Joint Fire Science Program

Fire Science Brief

RESEARCH SUPPORTING SOUND DECISIONS

Middle Fork of Boise River downstream of Steel Creek debris flow, 2004. Credit: C. Luce.

Fish and Forest Management: Not Necessarily at Odds

Summary

Resource managers of lands harboring sensitive aquatic species face tough choices. They could manage forests to reduce their wildfire potential, while possibly harming the sensitive species habitat, or they could leave forests untreated for wildfire, risking an uncharacteristic fire that may drastically alter critical aquatic species habitat. This study sought to develop a decision support framework to help managers understand the potential impacts of fire and resulting disturbances, such as debris flows, in this puzzle. The resulting fish population persistence model, Integrating Forests, Fish, and Fire (IF3), relies on existing geographic information system (GIS) data to discern where human impacts and prefire management activities are likely to affect stream habitat and sensitive stream fishes. The researchers applied the model to several fire-prone forests (Boise and Sawtooth National Forests in Idaho and Gila Wilderness in New Mexico) containing habitat for sensitive fishes. The model can identify areas where prefire management treatments are likely to make fish populations more resilient to disturbance from wildfire. The model can prioritize areas for prefire management based on likely net ecosystem benefits. IF3 can be used on its own or with existing decision-support tools, such as the Fire Effects Planning Framework (FEPF).

Key Findings

- The presence of fire-prone forests does not necessarily mean that sensitive fish populations are at risk. The context of current population constraints, including population size and connectivity, are critical factors.
- Analysis shows that surprisingly little of the studied landscape needs active human intervention to maintain forest or fish health.
- For the areas studied, the wildland urban interface, with the attendant roads and heavily impacted portions of the forest and greatest human need for fuel reductions, is not where sensitive fishes typically occur.
- Very often, forest restoration and aquatic restoration can be done in the same places and together in a coordinated fashion with net benefit to both resources.

Fish versus forests?

"There's a sense of conflict between aquatic and forest ecosystems," explains Charlie Luce, research hydrologist with the Rocky Mountain Research Station. "Some people have claimed that protecting fishes has resulted in overstocked fuels. And people on the fishery side say our continued logging and treatment of fuel conditions is harming the fish system. The truth is there are places where both can work well together and there are places where you can actually generate that conflict."

Most of the time when that kind of conflict arises, Luce asserts, the discussion just needs to be reframed. Perhaps it's not the right place for fuel treatment work or the treatments themselves need to be adjusted to better accommodate the fish, he says. "It's really one forest ecosystem with fish and the trees," Luce notes, "and we can't sacrifice one portion of that ecosystem to save the other."

Luce led a multidisciplinary team working to explore this perceived conflict through an extension of work begun under the National Fire Plan. The team wanted to develop a model that would help managers make decisions about where to place which forest and fuel treatment activities, and help them think about these decisions in a different way.

"There's a lot of enthusiasm on both sides of the spectrum," Luce says. "The fuel managers want to go out and treat everything that they can. They see a pretty widespread problem" with altered fire regimes. "And on the flipside the fish managers see a lot of hazard out there from the potential of people going in and working on all this area at the same time. I think what this model lays out is a framework for those two communities to talk about the risks of each of those stances in a more spatially explicit format."

Luce explains the way wildfire tends to affect fish in the West: part of the landscape, including stream-side riparian areas, burns over, which causes landslides, tree falls, and stream warming, and most fish there die. But then fish from nearby areas or migrating fish from the same stream repopulate the habitat within a couple of years. This mixing of fish from different areas strengthens the genetic diversity and resilience of the habitat patch. More resilient populations include more individuals of all life stages and life histories, in many and larger high quality habitat patches that are thoroughly interconnected.

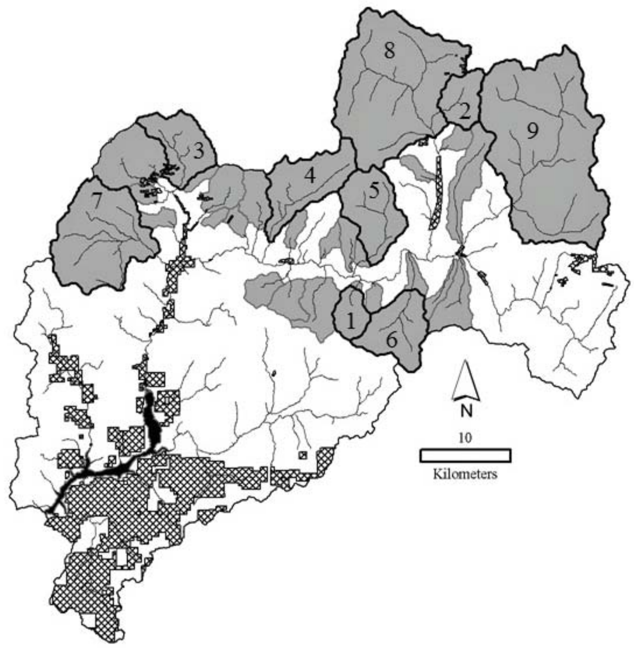
"Fire does kill fish," Luce acknowledges, "but its beneficial effects on habitat include importing gravel to stream beds and increasing the amount of woody debris and nutrients in streams." Fish lay their eggs in the gravel on the stream bed, so they won't spawn in a slickrock stream bottom. "Debris flows are helpful in the long term, but kill fish in the short term," Luce explains. Debris flows can also add to pooling, which is beneficial to fish.

