Institute for Natural Resources White Paper

Management of streams systems in an ecosystem dynamics framework
Recommendations from February 17, 2009 seminar

Institute for Natural Resources

Executive Summary

- There is considerable uncertainty as to what policies should flow from our understanding of disturbance dynamics in aquatic systems.

- Managing for the outcomes we expect from Oregon's streams and rivers, including clean water and salmon habitat, will require acceptance of considerable variation in the structure, function and composition of the riparian environment in response to disturbance events. Dramatic changes in streams—including what we might consider degradation—are necessary and desirable over different temporal and spatial scales.

- An appropriate vision statement for stream management is not "return streams to 1850 conditions," but "manage for a range of stream conditions that provide for self-sustaining populations of native species and contribute to a healthy and productive landscape."

- Managers need to perpetuate the ecological processes—including disturbance dynamics—that contribute to desired habitat and water quality. A landscape level approach is needed.

- Fine scale, spatially explicit landscape analysis can identify strategic opportunities to restore or maintain important components of ecosystem processes—such as large wood—that interact with disturbance dynamics to create desired outcomes like salmon habitat.

- Next generation policy frameworks should emphasize non-regulatory tools—including ecosystem services markets, credit trading schemes and direct payments—to provide incentives for diverse landowners to respond to the opportunities provided by landscape analyses. The analytical tools available include road assessment methodologies, landscape analysis to identify opportunities to reconnect floodplain habitat and cold water refugia, and landscape analysis of opportunities to conserve large wood in potential debris flow areas for future delivery to streams.

- INR has in the past suggested that concentrated rather than dispersed harvest, use of temporary road infrastructure, and use of alternative stream crossing infrastructure may be somewhat more conceptually consistent with our understanding of ecosystem dynamics than current management practices. We are not carrying forward these ideas because of concerns about feasibility and potential inconsistency with social and economic expectations. Experimentation with these ideas on state forestlands in the future may be appropriate.

- Management of aquatic ecosystems in response to climate change should mirror the management designed to perpetuate dynamic processes. It should include efforts to maintain stream flows, minimize floodplain and riparian diversions, and restore interactions between rivers and uplands.

- ODF, DEQ and other land management agencies need to establish formal mechanisms to communicate and collaborate about their management and regulatory actions.

Introduction

This paper synthesizes information from a February 17, 2009 seminar convened by INR to discuss management of stream systems in an ecosystem dynamics framework. The seminar involved 47 individuals, including INR's team of Oregon University System principal investigators, other members of the OUS community including faculty and students from a variety of fields, state and federal natural resource managers, private timberland managers, non-governmental organizations and the interested public. This was the first of four seminars INR is convening for the Oregon Department of Forestry (ODF) and Department of Environmental Quality (DEQ) as part of a larger multi-year project investigating the policy implications of ecosystem dynamics.[*] The seminars and resulting white papers will inform the final step in this project: A policy summit and workshop and final policy paper.

There is considerable uncertainty as to what policies should flow from our understanding of disturbance dynamics in aquatic systems. This paper is not the final word on how stream systems operate—or should operate—in Oregon. There is immense interest in and concern for management of water resources in Oregon. Different stakeholders have different conceptions of what constitutes good management. This paper attempts to integrate scientific perspectives and suggest new ways of achieving shared objectives.

There did appear to be consensus in the seminar that a) more could be done to improve stream function and productivity; b) good tools are emerging to support strategic decision-making about actions to improve stream function and productivity; and, c) non-regulatory market mechanisms hold promise to improve streams. INR recommends taking advantage of these areas of agreement by a) increasing cooperation between agencies and other actors; b) utilizing spatially explicit analytical tools to create priorities for management actions and track their progress; and, c) developing non-regulatory market mechanisms such as ecosystem services markets that will incentivize the actions on private lands that flow from strategic landscape analysis.

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[*] A description of the Ecosystem Dynamics can be found at http://www.oregon.gov/ODF/STATE_FORESTS/FRP/RP_Home.shtml#Dynamic_Forest_Ecosystems.

Management needs to accommodate dramatic changes to streams over time

"Are we in the business of managing forests or managing forest processes?"
—Gordie Reeves

As suggested by the quote above, there is little appreciation among policy makers or the public that stream systems change dramatically. All streams are not "pristine" at all times and departures from "pristine" conditions such as landslides, muddy waters, etc., are actually an integral element of the landscape-scale processes that help create the conditions we associate with "pristine" streams.

