |
| 2:10pm | ***Session 2: Model Applications*** |
| | A) Landscape Assessment Analysis & Temperature Modeling for Rivers in the Klamath Lake Drainage– *Boyd, M.; Leinenbach, P*.<br>B) Lewiston Reservoir Modeling – *Kamman, G.*<br>C) A Temperature Model of the Trinity River – *Zedonis, P.* |
| 3:10pm | ***Session 3: Habitat and Fish Models*** |
| | A) Advances in Integrated Fish Habitat Modeling Using 2-Dimensional Hydrology—*Ludlow, J.*<br>B) Individual-based Models for River Fisheries Management—*Harvey. B; Railsbeck, S.*<br>C) Modeling Wild Animals Is a Different Kind of Beast—*Williams, J.* |
| 4:10pm | ***Session 4: Modeling Roundtable Discussion, Question and Answer*** |
| | |
| 5:00pm | ***end modeling workshop*** |

# SCHEDULE OF PRESENTATIONS

## TUESDAY, MAY 22

| Times | | |
|---|---|---|
| 7:30am | Registration Begins **WEST GYM** | |
| 8:45am- | Opening (blessing) **WEST GYM** | |
| 9:00am | Plenary **WEST GYM** | |
| 10:15am-<br>10:30am | **BREAK** | |
| **Rooms** | **FOUNDERS 125** | **FOUNDERS 111** |
| **Times** | ***Watershed Coordination Roundtable*** | ***Fire I: Implications of Wildfire for Watersheds*** |
| 10:30am | | Fire And Landscape Dynamics In Watersheds Of The Klamath Mountains, *Skinner, C.* |
| 11:00am | | Effects Of Clearcuts And Site Preparation On Fire Severity, Dillon Creek Fire 1994, *Key, J.; Stuart, J.* |
| 11:20am | | The Influence Of Fire Suppression On Vegetation, Environmental Quality And Human Health In The Lower Klamath River Basin Of Northern California, *Pace, F.* |
| 11:40am | | Ecological & Watershed Implications Of Megram Fire, *Jimerson,T; Jones, D.* |
| 12.00pm | **LUNCH** | **LUNCH** |
| | ***Refuge Wetlands*** | ***Fire II: Fire Preparedness & Restoration*** |
| 1:00pm | Relationship Between Flows In The Klamath River And Lower Klamath Lake Prior To 1910, *Weddell¸ B.* | Following A Major Wildfire-Fuel Treatment Opportunities, *McClelland R.; Salazar, L.* |
| 1:20pm | Habitat, Wildlife, And Water Management On Lower Klamath National Wildlife Refuge, A Comparison To The Historic Past, *Mauser, D.* | Rehabilitation And Monitoring Of The Lowden Fire In The Trinity River Watershed, *Frost, P.; Paris, R.* |
| 1:40pm | Refuge Wetlands: Do They Degrade Or Improve Water Quality In The Klamath Basin? *Mayer, T.* | Reversing The Effects Of Fire Suppression On Native Ecosystems In The Mid Klamath Region, *Tripp, W*. |
| | ***Riparian and Wetland Restoration*** | |
| 2:00pm | Restoration Of The Williamson River Delta: A Progress Report, *McCormick, P.; Stern, M.; Matthews, G.* | Community Planning Regarding Fire On The Salmon River, *Villeponteaux, J.* |
| 2:20pm | Long Term Case Study: Riparian Meadow Restoration In The Upper Sprague River Watershed, *Todd, R.* | Community Participation In Fire Management Planning-A Case Example From Trinity County, Ca, *Everett, Y.* |
| 2:30pm | | Fuels Treatment On Private Lands: The Case Of Long Canyon, *Baldwin, K.* |
| 2:40pm | Shasta CRMP Riparian Restoration, *Webb, D.* | Fuels Treatment On Public Lands: Small Diameter Thinning And Utilization, *Danks, C.; Jaegel, R.* |
| 3:00pm<br>3:10pm | **BREAK** | **End Sessions** |
| 3:20pm<br>3:30pm | A Wildlife And Fish Friendly Grazing Program, *Byrne, M.; Byrne, D.* | |
| | ***Basin Catchment Roundtable*** | |
| 3:40pm | Invited participants include:<br>*Alice Kilham*, Klamath Compact Commission Chair<br>*Andrew Stuedli*, Klamath Co. Economic Development Assn.<br>*Woody Deryckx*, Klamath Basin Ecosystem Foundation<br>*Mike Connelly,* Cloverleaf Watershed Council<br>*Stephanie Carpenter*, Klamath Watershed Council<br>*Petey Drucker*, SSRC<br>*Pat Frost*, Trinity RCD<br>*Dave Webb*, Shasta River CRMP | |
| 5:30pm | **Panel Ends** | |

# S C H E D U L E  O F  P R E S E N T A T I O N S

## TUESDAY, MAY 22

| Times | | |
|---|---|---|
| 7:30am | Registration Begins **WEST GYM** | |
| 8:45am- | Opening (blessing) **WEST GYM** | |
| 9:00am | Plenary **WEST GYM** | |
| 10:15am- | **BREAK** | |
| 10:30am | | |
| **Rooms** | **FOUNDERS 118** | **FOUNDERS 163** |
| **Times** | ***Geology, Streams, and Sediment*** | ***Role of Hatcheries in Recovery and Restoration of Klamath Basin Fish Stocks*** |
| 10:30am | | Note: order of panelists' unavailable, but will include:<br>Operating Klamath-Trinity Salmon Hatcheries As If Restoration of Wild Fish Mattered, *Hankin, D.* |
| 10:40am | Summary Of Current Ongoing Geologic Investigations In The Klamath Basin In Oregon, *Hladky, F.; Waff, H.* | Coordination of Hatchery Management Practices with Endangered Species Act Compliance, *Witalis, S.* |
| 11:00am | 1997 Flooding In Three Northern California Klamath Mountain Streams: Influences Of Sediment And Wood Input Magnitude On Flood Effects, *Mondry, Z.; Hilton, S.; Elder, D.; De la Fuente; J.; Baldwin, K.* | The New Challenge For Klamath-Trinity Hatcheries, Conserving Wild Salmon And Steelhead Populations While Augmenting Runs To Support Fisheries, *Higgins, P.* |
| 11:20am | Influence Of Riparian Vegetation On The Legacy Of Debris Floods In The Klamath Mountains, *Lisle, T,; Hilton, S.; Mondry, Z.; Sutherland, D.* | Title unavailable; *Manji, N.* |
| 11:40am | Understanding And Treating Granitic Sediment In The Scott River Sub-Basin, *Sommarstrom, S.* | |
| 12.00pm | **LUNCH** | **LUNCH** |
| | ***Threatened & Endangered Suckers*** | ***Management Of Invasive Species & Weeds*** |
| 1:00pm | The Complex Taxonomy And Genetics Of Klamath Basin Lampreys And Suckers, *Markle, D.* | USFWS Invasive Species Directives With Implications to the Klamath Basin National Wildlife Refuge Complex in CA and OR, *Johnson, S.* |
| 1:20pm | Population Genetics Of Klamath Basin Suckers, *Tranah, G.; May, B.* | Mgmt. of Noxious Weeds on the Salmon River Without Using Chemicals;<br>*Salmon River Restoration Council* |
| 1:40pm | Habitat Utilization And Foraging Success Of Larval Lost River Suckers (Deltistes Luxatus) And Shortnose Suckers (Chasmistes Brevirostris) In The Williamson River And Upper Klamath Lake, *Cooperman, M.* | Panelists Include:<br>*Petey Brucker,* Watershed Community Perspective<br>*Marla Knight*, Land Mngt. Agency Perspective |
| 2:00pm | Hybridization in Modoc Suckers: Fact or Fiction? *Kettratad, J; Reid, S.* | *Bill Tripp*, Tribal Cultural Perspective<br>*Andrea Pickard*, California Native Plant Society |
| 2:20pm | Ecology of Adult Lost River & Shortnose Suckers on Tule Lake NWR, *Mauser, D.* | ***Watershed Assessment Methods*** |
| 2:40pm | | Failure Analysis: The Monitoring Imperative, *Furniss, M.* |
| 3:00pm | **BREAK** | **BREAK** |
| 3:10pm | | Ecosystem Restoration Office Baseline Bioassessment For The Upper Upper Klamath Basin, *Weekley, F.* |
| 3:20pm | ***Get the Scoop on TMDLs*** | |
| | Includes 15 minute talks: | |
| | TMDLs In The Upper Klamath Basin, *Kirk, S.* | |
| 3:30pm | The North Coast Regional Board's Approach To TMDLs, *Leland, D.* | North Coast Watershed Assessment Program: The Benefits Of An Interagency, Collaborative Approach, *Bleier, C.* |
| | TMDLs And Tribes, *McKernan, K.* | |
| | N. Province TMDL Implementation Strategy for USFS Lands, *Carolyn Cook* | |
| | Can Science Save the Klamath River with TMDLs?, *Tim McKay* | |
| 3:50pm | | The Use Of Historical Information To Establish Baseline Conditions For Ecological Restoration, *Ross, D.* |
| 4:10pm | | Fractal Analysis Watershed Project, *VanRooyen, C.; Ritter, J.; Hansen, M.; Emmen, B.* |
| 4:30pm | | Creating An Interactive Online Data Repository For The Klamath Basin: Establishing A Prototype Klamath Web GIS, *Steinberg, S.* |
| 4:50pm | | The California Habitat Restoration Database: An Overview Of Restoration Data For The Klamath Basin, *Carlson, R.; Allen, S.* |
| 5:10pm | TMDL Question and Answer Period | The Systems Impact Assessment Model (Siam) Development And Application, *Bartholow, J.; Flug, M.; Campbell, S.; Heasley, J.; Hanna, B.* |
| 5:30pm | **Panel Ends** | **Session Ends** |