Debris flow from Lake Creek damming Middle Fork Boise River (see impounded logs and lake on right).
Credit: C. Luce.

GIS analysis and fish persistence modeling feed a decision-support framework

The study included three phases: (1) development of methods for high-resolution geographic information system (GIS) analysis of a test watershed, the South Fork Boise River (SFBR) in Idaho, (2) development of the fish (bull trout for SFBR) population persistence model, which indicates the probability that a stream reach would support fish spawning and rearing post-wildfire, and (3) application of the resulting decision-support framework to two more watersheds.

The researchers used GIS to superimpose for the SFBR (1) dry mixed-conifer forests that are unlike their historical condition because of past management, (2) critical stream habitat for sensitive fishes, (3) stream habitats degraded by sedimentation from roads, (4) road crossing barriers to fish migration, and (5) the wildland-urban interface (WUI). Luce's group examined the size of each of the fish networks, the potential for debris flows to kill the fish in those networks, and how to make those networks more resilient to disturbance. All of this information went into the fish population persistence model for bull trout. They also modeled post-fire stream temperature changes.



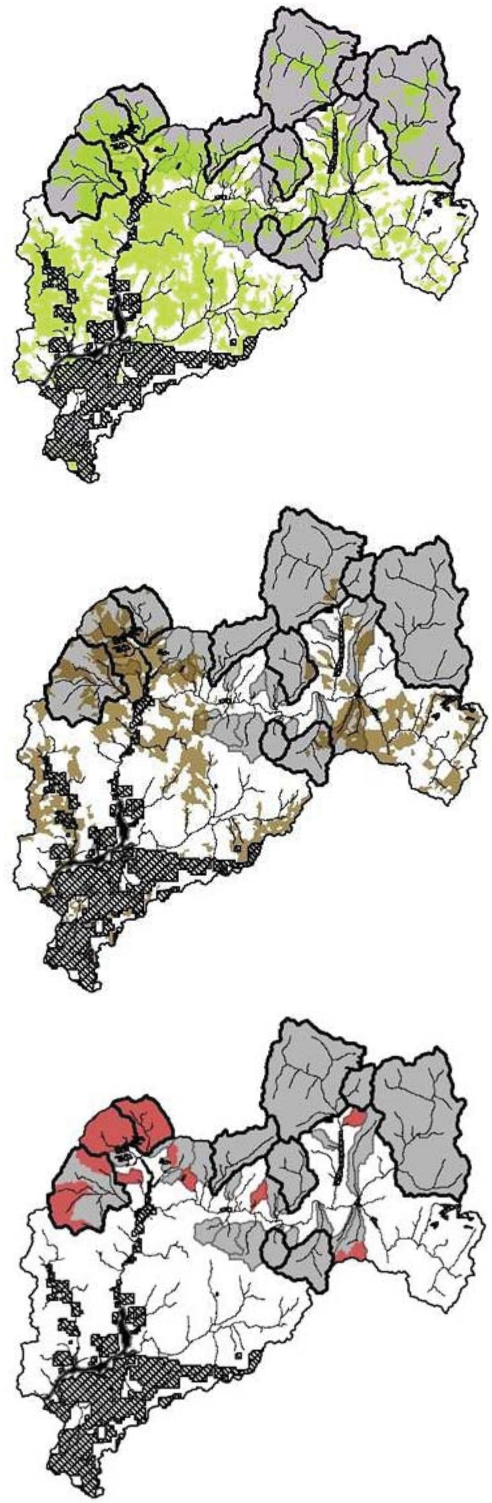
The SFBR study area. Occupied bull trout patches are numbered. Credit: Matt Dare.

They classified the entire watershed in patches as (1) WUI (using private land as a surrogate for the WUI), (2) wildlands, or (3) "restoration matrix." They labeled a patch as "restoration matrix" when either the forest or the streams or both would require restoration before wildfires could be allowed to burn in a wildfire use context.