Although managers strive to "protect" streams for salmon, salmon are in fact highly adapted to dramatic changes to stream systems, as evidenced by straying of adults, high fecundity, and the mobility of juveniles.

Managing for a range of conditions and ecological processes through time and space will require acceptance of dramatic changes to the structure, function and composition of the riparian environment. This type of management may present significant challenges to prevailing systems of land tenure. New terminology and concepts are needed to capture the intent of management that emphasizes processes, and changes in management practices will be required to achieve many desired outcomes.

The historical processes and conditions that characterize Oregon streams are a useful point of reference for managers, but we should not expect to duplicate every process or stream condition that existed in the past. An appropriate vision statement for stream management is not "return streams to 1850 conditions," but "manage for a range of stream conditions that provide for self-sustaining populations of native species and contribute to a healthy and productive landscape."

Figure 1 (all figures at the end of this document) illustrates the hypothetical variability in salmon habitat over time and space in stream systems in western Oregon. In the Oregon Coast Range only 30% to 60% of streams were historically in a condition that supported strong runs of salmonid species. Variation in the distribution of good salmon habitat is driven by disturbance dynamics, including intense and interacting events like large forest fires, storms, landslides, and floods. The 1996-'97 flood events in western Oregon, for instance, played a beneficial role, putting large amounts of wood and gravel into streams. This material will move through stream systems at some point in the future, hopefully replaced by material from future disturbance events.

The variability within and across landscapes for a particular system component that serves as a regulation standard creates a distribution of values if measured through time. These distributions serve as quantitative records of system behavior that regulations are created to maintain. Rather than use a single value for a standard, our current understanding of stream dynamics indicates that it may be more appropriate to compare distributions of values that emerge from a system through time. Writing new regulatory standards that embrace this concept should be a collaborative inter-agency effort.

Dynamic ecosystems and static standards

"We may not meet, or want to meet, the standard throughout all temporal ranges in which the standard may be applied. We can't and don't want to meet the standard all the time because stream conditions are variable in response to disturbance. Streams probably didn't meet our standards all the time prior to Europeans' arrival."
—Gordie Reeves

"Protection is not static. Protection recognizes dynamic events."
—Stan Gregory

Managers of Oregon's rivers and streams face a paradox: Our knowledge of disturbance dynamics implies management flexibility while current stream conditions in Oregon seem to demand robust regulatory control.

On the one hand, scientists now recognize that disturbance creates highly variable stream conditions—good salmon habitat, for instance, was never present in all streams capable of supporting good salmon habitat at every point in time. Our current understanding of dynamism and variability suggests that we be flexible in implementing water quality standards, accepting that many streams will not have good habitat and allowing forms of "degradation," including elevated turbidity, temperature and sedimentation to the extent that these conditions are part of disturbance dynamics that will yield high quality habitat in the future (Reeves and Duncan 2008; Poole *et al.* 2004).

On the other hand, the evidence suggests that Oregon streams and rivers have less salmon habitat than the historical range of variability, and that declines in productivity are the result not of the variation expected from desirable natural disturbance dynamics but from a variety of anthropogenic stressors. Streams found in ownerships managed for intensive timber harvest, for instance, generally have been structurally simplified, have higher levels of fine sediment, and lower levels of large wood relative to reference sites (Rodgers *et al.* 2005; Thom *et al.* 2000; Thom and Jones 1999). This fact suggests regulation of detrimental anthropogenic disturbance to streams is necessary and appropriate.

Complicating this muddied management picture is the fact that many "natural" disturbance dynamics may not currently have positive or desired impacts to stream systems. For instance, a storm-related debris torrent may interact with recent anthropogenic activity and deliver nothing but fine sediment to streams instead of large wood and gravel. Some "unnatural" anthropogenic disturbances may be positive and desirable. For instance, forest thinning may promote faster tree growth and accelerate recruitment of large wood to streams.

We currently lack the conceptual models or analytical tools to successfully balance the regulatory flexibility suggested by our knowledge of disturbance dynamics and the necessity of improving degraded streams.