# S C H E D U L E O F P R E S E N T A T I O N S

## WEDNESDAY, MAY 23

| Rooms | FOUNDERS 163 | FOUNDERS 118 |
|---|---|---|
| **Times** | ***Road Restoration*** | ***Hydrology*** |
| 8:00am | Road Decommissioning And Its Effects On Fine Sediment Loading Into Two Bull Trout Occupied Streams On The Fremont National Forest, *Speas, C.* | Hydrogeophysics In The Klamath Basin Of Oregon, *Waff, H.; Hladky, F.* |
| 8:20am | Watershed Level Road Inventories On Private Forestland, *Farber, S.* | Quantitative Investigation Of The Regional Ground-Water Hydrology Of The Upper Klamath Basin, *Gannett, M.* |
| 8:30am | | |
| 8:40am | Transportation Planning And Erosion Prevention On The Six Rivers National Forest, *Cook, C.* | Hydrogeology Of The Klamath Marsh, Klamath County, Oregon, *Cummings, M.; Melady, J.* |
| 8:50am | | |
| 9:00am | Are We Decommissioning The Right Roads? *Pace, F.* | Bedload Measurement And Prediction In The Upper Klamath Basin, *Dawdy, D.; Weinhold, M.* |
| 9:20am | Forest Road Sediment Source Inventory: Applications, *Olson, A.; Elder, D.* | Three Challenges For Instream Flow Modeling, *Williams, J.* |
| 9:40am | Road Decommissioning Within The Karuk Ancestral Territory, Mid-Klamath River Basin, *Burnson, D.* | Assessing Interim Instream Flow Needs In The Main Stem Klamath River: Application Of Advanced Integrated Habitat Modeling, *Hardy, T.; Addley, C.* |
| 10:00am | **BREAK** | **BREAK** |
| 10:10am | | |
| 10:20am | Road Decommissioning: How Effective Is It? *Madej, M.* | Hydrologic Similarity Of Small Mountain Streams In The Upper Klamath River Basin, *Hahn, A.; Richards, S.; Lucas, W.; Pence, J.* |
| 10:40am | Road Related Restoration Projects-South Fork Trinity River, *Spear, J.* | Methodology And Concepts Used To Determine Instream And Out – Of – Channel Flow Requirements For US Forest Service Streams In The Upper Klamath Basin Of Oregon, *Ford, R.; Sullivan, T.; Lucas, W.; Smith, T.* |
| | | ***Water Quality*** |
| 11:00am | | Physical And Chemical Water Quality Monitoring In The Klamath River Basin: 2000, *Deas, M.* |
| 11:20am | Watershed Restoration On The Hoopa Valley Indian Reservation, *Blomstrom G.; Norton, K.* | Nitrogen And Phosphorus Losses From Drained Wetlands Adjacent To Lake, Oregon, *Snyder, D.* |
| 11:40am | Road Improvement Techniques To Reduce Sediment Runoff, Klamath County, OR, *Sokol, C.* | Recent Paleolimnology Of Upper Klamath Lake, Oregon, *Eilers, J.; Kann, J.; Moser, K.; Amand, A.; Gubala, C.* |
| 12:00pm | **LUNCH** | **LUNCH** |
| | ***Restoration Projects*** | ***Water Quality,cont.*** |
| 1:00pm | A Private Property Owner's Aquatic Restoration Efforts, *Root, J.* | Water Quality Impacts To The Klamath River From The Klamath Straits *Drain, Mayer, T.* |
| 1:20pm | The Crooked Creek Channel Narrowing Project, *Norman, R.; Matthews, G.* | Nutrient Loading In The Klamath Basin, *Rykbost, K.* |
| 1:40pm | Baseline And Pre-Restoration Biological And Water Quality Monitoring For The Root Ranch Crooked Creek System, *Kann, J* . | Pesticide Impact Assessment In Tule Lake And Lower Klamath National Wildlife Refuges, *Hawkes, T.; Johnson, S.* |
| 2:00pm | The Wood River Channel And Wetland Restoration Project: 1997-2001, *Matthews, G.* | Reassociating Wetlands With Upper Klamath Lake To Improve Water Quality, *Geiger, N.* |
| | | ***Salmonids*** |
| 2:20pm | Wood River Wetland Monitoring-The First Five Years, *Watkins, W.* | Modeling Microhabitat For Fall Chinook Life Stages In The Klamath River (Iron Gate Dam To The Scott River), *Henriksen, J.; Shaw, T.* |
| 2:40pm | Restoration Of The Williamson River Delta: A Progress Report, *McCormick, P.* | Spawning Gravel Quality In The Trinity River Mainstem And Tributaries, *Barnard, K.* |
| 3:00pm | Competing, Complimentary, And/Or Replacement Strategies For Watershed Restoration In The Klamath Basin, *Gearheart, R.* | Regional Estimation Of Juvenile Coho (Oncorhynchus Kisutch) In Tributaries To The Lower Klamath River, Ca 2000, *Voight, H.* |
| 3:20pm | **BREAK** | **BREAK** |
| 3:40pm | Establishing Success Measures For Abating Threats In 1st To 3rd Low Gradient Streams In The Upper Klamath Basin, *Bienz, C.* | Residence Time Of Juvenile Chinook Salmon In The Klamath River Estuary, *Wallace, M.* |
| 4:00pm | Update On Scott River Dredge Tailings Floodplain Restoration Project, *Hesseldenz, T.* | Salmonid Use And Physical Characteristics Of Thermal Refugial Areas The Mainstem Klamath River From Iron Gate Dam To Weitchpec, CA, *Belchik, M.* |
| 4:20pm | Seasonal Wetland/Cropland Rotation On Tule Lake National Wildlife Refuge An Integrated Pest Management Approach, *Green, M.* | Disease And Elevated Water Temperature In The Klamath River Basin, *Foott, J.* |
| 4:40pm | Western Juniper: Water Sucking Weeds Or Money Trees, *Long, D.* | Pinniped Predation On Fall-Run Chinook, *Hillemeier, D.; Williamson, K.* |
| 5:00pm | Reach, Inc. Workforce 2001 Sustaining People, Communities And The Earth, *Everson, B* . | Response Of A Resident Bull Trout Population To Nine Years Of Brook Trout Removal, Crater Lake National Park, Oregon, *Buktenica, M.; Mahoney, B.; Mahoney, S.* |
| 5:20pm | **End Session** | **End Session** |