The scientists looked at how the probability of fish persistence would change as a result of various fish and/or forest management practices. Prefire management options considered included "(1) reconnecting isolated or fragmented habitat patches by removing barriers, (2) repairing or removing roads in patches where road density could be contributing to fine sediment loads in stream channels; and (3) treating fire-prone terrestrial fuels with varying intensity to limit the size and/or severity of future wildfires within habitat patches." They modeled various degrees of fire severity and patch area burned.

When you implement a wildland fire use policy, initially you usually end up with large burned patches, but as this policy is applied consistently over time, you'll have smaller burn patches because fires won't spread as much. "So initially you take a risk as you correct the system" for long-overdue wildfire, Luce says, "but in the long term what you get is stability. So we looked at how that projected stability would help the system."

After developing the IF3 fish population persistence model for the SFBR in Idaho with bull trout data, the team applied it in the Gila River watershed, New Mexico, for Gila trout, then to the Clear Creek watershed, a tributary of the South Fork of the Payette River, in central Idaho, again for bull trout. Both of these are federally endangered fish.



Distribution of vegetation restoration opportunities (green), road restoration opportunities (brown), and barrier restoration opportunities (red) in the SFBR. Dark grey polygons represent bull trout habitat; black lines define occupied habitat. Cross-hatching defines private land. Patch numbering in center panel conform to those in SFBR study area map shown above. Credit: Matt Dare.

Fish and forest resiliency

South Fork Boise River, Idaho

Research results for the SFBR, where the dominant vegetation ranges from sage brush to subalpine fir, depending on elevation, showed that much of the area can be classified as wildlands, a classification indicating that the forest can handle normal fire activity in a way that should result in ecosystem benefits. Most bull trout habitat in the SFBR is in wildlands. The area designated restoration matrix was nearly half the total area of the watershed. Restoration opportunities there related mainly to thinning forest vegetation.

Persistence models for SFBR showed that some bull trout populations were likely to be affected only by uncharacteristic wildfire, which means that they would benefit from forest restoration that reduced wildfire spread and severity. Many bull trout habitats in the SFBR were large enough that even uncharacteristic wildfire presented little threat to persistence. In these large habitats, postfire debris flows may be widespread, but they are unlikely to threaten bull trout populations because they would probably occur upstream from most spawning and rearing habitat.

"We need to build a more fire-resilient landscape here," says Luce, which means that we expect occasional large and severe fires, but these do not wipe out the forest. It is able to recover from them naturally. The natural fire return interval on the SFBR varies with elevation, from about 7 years in ponderosa pine areas to 200–300 years at high elevations. Occasional severe fires are beneficial in the long-term for this fish habitat, but not necessarily for present fish. Connectivity and restoration of fish habitat are important in the SFBR.

Clear Creek, Idaho

In Clear Creek, the dominant vegetation is ponderosa pine and Douglas fir. The habitat needs are essentially the same as for SFBR, although taking out barriers to fish movement, such as culverts, is especially important to build connectivity here.

Culvert on Rapid River, tributary to Middle Fork Boise River, that was a barrier to fish passage. Credit: C. Luce.

Bull trout habitat in Clear Creek occurs among high-elevation conifers, typically with 100 to 200 years between fires. To maintain the migratory fish population, Clear Creek habitat must remain connected to the main stem of the South Fork of the Payette River. The bull trout's migratory nature acts as a natural protectant against detrimental effects of fire.

Gila Wilderness, New Mexico

Ponderosa pine dominates the Gila, and its natural fire return interval is about 10 years. The key here is to "maintain endangered species habitat," Luce explains. Eight distinct populations of Gila trout are currently maintained separately. If we reintroduce fire there, we don't want it to wipe out one of these patches. Where we can reinstitute a more natural fire regime for the area, we will have more frequent low severity fire, which is better for these patches because these are less likely to spawn debris flows.

"We need to build a more fire-resistant, self-maintaining landscape here," Luce says. This is a wilderness, so managers are mainly limited to wildland fire use treatments. Wildfires can burn out excessive fuels, leaving low-fuel conditions and large trees that can resist fire.

"Connectivity is not important here," says Luce, because barriers keep out invasive fish species in many places, allowing Gila trout to survive. Invasive fish previously forced Gila trout into higher elevations. These habitat patches are all above barriers now, which protect them from invasive fish, but also prohibit mixing of fish from different patches.

Luce's group identified streams in other parts of the basin that are candidates for renovation and introduction of this endangered fish. These expansions of territory would make the populations more stable.

Fish and forest restoration needs

Luce was surprised to learn from the analysis that "there's a lot more of the landscape in the cases we looked at that doesn't need explicit human intervention, either for the fish or for forests, than we might have expected." He continues, "We found that the WUI is actually a pretty restricted piece of ground, and for the most part the WUI and the roads and the heavily impacted portions of the forest aren't the same places where the endangered fishes are."