In this paper, we emphasize two related ways to attempt to strike a balance and improve management:

Emphasize fine-scale, spatially explicit landscape analysis: Analytical tools and methodologies exist that can be used to characterize the potential of different sites to interact with expected future disturbances. Fine scale analysis will enable managers to move beyond uniform application of prescriptive rules and develop more site-specific goals and regulations.

Restore the functionality of disturbance events: Managers should use these analytical tools and methodologies to prioritize management that "sets the stage" for disturbance. For instance, management based on landscape analysis should emphasize recruitment of large wood in unstable areas in anticipation of debris flows and future delivery of wood to streams, or by management action to reconnect rivers with historical side channels and floodplains in anticipation of future flood events.

Both these suggestions speak to 1) integrating management of riparian and upland areas and 2) restoring ecological processes. They are responsive to management recommendations of the Independent Multidisciplinary Science Team (IMST 1999), a scientific review panel charged with advising the State of Oregon on matters of science related to the Oregon Plan for Salmon and Watersheds. The IMST observed that:

> Managing riparian areas differently than upslope areas as a strategy for protecting fish habitat is scientifically valid only if it is done with the goal of maintaining the dynamics of landscape structure and function. Sharp demarcations between riparian forest and upslope forest, and between fish bearing and nonfish-bearing streams are not consistent with the historic pattern.
> …
> There is a critical need to restore the ecological processes that produce and deliver large wood to the streams as well as upslope areas. Current riparian protection, large wood management, sedimentation and fish passage policies are not adequate because they are dominated by site- and action-specific strategies. Sharp distinctions in the management of riparian zones (as compared to upslope forests), based on the size of the stream and the presence or absence of fish, will result in a failure to maintain the dynamics of structure and function of riparian zones across the landscape.

The two management recommendations above, and several other management recommendations discussed during the course of INR's Ecosystem Dynamics Project, are described in more detail below.

Next generation strategic management actions

"The next steps in attainment need to be incentivization, not more regulation. Regulation has accomplished as much as it can."
—Michael Cloughesy

Use of the quote above is not meant to indict regulation as an important tool to accomplish management objectives, but to speak to opportunities. Regulatory policies by their nature limit degradation. Regulatory policies are not necessarily as well suited to proactively re-establish desired disturbance processes as incentivization policies may be. Although there is conceptual tension between static protection schemes and the flexibility implied by dynamic stream processes, this may be a false choice. Instead, the real management challenge is in development of "next generation" stream management methods which mate fine-scale, spatially explicit landscape analysis with market based incentives to integrate terrestrial and riparian management, allow managers to make better strategic choices, provide diverse sources of revenue for landowners, and leverage improved stream productivity over the long term without increased regulatory costs.

The work of David Hulse, Stan Gregory, and others, for instance, demonstrates that thermal conditions in the Lower Willamette River are variable, and that mapping existing and potential refugia enables strategic investments that reconnect habitat (Baker *et al.* 2004).

For another example, the ODF has developed a survey methodology that can be used to identify priorities for application of durable aggregate on low volume roads (Mills and Dent 2007). There may be opportunities through a federal Clean Water Act Section 319 grant, Northwest Power Planning Council grant, or Oregon Watershed Enhancement Board grant to implement this rapid road survey protocol on all or some roaded Oregon forestlands, enabling strategic mitigation actions.

The delivery of large wood to streams is an important function of disturbance dynamics. Large wood has been identified as a critical component of salmon habitat, and a major potential contribution to salmon recovery from forest practices. Figure 2 illustrates the interaction between upland habitat elements (large wood) and disturbance events (fires, storms and landslides. According to the ODF and DEQ (2002), although currently required riparian buffers provide some large wood inputs to streams, riparian buffer rules are not specifically designed to provide the large wood delivery to streams to the degree that past disturbance processes did.

The amount of large wood delivered by landslides to streams in western Oregon varies widely, from as little as 10% to as much as 80% (Keller and Swanson 1979; Benda and Sias 1998; May and Gresswell 2003; Reeves et al. 2003). The precise range depends on topography and the prevalence of debris flows (May and Gresswell 2003). There are currently requirements in place to retain wood in debris-flow prone areas to accomplish public safety objectives (The Shallow, Rapidly Moving Landslides and Public Safety rules effective January 1, 2003). There are modeling tools available that would allow managers to prioritize additional headwater channels with the potential to fail and deliver wood to streams during disturbance episodes (Miller and Burnett 2007). Payments to landowners where these areas are located as part of an ecosystem services market is one non-regulatory strategy for restoring the functionality of disturbance processes. Protection of springs and other sources of cold water are also possible objectives of non-regulatory management actions.