# SCHEDULE OF PRESENTATIONS

## WEDNESDAY, MAY 23

| Rooms | FULKERSON HALL |
|---|---|
| Times | |
| 8:00am | Coping With Competition: An Economist's View Of Controversies Over View Of Controversies Over Related Resources, Nieme, E. |
| 8:20am | |
| 8:30am | Dividing The Harvest, *Pierce, R.* |
| 8:40am | |
| 8:50am | **Tribal View: Our Tradition, Our Future** |
| | Panel Presenters:<br>Susan Masten, Chairwoman of the Yurok Tribe (8:50 – 9:10 a.m.)<br>Leaf Hillman, Director of the Karuk Tribe (9:10-9:25 a.m.)<br>Danny Jordan, Self-Governance Coordinator, Hoopa Valley Tribe (9:30-9:45 am)<br>Elwood Miller, Dir., Dept.Fish & Wildlife for the Klamath Tribes (9:45-10:00 am) |
| 10:00am | **BREAK** |
| 10:10am | **Coastal Communities & Commerical Fisheries** |
| | Panel Presenters:<br>*Jimmy Smith* (moderator), Humboldt County First District Supervisor<br>*Bob Hallmark*, Former Board member of the Klamath Fisheries Ports Coalition<br>*Sandie Crockett*, Chair of the Klamath Fisheries Ports Coalition |
| 11:40am | California Commercial Salmon Fisheries: The Klamath Role In Management *Mullan, A.* |
| 12:00pm | **LUNCH** |
| 1:00pm | Citizens Along The Klamath River Discover Systemic Actions About Water And Livelihoods, *Hathaway, R.; William, R.* |
| | ***River Communities: Where Have The Tourists Gone?*** |
| 1:20pm | Economics Of Estuary Fishing, *Bostwick, V.* |
| 1:40pm | Historic Perspective And Current Conditions Of The Tourist Based Fishing Industry On The Trinity, *Rowley, M.* |
| 1:55pm | The Reality Of Owning A Fishing Resort And The Impacts Of Water Quality And And Fishing Regulations, *Reis, B.* |
| | ***Agricultural Perspectives*** |
| 2:10pm | Solving The Klamath Basin's Environmental Problems: A First Step, *Stuedli, T*. |
| 3:10pm | Power-Drought Planning For Farmers, A Win-Win Approach Toward Renegotiating Long Term Power Contracts, *Staunton, M.* |
| 3:30pm | **BREAK** |
| 3:40pm | |
| 3:50pm | Gussyfish: Looking For Home Where We Already Live, *Connelly, M.* |
| 4:40pm | **Perspectives On Water Use Roundtable** |
| 5:20pm | **End Rountable** |

# SCHEDULE OF PRESENTATIONS

## THURSDAY, MAY 24

| Times | | |
|---|---|---|
| 7:30am | Registration | |
| **Rooms** | **FOUNDERS 118** | **FOUNDERS 125** |
| **Times** | ***FERC Relicensing*** | ***Restoration Programs I*** |
| 8:00am | Overview Hydrolicensing Process, *Brown, R.* | Overview Of Restoration Projects Coordinated By The Klamath Tribes, *Gentry, D.* |
| 8:20am | What Is The Klamath River Hydroelectric Project? *Brown, R.; Olson, T.* | Watershed Restoration Planning And Implementation In The Lower Klamath Sub-Basin, *Gale, D.; Rhode, B.* |
| 8:40am | Licensee Issues And Concerns, *Olson, T.* | California Department Of Fish And Game Restoration And Planning Activities Within The Klamath Basin: Past, Present And Future, *Wheetley, M.* |
| 9:00am | State Water Quality Agencies Issues And Concerns, Kanz, R.; DeVito, P. | Forest Service And Bureau Of Land Management Unified Watershed Management, Upper Klamath Basin, *McNamara, M.* |
| 9:20am | State Fish And Wildlife Agencies Issues And Concerns, *Manji, A.; Stuart, A.* | The Klamath River Basin Conservation Area Restoration Program: Watershed Restoration Based On Partnerships Between Stakeholders, *Simmons, L.; Silveira, J.; Darr, B.; Eastman, D.* |
| 9:40am | Tribal Issues And Concerns, *Belchik, M.; Pierce, R.; Newberry, D.* | Klamath Basin Ecosystem Restoration Office: Watershed Restoration Activities, *Mullis, C.; Jainline, J.; Hamilton, A.; King, A.* |
| 10:00am | **BREAK** | **BREAK** |
| | | ***Restoration Programs II*** |
| 10:20am | Federal Fish And Wildlife Agencies Issues And Concerns, *Reck, D.; Brown, R.* | Walking The Fence - Balancing Fisheries, Wildlife And Cultural Concerns While Implementing The Development Of Shasta Valley Wildlife Area, *Smith, R.* |
| 10:40am | Federal Land Management Agencies Issues, Van de Water, D. | Ongoing Cooperative Watershed Assessment In Spencer Creek, Turaski, M. |
| 11:00am | FERC Roundtable Discussion--Q & A | Regulatory Agencies, Tribal Members And Landowners, *Gierak, R.; Bergeron, L.* |
| 11:20am | | The Five Counties Salmon Conservation Process Summary Of Activities And Future Direction, *Lancaster, M.* |
| 11:40am | Ferc Relicensing And The Economic Valuation Of Non-Market Resources, *Sevigny, M.* | A Global Perspective On The Biodiversity Of The Klamath-Siskiyou Ecoregion, DellaSala, D. |
| 12:00pm | **LUNCH** | **LUNCH** |
| | ***Fish and the Law*** | ***Bird Conservation Issues*** |
| 1:00pm | Endangered Species Act Consultation On The Effects Of Klamath Project Operations On The Endangered Lost River And Shortnose Sucker, *Buettner, M.* | Breeding Ecology Of White-Faced Ibis In The Upper Klamath Basin Of California, *Taft, M.; Mauser, D.; Arnold, T.* |
| 1:20pm | Evolution Of Management For Klamath Lake Redband Trout, *Messmer, R.* | Changing Patterns Of Waterfowl Use On Klamath Basin Refuges During Autumn And Spring Migration 1950-2000, Gilmer, D.; Yee, J.; Mauser, D.; *Hainline, J.* |
| 1:40pm | Recovery Planning For West Coast Salmonids, *Bryant, G.* | Bald Eagles (Haliaeetus leucocephalus) Nesting In The Oregon Portion Of The Klamath Basin, *Isaacs, F.; Anthony, R.* |
| 2:00pm | | Bear Valley National Wildlife Refuge Bald Eagle Habitat Improvement Project-An Update, *Beckstrand, J.; Thomson, D.; Bechdolt, M.* |
| 2:10pm | ***Status and Management Spring Chinook Salmon Roundtable*** | |
| 2:20pm | | Avian Botulism Risk Model And Adaptive Management Of Wetland Environmental Conditions To Reduce Avian Botulism Mortalities, *Hernandez, Y.; Botzler, R.; Samuel, M.* |
| 2:40pm | | Using A Wide-Scale Landbird Monitoring Network To Determine Landbird Distribution And Productivity In Conifer Forests Of The Klamath Bioregion Of Oregon And California, *Ralph, C.; Alexander, J.* |
| 3:00pm | **BREAK** | **BREAK** |
| 3:20pm | | Position Advocacy By Scientists Risks Science Credibility And May Be Unethical, *Mills, T.* |
| 3:40pm | | **End Session** |
| 4:10pm | **Chinook Panel Ends** | |
| 4:20pm | **SUMMARY SESSION- All Tracks** | |
| 5:00pm | **End Summary** | |