"Generally," Luce continues, "where humans have disrupted the aquatic ecosystem is low in the system, not so much the headwaters, and down low in the system are the places the endangered fish are less likely to use as spawning and rearing habitat." Dry and probably altered forests often coincide with high road density and associated stream disruption, and both of these degraded conditions occur mainly near the WUI.

Wildfire concerns tend to be greatest in the WUI, which is not typically where sensitive fish are, so the conflict between managing for forests versus fishes may be much less of a problem than is commonly perceived among land managers. Human activity tends to disrupt both the forests and the fishes. The places where we've built roads are the same places where we've isolated the fish via culverts, and added sediment to the waterways.

"The implication to us," wrote Luce and coauthors in a recent article in *BioScience*, "is that management objectives could converge over large areas of the SFBR." This summary applies to much of the Gila and Clear Creek watersheds as well. The overlap of the problem areas provides an opportunity for restoration that benefits both the forest and the fish.

Land managers can use IF3, Luce explains, as a framework for finding those opportunities of overlapping need, and also "to weed out fairly obvious conflict-ridden solutions," he continues.

IF3 allows resource managers to predict "the probability of losing fish stocks in the face of a severe fire," Luce explains. It can help decide where fuel treatments for fish might be beneficial or harmful or neutral. "It's a tool that can allow a resource manager to objectively do the analysis to avoid generalizations about fire," Luce says.

There is currently money available to decommission roads for the benefit of fish populations, but it would be impractical to decommission those roads without first treating the forests that they access if it is needed. By cooperating, the forest managers and the fish managers can split the funding, workforce, planning, and public outreach duties required for any restoration project. Luce says a successful strategy might involve using existing roads to restore forest health to a level where natural ignitions could maintain the health, then using the proceeds of any timber sales to decommission the roads, pulling out culverts and restoring fish populations along the way.

IF3 allows managers to prioritize proactive habitat management projects. This can help use limited time and money for restoration most efficiently. IF3 incorporates into the decision-making process potential outcomes of fire and fire-related management on forests and fish, which traditional methods of prioritizing projects do not.

IF3 really only works in the West, because most of the framework is set up for western fishes. There are some similar fishes in the Northeast, Luce notes, but the fire regime is very different there. In the Southeast, the fish assemblages are very different and there are many nonmigratory species.

To be continued

Luce describes the continuing research needs on the issue this way: "Probably the key piece is understanding the scale--how big of a fish population you need restored and how connected it needs to be to be resilient to wildfire." Especially for headwater spawners such as trout, scientists need a better understanding of how big a patch needs to be before a single wildfire or debris flow won't kill all of the fish in the patch at the same time. This size will affect the extent of restoration efforts focused on making patches resilient. Aquatic ecologists have some understanding of this dynamic now, but it is imprecise, and that translates into greater risk to fish if they estimate low or greater cost for restoration if they estimate high. The expertise of the whole interdisciplinary team will help answer these questions.

Management Implications

- Prefire management, such as reconnecting isolated fish populations, increases persistence probabilities and population resiliency. Management needs are best determined on a site-specific basis.
- The IF3 framework is useful for prefire management planning and prioritizing and also for incident-based decision making. For the latter, IF3 can provide information about how and where wildfire is likely to affect sensitive fish populations. In places where fish are resilient, post-fire stabilization, for instance, may not be recommended.
- IF3 is useful for exploring potential impacts of climate change (i.e., the effects of increasing stream temperature on fish persistence). For example, if in the future bull trout spawn and rear farther upstream due to warmer waters, debris flows may become a greater threat to their persistence in the SFBR and other watersheds.

Debris flow fan at mouth of Steel Creek being cut into by Middle Fork Boise River. Credit: C. Luce.

An added complication to this story, Luce says, is that, "This kind of work is probably all the more important for managers to think through as we go into climate change. We really can't afford to treat the two [resources] separately. Both the forests and the fish are being pushed by other drivers of change. Some of the places that look safe in our maps now may not be safe in the future" with climate change. The team will continue to analyze what fire might do, what climate change might do, how the fish might respond, and how managers can help both the fish and the forests thrive despite climate change.

Further Information: Publications and Web Resources

Rieman, B.E., P.F. Hessburg, C. Luce, and M.R. Dare. 2010. Wildfire and management of forests and native fishes: Conflict or opportunity for convergent solutions? *BioScience* 60(6): 460-468.

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Results presented in JFSP Final Reports may not have been peer-reviewed and should be interpreted as tentative until published in a peer-reviewed source.

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