# S C H E D U L E   O F   P R E S E N T A T I O N S

## THURSDAY, MAY 24

| Times | |
|---|---|
| 7:30am | Registration |
| **Rooms** | **FOUNDERS 163** |
| **Times** | ***Mollusks, Amphibians, Mammals*** |
| 8:00am | Biogeography, Endemism, And Ecology Of An Ancient Lake Mollusk Fauna: A Baseline Freshwater Mollusk Survey Of The Upper Klamath Lake Drainage And Adjoining Regions, South-Central Oregon, *Frest, T.; Johannes, E.* |
| 8:20am | Associations Between Stream Size and Abundance of Amphibians & Small Mammals in a N.W. CA Watershed, *Waters, J.; Zabel, C.; McKelvey, K.; Welsh, H.* |
| 8:40am | Responses Of Native Herpetofauna To Flow Regime Management On The Mainstem Trinity River Of Northwestern California: Two Case Studies, *Welsh Jr., H.; Lind, A.; Reese, D.* |
| 9:00am | Status Of The Oregon Spotted Frog (Rana Pretiosa) In The Klamath Basin, *Reid, S.; Ross, D.* |
| 9:20am | |
| 9:40am | A Comparison Of Abundance, Assemblage, And Nocturnal Activity Of Amphibians In Old Growth And Second Growth Redwood Forest Creeks In Humboldt County, California, *Ashton, D., Marks, S.; Welsh, H.* |
| 10:00am | **BREAK** |
| | ***Trinity River Through Time*** |
| 10:20am | Yurok Perspective Of Trinity River Fisheries Resources, *Fletcher, T.; Masten, S.* |
| 10:40pm | Honey, I Shrunk The Channel, *Trush, W.* |
| 11:00am | Physical Habitat Modeling Of Stream Channel Rehabilitation In The Trinity River: A Comparison Of Existing And Potential Future Aquatic Habitat, *Payne, T.* |
| 11:20am | Evaluation Of The Effects Of The Trinity River Channel Restoration Program On Herpetofauna Abundance And Habitat Availability, *Williamson, J.; Lang, J.; Glase, J.* |
| 11:40am | Trinity River Flow Evaluation And Recommendations, *Glase, J.; Polos, J.; Gray, A.; Zedonis, P,; McBain, S.* |
| 12:00pm | **LUNCH** |
| | ***Trinity River Restoration*** |
| 1:00pm | Trinity River Fisheries Restoration Policy And History: 1980-2000, *Newberry, D.* |
| 1:20pm | Klamath/Trinity River Basin Co-Management, *Orcutt, M.* |
| 1:40pm | The Record Of Decision And Its Litigation Status, *Stokely, T.* |
| 2:00pm | Restoration Through Stream Flows And Mechanical Modification (Past And Future), Mendenhall, B. |
| 2:20pm | Addressing Impacts To Flood Plain Property From Increased Trinity River Releases, *Solbos, E.* |
| 2:40pm | Scientific Components Of The Trinity River Adaptive Environmental Assessment And Management (Aeam) Program, *McBain, S.; Stalnaker, C.; Wittler, R.; Polos, J.* |
| 3:00pm | **End Trinity Session** |
| 5:00pm | |

# APPENDIX B

## Workshop Descriptions and Klamath Basin Conference Modeling Workshop Summary

## WORKSHOP DESCRIPTIONS--MONDAY, MAY 21

Summaries of the content and/or background of the Monday Workshops are provided on the following pages in descriptions provided by the session organizers. Both the GIS and the Modeling workshops have a series of individual presentations that are listed in the Daily Schedule of Presentations (Monday) on page A-1, Appendix A. Abstracts for those presentations are listed in the index starting on page 28, by topic section and then alphabetically by first author.

### FARM/RANCH WATER QUALITY PLANNING

**Instructor**: Shauna Foster, Extension Agent—Watershed Education, OSU Klamath County Extension Office, 3328 Vandenberg Rd., Klamath Falls, OR 97601; phone: (541)883-7131; email: shauna.foster@orst.edu
**Instructor**: Ron Hathaway, Staff Chair, OSU Klamath County Extension Office, 3328 Vandenberg Rd., Klamath Falls, OR 97601; phone: (541) 883-7131; email: mailto:ron.hathaway@orst.edu

This course is designed to help landowners and land managers develop management plans addressing resource issues for their properties. Regulations and resources affecting the Klamath Basin watershed area will be discussed. Management plans can be worked on in the privacy of one's own home, the course is a starting point.

### GEOGRAPHIC INFORMATION SYSTEMS AS A MANAGEMENT TOOL

**Session Organizer**: Gary Emery, GIS Coordinator, Fisheries Dept, Hoopa Valley Tribe, P.O. Box 417, Hoopa, CA 95546; phone: (530) 625-4267 x22; email: mailto:gis@pcweb.net
**Moderator**: Steven Steinberg, Faculty, Natural Resources Planning & Interpretation Dept., Humboldt State Unversity, Arcata, CA 95521

This session will feature a panel of GIS analysts and coordinators who will discuss current GIS issues and use of specific GIS projects in resource planning and management. After individual presentations by panelists, there will be an audience/panelist question and answer session.

### MODELING AND ITS ROLE IN THE KLAMATH BASIN

**Session Organizer and Moderator**: Michael Deas, Watercourse Engineering Inc., 1732 Jefferson Street, Suite 7, Napa, CA 94559; phone: (707) 265-6560; email: mjbdeas@jps.net

Fundamentally a model is an abstraction of reality because in most cases nature is simply too complex to understand. More formally, a model is a mathematical representation of selected processes or relationships that clearly imply a correlation and/or infer cause and effect. With increasing frequency models are used to predict the future because decision making is a forward-looking process. To extend beyond experience and judgement alone, models can be used to predict scientific information. Models are also useful in providing insight into processes that are infeasible, difficult, or expensive to monitor/analyze. It is through the application of models, and especially inferences of cause and effect, that we gain understanding of nature. Generally, the physical models that are used depend upon the fundamental rules of nature, called laws, and that these laws are fixed in space and time, e.g., conservation of energy, mass, or momentum. If this were not the case there would be no rational method for prediction. Beyond these fundamental laws, models depend on information. Information to represent relationships of physical processes and measured observations to drive and test models. By their very definition, models are imperfect representations of the world.

The session theme was built around five questions that were posed to all presenters:
What was <u>your</u> problem? What was your objective?
Why was a model necessary?
What information was necessary to complete the modeling study?
What did you need from the model (output) and how did you use it to meet your objective?
What are the model capabilities, limitations, and restrictions?
The questions were selected to provide information on a few critical modeling study issues, for people who are not necessarily doing modeling work, but instead are involved in modeling via oversight, management, regulatory purposes, review of study results, funding, etc.

**PROJECT WET (WATER EDUCATION FOR TEACHERS)**

**Instructor**: Denise Buck, Extension Agent, Natural Resources Education, OSU Extension Service, 3328 Vandenberg Rd., Klamath Falls, OR 97601; phone: (541)883-7131; email: denise.buck@orst.edu

Project WET is an international, interdisciplinary water science and education program for K-12 educators. This will be an informative, interactive and fun workshop. Each participant will receive the Project WET Curriculum and Activity Guide with 90-plus hands-on, easy-to-use, fun and innovative activities.

**PROPER FUNCTIONING CONDITION (PFC)**
**Instructor**: Lorena Corzatt, Hydrologist, Riparian Team; phone: (541) 882-9578; email: mailto:lcorzatt@oregonvos.net
**Instructor**: Mike Borman, State Rangeland Specialist, Extension Rangeland Resources, 202 StAG, Oregon State University, Corvallis, OR 97331; phone: (541) 737-1614; email: mailto:michael.borman@orst.edu

With emphasis on achieving riparian restoration through cooperative efforts within watersheds, this workshop focuses on bringing people with diverse values together and implementing the use of the PFC assessment method as a key tool for a collaborative, landscape approach.

**RIPARIAN HABITAT JOINT VENTURE**
**Instructor**: Ann Chrisney, RHJV Coordinator, Point Reyes Bird Observatory, 4990 Shoreline Hwy, Stinson Beach, CA 94970

California Partners in Flight (CPIF) launched the ambitious Riparian Habitat Joint Venture (RHJV) project in September 1994. The RHJV, modeled after the successful joint venture projects of the North American waterfowl plan, reinforces other collaborative efforts currently underway which protect biodiversity and enhance natural resources as well as the human element they support. To date, eighteen federal, state and private organizations[1] have signed the landmark cooperative agreement to protect and enhance habitats for native landbirds throughout California.

By developing a coordinated statewide effort, increasingly fragmented habitat patches can be connected and enlarged into an extensive network of riparian forests capable of supporting viable breeding populations of native birds. A wide variety of other species of plants and animals will benefit through the protection of forests along our rivers, streams and lakes. Further, RHJV results and recommendations will be fully integrated into other multi-species planning efforts through participation of member organizations.

The six objectives of the RHJV are:

1) Compile existing information on riparian habitat throughout the state to identify key riparian areas, as well as information gaps. Promote and coordinate efforts to obtain the information.

2) Develop guidelines for the protection of existing riparian habitat on public lands and recommend alternatives for protection of habitat on private lands.

3) Restore riparian habitat on public and private lands using commonly accepted, scientifically valid restoration techniques.

4) Enhance the productivity and biodiversity of riparian communities using appropriate management techniques

5) Establish a network of high-quality riparian habitats throughout California to enhance and protect native birds.

6) Educate the general public and resource managers about the status and value of California's riparian habitat.

A major achievement of the RHJV partnership is the development of a statewide Riparian Bird Conservation Plan based on current, scientifically valid data and the collective expertise of the state's top ornithologists. This plan is the guidance document for RHJV riparian conservation and action. The Conservation Plan is based on fourteen riparian-associated bird species selected to serve as indicators of a range of natural riparian habitat conditions [2]. The Plan synthesizes and summarizes current scientific knowledge on the requirements of the fourteen focal species. It also provides recommendations for habitat protection, restoration, management, monitoring, and policy to ensure the long-term persistence of birds and other wildlife dependent on riparian ecosystems. The Conservation Plan is a living document which will be improved and updated as new

[1] Ducks Unlimited, National Audubon Society, National Fish and Wildlife Foundation, Point Reyes Bird Observatory, Sacramento River Partners, The Nature Conservancy, The Resources Agency, California Department of Fish and Game, California Department of Water Resources, Wildlife Conservation Board, State Lands Commission, National Park Service, Natural Resources Conservation Service, U.S. Bureau of Land Management, U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, U.S. Forest Service, U.S. Geological Survey

[2] Bank Swallow, Bell's Vireo, Black-headed Grosbeak, Blue Grosbeak, Common Yellowthroat, Song Sparrow, Swainson's Hawk, Swainson's Thrush, Warbling Vireo, Willow Flycatcher, Wilson's Warbler, Yellow-billed Cuckoo, Yellow-breasted Chat, Yellow Warbler

information becomes available from the field and implemented through bioregional working groups.

**WATERSHED & ENVIRONMENTAL SUSTAINABILITY TECHNIQUES (WESt)**
Instructor: John Buckhouse, Professor--Rangeland Resources, 308 StAG, Oregon State University, Corvallis, OR 97331; phone (541) 737-1629; email: mailto:john.buckhouse@orst.edu

WESt is farmers and ranchers and watershed working groups working together to improve how we take care of soil, water, grass, trees, fish, wildlife and other precious natural resources. "I come out and talk about what they can do on their land, rather than just sitting back reacting to new regulations" (John Buckhouse). The WESt program is designed to enable neighbors, living within the confines of the same local watershed, to understand and properly manage their properties and their watershed. It enables ranchers/landowners to work cooperatively, while maintaining independence, learn about and improve their watersheds, write their own plans and influence their own destinies.

**KLAMATH BASIN CONFERENCE MODELING WORKSHOP SUMMARY**
**Steven Steinberg, NRPI Department, Humboldt State University**

Moderator: Mike Deas (Watercourse Engineering, Inc.)
Participants:
Nancy Parker (U.S. Bureau of Reclamation)
John Ritter (Oregon Institute of Technology)
John Bartholow (U.S. Geologic Survey, Biological Resources Division)
John Williams
Greg Kamman (Kamman Hydrology and Engineering)
Paul Zedonis (U.S. Fish and Wildlife Service)
Steve Kirk (Oregon Dept. of Environmental Quality)
Bret Harvey (U.S. Forest Service)
Jennifer Ludlow (Utah State University

Outlined herein are general summary notes of the modeling workshop. The session introduction is included to provide background for the summary notes. If it were necessary to sum up the general findings of the model workshop in three points they would be

(1) models are useful provided there is a clear objective for their application, interpretation, and use of results,
(2) models often demand substantial data requirements and are likewise labor intensive to implement and apply, and
(3) models are not a precise tool, and they should be used as one of possibly several tools to help decision makers and resource managers.

## WORKSHOP FINDINGS

### Modeling and its Role in the Klamath Basin: Introduction (Mike Deas)

Fundamentally a model is an abstraction of reality because in most cases nature is simply too complex to understand. More formally, a model is a mathematical representation of selected processes or relationships that clearly imply a correlation and/or infer cause and effect. With increasing frequency models are used to predict the future because decision making is a forward-looking process. To extend beyond experience and judgement alone, models can be used to predict scientific information. Models are also useful in providing insight into processes that are infeasible, difficult, or expensive to monitor/analyze. It is through the application of models, and especially inferences of cause and effect, that we gain understanding of nature.

Generally, the physical models that are used depend upon the fundamental rules of nature, called laws, and that these laws are fixed in space and time, e.g., conservation of energy, mass, or momentum. If this were not the case there would be no rational method for prediction. Beyond these fundamental laws, models depend on information. Information to represent relationships of physical processes and measured observations to drive and test models. By their very definition, models are imperfect representations of the world.

The session theme was built around five questions that were posed to all presenters:

1) What was <u>your</u> problem? What was your objective?
2) Why was a model necessary?
3) What information was necessary to complete the modeling study?
4) What did you need from the model (output) and how did you use it to meet your objective?
5) What are the model capabilities, limitations, and restrictions?

The questions were selected to provide information on a few critical modeling study issues, for people who are not necessarily doing modeling work, but instead are involved in modeling via oversight, management, regulatory purposes, review of study results, funding, etc.

**Nancy Parker** – *Klamath Project Operation Simulation Model*

- Computer modeling applications force participants and stakeholders to quantify, i.e., characterize the important components in the system. One of the most valuable benefits of modeling projects is the identification of what is most important and what is less important. This is not always a straightforward task
- A good objective is requisite to successful modeling. The objective must focus the effort so that it is clear what the model is designed to do.
- System simplification is the rule in model development and application. Clearly identifying simplifications and their potential impact on model uncertainty and confidence can aid in model application.
- Identify the required model output early in the process.
- Many models are used to aid in estimating the impacts of various operating criteria or response to hydrologic events. As such, the "rules" and "data" change quickly. Identifying the most common variables to be changes can increase the flexibility of a model by not "hardwiring" critical parameters, e.g., water use priorities. Such forethought can result in a model that can effectively evolve with changing conditions.

**John Ritter** – *Basins: A Decision Framework Structure for Managing Aquatic Resources in the Upper Klamth Basin*

- When addressing regulatory or other processes where stakeholders are involved, it is often useful to have a graphical user interface as a visualization tool. Such tools can be very helpful for committee use. Further, many graphical user interfaces ease model use and provide utilities for data management (both input and output).
- Graphical user interfaces can also hide some of the more complex components of a modeling framework. It is important to understand what is going on "behind the scenes" in your model.
- Many modeling efforts, especially those at the basin scale, require lots of data and many parameters. A clear understanding of the source and quality of model data as well as the required parameters is necessary. For example, the implications of non-local data or data estimates can increase model uncertainty.
- When adopting modeling frameworks there is a large amount of work in model implementation. Gathering the requisite data, loading it into the model, and calibrating and validating the model.

**John Bartholow** – *The System Impact Assessment Model (A|SIAM) Development and Application*

- Identification of objectives, and as necessary sub-objectives is necessary. The objectives can be prioritized.
- Used "off the shelf" (e.g., readily available from federal or state agencies) models to create a modeling framework, run through a graphical user interface. Off the shelf models have often been widely used and may include a level of peer review.
- Existing software can be used to "link" independent models through a graphical user interface.
- Data demands are great when employing multiple models in a modeling framework. Date types may include hydrology, water use and demands, instream requirements, reservoir rules, geometry, legal and institutional arrangements.
- Modeling applications have inherent strengths and weaknesses. Their potential benefits include the integration of physical, chemical, and biological processes; providing quick insight to system response (screening); and data management and output processing. Some of the weaknesses may include the fact that assumptions may not always be clear and uncertainty may be difficult to quantify, especially in large modeling frameworks. It is important to make this information available and let the user evaluate the appropriateness of the model application.

**Steve Kirk** – *TMDLs in the Upper Klamath Basin*

- Models applied to set regulatory criteria are under much more scrutiny than many other model applications. Model application must be legally defensible.
- The data requirements and time to implement the model (gather data, prepare data and select model parameters, and calibrate and validate the model) can be very large (e.g., months).
- Detailed documentation of the model and applications is important in regulatory applications.
- Regulatory applications are somewhat different than impact analysis or operational studies. The latter studies often assess several alternative conditions for comparison and assessment. Conversely, regulatory studies may not look at alternative applications, but rather identify potential conditions, loading capacities (e.g., TMDL), and demonstrate water quality standards attainment. For these purposes a deterministic model is applied. Robust analysis required.

**Greg Kamman** – *Lewiston Reservoir Modeling*

- Computer simulation model (BETTER) employed to assess temperature control in the Trinity River downstream of Lewiston Dam, with a specific objective of meeting temperature objectives.
- BETTER is a two-dimensional model, allowing the representation of longitudinal as well as vertical variations in the reservoir. Geometry was challenging to represent.
- Models were run in series to assess this system, with Trinity Lake modeled first, passing information to the Lewiston Lake BETTER model, and subsequently output from BETTER was passed to SNTEMP for river simulation.
- The models did not run on the same time step, nor were they run by the same people (or organizations). Logistical challenge, yet still provided relatively rapid assessment of alternative operations.

**Paul Zedonis** – *A Temperature Model of the Trinity River*

- Goal of SNTEMP application was to simplify the understanding of a complex system and examine temperature effects of water resources development and river regulation.
- One-dimensional, steady flow application
- Limited data availability for certain parameters (e.g, synthesized tributary hydrology).
- Linked to BETTER model for upstream flow and temperature conditions
- Modeling was labor intensive.
- Model performed well and assisted in obtaining project goals, but noted that it is a "model" and "not perfect." Model used to complete large amount of comparative analysis.

**Jennifer Ludlow** – *Advances in Integrated Fish Habitat Modeling Using Two-Dimensional Hydraulics*

- Two-dimensional model to simulate system hydraulics for assessment of instream flows necessary to protect aquatic resources.
- Noted that precision and accuracy are not equivalent concepts, and that input data quality directly affects output quality (e.g., garbage in equals garbage out)
- High precision information required in these complex and detailed modeling efforts.
- Geometry was especially critical. Large amount of data was required because habitat components are small.
- Computationally intensive models.
- Wetting and drying added to accommodate variable river stage.
- Three-dimensional models were not applied – too complex.

**Bret Harvey** – *Individual-Based Models for River Fisheries Management*

- Habitat is not the only parameter important in population dynamics. There are many interacting factors, and these interactions are difficult to capture in experiments. Thus, resource managers are in a poor position to prioritze management actions. Models can help.
- Individually-based spatially explicit model (IBM) examines habitat dynamics, feeding and growth, mortality risks, spawning and egg incubation and other factors (some components better defined than others).
- Data needs are extensive, because they are on a scale relevant to individual fish.
- Pros: can include many factors, can forecast and assess impacts of multiple factors, output relative to resource management
- Limitations: Scales must be relevant to animals, need lots of information…information that is not always easy to collect.

**John Williams** – *Modeling Wild Animals is a Different Kind of Beast*

- Models are not for precise predictions, but to provide clearer characterization of system insight.
- Lots of uncertainty in modeling, often poorly quantified.
- Cites Ludwig, stating that effective management models cannot be realistic due to prediction error from approximations (decrease with model complexity) and estimations (increase with model complexity). At best it is a balance between these two scenarios.
- Models (1) clarify how you think the system works, (2) are useful for testing monitoring programs, and (3) valuable for carrying out experiments.

# APPENDIX C

## Session Descriptions

## SESSION DESCRIPTIONS

Content and/or background of organized sessions are summarized on the following pages in descriptions provided by session organizers. Sessions are listed below in chronological order based on date and time the sessions occur in the symposium schedule; concurrent sessions are listed in alphabetical order. Please see "Daily Schedule of Presentations" Section starting on page 12 for listing of individual presentations and authors. Abstracts for individual presentations within these sessions are listed alphabetically by first author in the Abstracts Section (starting on Page 33).

### TUESDAY MORNING, MAY 22

**10:30 a.m**.
**Fire Session I: Implications of Wildfire for Klamath Basin Watersheds**—Individual Presentations
**Session Organizers**: Yvonne Everett and Jim Villeponteaux
**Moderator**: John Stuart

Wildfire in the uplands is a critical factor affecting watersheds in the Klamath Basin. There have been several large fires in the area recently and they have catalyzed local interest in the effects of fire on the watersheds and specifically on fish and water quality. While most people agree that fire is a natural disturbance regime in the region and vital to its ecosystems, there is considerable discussion about the dynamics of wildfire and the role forest management has played in influencing them. Further, as a result of growing interest in managing with fire while avoiding catastrophic wildfire, a number of pre-fire treatment and post fire restoration responses are emerging. This two session set of presentations addresses this interest. In this first panel, current research on fire behavior and fire impacts in the Klamath Basin is presented.

**Geology, Streams, and Sediment—**Individual Presentations
**Moderator:** Phil Norton

**Role Of Hatcheries In Recovery And Restoration Of Klamath Basin Fish Stocks—**Individual Presentations and Roundtable Discussion
**Session Organizer and Moderator:** George Kautsky

Irongate and Trinity River Hatcheries were constructed in the mid 1900's for fisheries mitigation in the Klamath Basin. The original purpose for those facilities may need to be revisited in context of restored habitat and ESA. Managers are challenged to identify the future role of these facilities. The objective of this session is to provide an opportunity to gain perspectives in new directions for hatchery operations in the Klamath Basin.

**Watershed Coordination--**Roundtable Discussion
**Session Organizer and Moderator:** Jim Carpenter

Senator Hatfield appointed the Upper Klamath Basin Working Group in the spring of 1995 in response to a number of natural resource challenges brought to a head by drought condition in 1992 and 1994. The 104th Congress formalized the Group under the Oregon Resources Conservation Act (ORCA). The legislation further required that the Working Group establish a Cooperative Agreement among the four federal working groups in the Klamath Basin: The Upper Klamath Basin Working Group; the Klamath River Fisheries Task Force, the Trinity River Task Force and the Klamath Compact Commission with two representatives from each group. This Cooperative

Agreement has been written and accepted by all four Groups and signed by Interior Secretary Babbitt. This panel discussion at the Symposium will be an opportunity for the Coordination Group to present our efforts in a public forum, and for the Upper Klamath Basin Working Group to discuss it's basin wide Restoration Plan now under development.

## TUESDAY AFTERNOON, MAY 22

**1:00 p.m.**
**Fire Session II: Fire Preparedness and Restoration—**Individual Presentations
**Session Organizers and Moderators**: Yvonne Everett and Jim Villeponteaux,

In this second fire session, examples of current restoration and fire preparedness implementation activities ongoing in Klamath Basin watersheds and communities are discussed. Please see Fire Session I (Tues. Morning) description for more details.

**Refuge Wetlands**—Individual Presentations
**Session Moderator:** Phil Norton

**Threatened and Endangered Suckers—**Individual Presentations
**Moderator**: Mark Buettner

**1:20 p.m.**
**Management of Noxious Weeds on the Salmon River without Using Chemicals—** Roundtable Discussion
**Session Organizer and Moderator:** Petey Brucker
Panelists Include:

- Petey Brucker – SRRC – Watershed Community Perspective
- Marla Knight – US Forest Service Botanist – Land Managing Agency Perspective
- Bill Tripp – Tribal Cultural Perspective
- Andrea Pickard – California Native Plant Society

Presence and management of noxious weeds pose a significant problem to fish. The health of fisheries habitat is closely related to soil disturbance. Rate of recovery from the disturbance is related to watershed/fisheries health. Noxious weeds are closely associated with soil and vegetation disturbance. Most priority invasive weeds need soil disturbance to establish themselves. Once present, these weeds can retard recovery of native plant communities in aquatic, riparian and upslope habitats and will increase soil erosion. Until now the battle against noxious weeds has taken place in watersheds with a significant agricultural presence – now the battle has come to wildland watersheds, like the Salmon River. Federal, state, and county land managers are launching a full-scale war on several of these species. The tool almost exclusively chosen by the managers is chemical herbicides. Large-scale use of these chemical in or adjacent to the waterways poses a threat to the fisheries. Salmonids are known to suffer various ill effects when exposed to many of these herbicides. The SRRC has developed a non-chemical approach that relies on the involvement of community members, resource users, tribes and the managers.

**2:00 p.m.**
**Riparian and Wetland Restoration Session—Individual Presentations**
**Session Organizers:** Pat Higgins, Akimi King, and Kim Mattsen
**Moderator:** Kim Mattsen
Millions of dollars have been invested in riparian restoration in the Klamath Basin and other areas of Northern California over the last decade. Sub-basin partners in riparian restoration will share experiences of what has worked and what has not, including case studies.

**2:40 p.m.**
**Watershed Assessment Methods Session—**Individual Presentations
**Moderator:** Faye Weekley

**3:20 p.m.**
**Get The Scoop on Total Maximum Daily Loads (TMDLs)---**Individual Presentations and Roundtable Discussion
**Session Organizer and Moderator:** Chris Heppe

Many water bodies in the Klamath Basin do not presently meet water quality standards. The States of Oregon and California have placed these "impaired" water bodies on the Clean Water Act Section 303(d) list which describes the pollutants that limit the attainment of water quality objectives or beneficial uses (i.e., fish habitat, domestic water supply, agricultural use, etc.) in each water body. As required by Section 303(d), a TMDL must be developed for water bodies on the list. A TMDL is a watershed assessment and planning tool to identify pollutant load capacities and load allocations that are necessary to implement water quality standards and to protect beneficial uses. Once a TMDL and the associated implementation plan is established, the State is responsible for working with appropriate land and water managers to implement the TMDL and ensure that water quality standards are achieved.

Since the Klamath basin lies in two states and several ownership jurisdictions, coordination regarding TMDL development and implementation is imperative. The Oregon Department of Environmental Quality (ODEQ) is in the process of developing and finalizing several TMDLs in the upper basin while the Northcoast Regional Water Quality Control Board is the early stages of TMDL development on the California side. The purpose of this session will be to hear from several individuals (including agencies, tribes, land managers, interest groups, etc.) regarding the status of total maximum daily load (TMDL) development in the Klamath Basin and to provide a forum for discussing associated issues.

**3:40 p.m.**
**Basin Catchment--**Roundtable Discussion
**Session Organizer and Moderator:** Jim Carpenter
Invited participants include:

- Alice Kilham, Klamath Compact Commission Chair
- Andrew Stuedli, Klamath Co. Economic Development Assn.
- Woody Deryckx, Klamath Basin Ecosystem Foundation
- Mike Connelly, Cloverleaf Watershed Council

Stephanie Carpenter, Klamath Watershed Council, West Klamath Lake Subasin
Petey Brucker, SSRC
Pat Frost, Trinity RCD
Dave Webb, Shasta River CRMP

An informal sharing of perspectives from a panel of activists engaged in resource work from throughout the Basin. Watershed Councils, CRMP's Advisory Groups, Non-Profits, and other locally organized coalitions of concerned Klamath stakeholders will discuss what's working and what's not, in a free ranging overview of the diversity of interests up and down the river. Though everyone works on what are perceived as their own local and pressing issues, the common thread of the Klamath River ties all of our efforts together. The Roundtable will explore the common ground in an attempt to establish a holistic vision for the Basin from our collective views.

**WEDNESDAY MORNING, MAY 23**

**8:00 a.m.**
**Hydrology Session—**Individual Presentations
**Moderator:** Sue Mattenberger

**Road Restoration Session—**Individual Presentations
**Session Organizers:** Pat Higgins, Akimi King, and Dave Ross
**Moderator:** Mary Erickson
Roads have been recognized as the largest source of erosion during large storm events, and fisheries restoration has shifted its emphasis from stream manipulation to watershed work. What have we learned during the last decade? Can we tell if the strategy is working and what is the scope of work left to be done?

**8:50 a.m**.
**The Tribal View: Our Tradition, Our Future**--Panel of Individual Presentations
**Session Organizer:** Klamath River Inter-Tribal Fish & Water Commission
**Moderator:** Troy Fletcher
Presenters:
Susan Masten, Chairwoman of the Yurok Tribe (8:50 – 9:10 a.m.)
Leaf Hillman, Director of the Karuk Tribe (9:10-9:25 a.m.)
Danny Jordan, Self-Governance Coordinator of the Hoopa Valley Tribe (9:30-9:45 am)
Elwood Miller, Director, Dept.Fish & Wildlife for the Klamath Tribes (9:45-10:00 am)

Salmon far exceeds other resources in its importance to the diet and cultures of the Hoopa Valley, Karuk, and Yurok Tribes who have historically lived in the Lower Klamath Basin. The United States Court of Appeals recognized the primary importance of salmon to these tribes when the court concluded that the fishery was "not much less necessary to the existence of the Indians than the atmosphere they breathed." The abundance of salmon has always been an important measure of tribal well being where feasting is not simply an exercise in eating, but has deep-rooted connections to the vitality of the Earth and a traditional connotation of community health. The timing and cycle of many tribal societal, religious, and economic activities were made to closely coincide with the seasonal and geographic variations in fish runs, particularly the arrival of the first salmon. Prior to the construction of hydropower dams on the upper Klamath River, which blocked the annual migration of salmon, the culture of Klamath Tribes of the upper Basin was also tied to the salmon along with the valuable suckers of the upper Basin. Representatives of the four Tribes of the Klamath River Inter-Tribal Fish and Water Commission will discuss their traditional and contemporary use of fisheries of the Basin and current relevant management issues.

**10:10 a.m.**
**Coastal Communities and Commercial Fisheries**: **The Economic and Social Impacts of Declining Fisheries on Coastal Ports and Communities of the Klamath Management Zone--** Panel
**Session Organizer:** Paul Kirk
**Moderator:** Jimmy Smith
Presenters:

Jimmy Smith (moderator) Humboldt County First District Supervisor; Chairman of the California Salmon Stamp Committee; Board member of the Klamath Fisheries Port Coalition; Member of Humboldt Fisherman's Marketing Association; formerly, President of the Humboldt Bay Harbor Recreation and Conservation District and First District Harbor Commissioner.

Bob Hallmark Former Board member of the Klamath Fisheries Ports Coalition; owner and operator of the Trinidad Marina; commercial salmon and crab fisherman

Sandie Crockett Chair of the Klamath Fisheries Ports Coalition; Commissioner of the Crescent City Harbor District; Business owner of Sandie's (bait & tackle shop and restaurant) in Crescent City.

This session will provide the economic history of coastal ports and overview relative to coastal commercial and recreational fisheries. It will give an overview of ports and communities' hardships with declining fisheries and economies. Port-specific economic impacts to commercial and recreational, marinas, party boats and support services will be discussed. Also, an overview will be provided of the development process and function of the Klamath Fisheries Ports Coalition: How it has remained a functioning body despite the contentious salmon allocation issues with which it must deal.

**11:00 a.m**.
**Water Quality Session**—Individual Presentations
**Moderator:** Kim Mattson
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**WEDNESDAY AFTERNOON, MAY 23**

**1:00 p.m.**
**Restoration Projects Session**—Individual Presentations
**Moderator:** Wedge Watkins

**1:20 p.m.**
**River Communities: Where Have All the Tourists Gone?--Panel of Individual Presentations**
**Session Organizer and Moderator:** Ronnie Pierce
Presenters:

Virginia Bostwick, former owner of campground at the mouth of the Klamath River, former member of Klamath Fishery Management Council (1:20-1:40 p.m.)
Marc Rowley, owner of Big Foot Rafting Co. in Willow Creek (1:40-1:55 p.m.)
Blythe Reis, owner of Sandy Bar Ranch on the Klamath River (1:55-2:10 p.m.)

Many small riverine communities of the Lower Klamath Basin were established to provide services to a tourist industry centered on the River's once famed recreational salmon fishery. Since 1986, recreational fishing in the River has been the subject of intense quota based management and regulation aimed at protecting declining runs of fall chinook salmon. Recent regulations to protect steelhead have further impacted the local tourist economy. Representatives from the lower Klamath Basin river communities, from the estuary of the Klamath up to the mid-Klamath and Trinity River, will discuss changes in their local recreational fishing based economies, and thoughts on their future economic survival.

**2:20 p.m.**
**Salmonids Session**—Individual Presentations
**Moderator:** Phil Detrich

**4:40 p.m.**
**Perspectives on Water Use**--Roundtable Discussion
**Session Organizer and Moderator:** Ernie Nieme

In this discussion, panel members will recap different perspectives about the use of water and related resources in the Klamath River Basin, consider alternative scenarios regarding future use of these resources, and seek to identify opportunities for working together to promote mutual interests.

**THURSDAY MORNING, MAY 24**

**8:00 a.m.**
**Klamath River Hydroelectric Project (FERC) Relicensing Forum—**Individual Presentations and Roundtable
**Session Organizer and Moderator:** Randy Brown

PacifiCorp, licensee for the Klamath River Hydroelectric Project, began the hydropower relicensing process on December 15, 2000 when they filed a Notice of Intent (NOI) with the Federal Energy Regulatory Commission (FERC). The NOI initiates a 5-year proceeding during which the licensee will review past operations, existing reports, and conduct studies to gather additional information to be included in their application for a new license. Once the application has been accepted as complete, the FERC is then responsible for conducting an environmental review of the applicant's proposed project operations and facilities in addition to other reasonable alternatives, following the requirements of the National Environmental Policy Act.

The federal relicensing of hydroelectric projects provides a unique opportunity to reconsider and evaluate the design and operations of these facilities using present day standards. The Federal Power Act (FPA) of 1920, as amended by the Electric Consumers Protection Act of 1986, directs the FERC to adopt the project that in their judgement is best adapted to a comprehensive plan for improving a waterway. Under the FPA, developmental and non-developmental objectives of a project are to be given equal consideration and FERC must balance the competing uses of a waterway when considering the issuance of a new license.

Federal licenses for major hydropower projects are issued for periods ranging from 30 to 50 years. Some projects, such as Klamath River, include facilities that predate the FPA. If these facilities have not significantly changed in design or operation since they were constructed, it is unlikely that issues associated with these facilities have been addressed in light of existing laws , statutes , and regulations concerning natural and cultural resources.

The Klamath River Hydroelectric Project license encompasses eight individual projects spread over 64 miles of the mainstem Klamath River starting upriver with the Eastside and Westside projects located at the outlet of Upper Klamath Lake in Klamath Falls, Oregon and ending at Iron Gate Dam, located near Hornbrook, California approximately 190 river miles from the ocean. The last project facility, constructed in 1963, Iron Gate Dam now constitutes the upstream limit of migration for anadromous fish on the mainstem Klamath River.

A wide range of issues will be addressed during the relicensing of the Klamath River Hydroelectric Project. These issues include power generation, water quality, water supply and irrigation, fish and wildlife, recreation, aesthetics, cultural & historic heritage, project economics, impacts to federal and state lands, and public safety. In addition to the Federal Power Act numerous federal and state laws and regulations must also be considered and addressed. Some of these include the Clean Water Act, Wild and Scenic Rivers Act, Endangered Species Act, and Fish and Wildlife Coordination Act, to name but a few.

This forum will provide the opportunity for an overview of the Klamath River Hydro Project, the FERC's hydropower licensing process, and the roles that federal and state agencies, Tribes, and the Licensee have in that process. The forum should also provide ample opportunity for questions and exchange of information between the speakers and the audience.

**Mollusks, Amphibians, and Mammals Session**—Individual Presentations
**Moderator:** Dave Ross

**Restoration Programs Session**—Individual Presentations
**Moderator:** Curt Mullis

**10:20 a.m.**
**Trinity River Through Time: Dynamic to Enhanced**—Individual Presentations
**Session Organizer and Moderator:** Brandt Gutermuth

The unregulated Trinity River was a meandering and dynamic alluvial river with a broad floodplain. High flows frequently changed the shape and path of the riparian corridor and maintained the complexity of aquatic habitats which supported abundant and diverse salmonid populations. After construction of the Trinity River Division, the headwaters were lost along with the magnitude and variability in flows which had maintained the associated aquatic community. After construction of the dam, enhancement efforts were made to maintain and recover the river, but many of the River's living resources were lost along with the historic variability in flows

**THURSDAY AFTERNOON, MAY 24**

**1:00 p.m.**
**Bird Conservation Issues Session**—Individual Presentations
**Moderator:** Jeffrey Dunk

**Fish and the Law Session**—Individual Presentations
**Moderator:** Ron Larson

**Trinity River Restoration**—Individual Presentations
**Session Organizer and Moderator:** Brandt Gutermuth

When the Trinity River Division began operation in 1963, up to 90% of the river's flow was diverted and 109 miles of the upper watershed, and its coarse sediment contribution, were isolated from the system. People developed the floodplain and the waters of the Trinity River were utilized for other arguably valuable intentions. Yet, fish need water. Recent studies have determined that, in order to restore Trinity fishery resources to their historic condition, a more natural hydrograph is required. With the effort to restore 48% of its historic flows, political battles for water and power allocation have arrived and efforts must be made to mechanically assist the river in recovering its self-sustaining dynamic condition. These are the challenges that are immediate in restoring a self-sustaining Trinity River fishery.

**2:10 p.m.**
**Status and Management of Spring Chinook Salmon—**Roundtable Discussion
**Session Organizer and Moderator:** Petey Brucker

This roundtable discussion will focus on the status and potential actions needed to recover Klamath Basin Spring Chinook Salmon. Panelists include representatives from tribes, managing/regulating agencies, ocean fishing, and Salmon River Restoration Council (SRRC).

Spring Salmon are listed by the USFS as a Sensitive Species. The USFS has projected (West et. al.) that this run will go extinct if current management impacts continue. In 1996 NMFS determination that identified spring and Fall Chinook as being the same species used limited genetic information taken only from hatchery fish in the Trinity. NMFS suspected that a genetic transgression with Fall Chinook in the hatchery may be have occurred and adequate scientific information may be lacking for these wild fish for their investigations. The Spring-Run is highly valued for cultural and commercial purposes by fishing interests, both tribal and non-tribal. The SRRC considers the Springers to be a driving force behind restoration efforts in the Salmon River, which until recently has been identified as being the most viable refugia for the Springers in the Klamath. Low numbers, lack of management mitigations and limited regulatory protection have caused the SRRC to increase its' focus on the at-risk Spring Chinook.

**4:20 p.m.**
**Summary –All Sessions**
**Session Organizers and Facilitators:** Yvonne Everett and Betsy Watson

This will be a facilitated summary session to summarize key points from all of the previous sessions throughout the symposium. The symposium notekeepers will present their findings regarding key issues, and we will seek comments and discussion from participants on what should be carried forward to the final plenary session on Friday.