Figure 3 provides an example of how fine-scale landscape analysis could identify key areas for maintaining large wood for future delivery to streams. Figure 4 illustrates how spatially explicit analysis could be applied to more strategically and effectively conserve fish habitat.

Concentrated harvest and temporary transportation infrastructure

"In terms of these large scale harvests, socially, we are not going to go there. What are the individual components that we can get to?"

—Kevin Birch

Since salmon and many salmon streams in Oregon appear to be adapted to large disturbance events that put large pulses of material into streams, an INR synthesis paper and subsequent discussion in our seminar suggested that anthropogenic disturbance such as timber harvest might be designed to approximate the temporal and spatial pattern of natural disturbance.[†] Instead of small harvest units being harvested constantly in multiple watersheds, very large harvest units would be planned for just one watershed at a time while other watersheds "rest." The difference in these approaches is illustrated in Figure 4.

Although the alternative management strategy shown in Figure 4 is conceptually consistent with our understanding of stream disturbance dynamics in the Oregon Coast Range, it is not clear how applicable this model is for other stream systems. Many questions also remain about the degree to which timber harvest approximates the ecological effects of natural disturbance like wildfire. Finally, it may be difficult to achieve public acceptance of very large harvest units as contemplated in the concentrated harvest model.

INR has also suggested that managers make more use of different types of transportation infrastructure. For instance, managers might rely more on temporary logging roads that could be hydrologically stabilized following timber harvest. For another example, more hardened stream fords could be utilized instead of traditional culvert or bridge crossings that may allow less material to pass through stream systems. Although these different types of transportation infrastructure may be more conceptually consistent with our understanding of stream dynamics, there are questions as to technical feasibility. Most forestland managers desire continuous access to their forestlands for multiple treatments and fire protection.

[†] The synthesis paper can be downloaded at http://www.oregon.gov/ODF/STATE_FORESTS/FRP/RP_Home.shtml#Dynamic_Forest_Ecosystems.

At this point in the project, we do not intend to further develop our ideas for concentrated rather than dispersed harvest, increased use of temporary roads or increased use of hardened fords or other alternative stream crossing systems. Uncertainty as to the efficacy of these approaches should not, however, prevent further creative dialogue about these and other innovative management options. Experimental implementation of these concepts on a small scale in state forests in the Oregon Coast Range (the Tillamook and Elliot State Forests) may demonstrate the benefits of these approaches.

Climate change

Mitigation and adaptation in aquatic ecosystems in response to climate change should mirror the management designed to perpetuate dynamic processes. It should include efforts to maintain stream flows, minimize floodplain and riparian diversions, and restore interactions between rivers and uplands.

INR's team will develop more specific climate change mitigation and adaptation recommendations in later papers.

Collaboration and communication between agencies

All of the agency personnel that we have convened are passionate about managing stream systems for public benefits and ecological integrity. However, at times there appears to be a lack of clarity among agency personnel as to what exactly other agencies are doing to accomplish these goals. The nature of irregular change in dynamic landscapes suggests that agencies might be well served by learning opportunities on a regular basis.

ODF, DEQ and other state and federal land management agencies (i.e. Department of State Lands, Environmental Protection Agency, Forest Service, Bureau of Land Management, Department of Agriculture, Department of Land Conservation and Development, Department of Fish and Wildlife and Oregon Watershed Enhancement Board) need to establish formal and mechanisms to communicate about their management and regulatory actions, and to collaborate on implementing the recommendations in this report.

INR proposes that ODF, DEQ and other land management and regulatory agencies involved in stream management (such as OWEB and EPA) convene interagency stream action group(s) that:

- Share information about development of TMDLs, water quality standards and other Clean Water Act regulatory measures.
- Share information about implementation of the Oregon Forest Practices Act, state forest management plans and other land management plans that achieve water quality objectives.

- Create partnerships with universities, other agencies and NGOs to conduct strategic landscape analysis that identifies key areas for perpetuating desired stream processes.
- Develop ecosystem service markets and other funding mechanisms to implement management actions in areas identified by landscape analysis.
- Test the next generation management methods highlighted in this report and subsequent research.

Figures

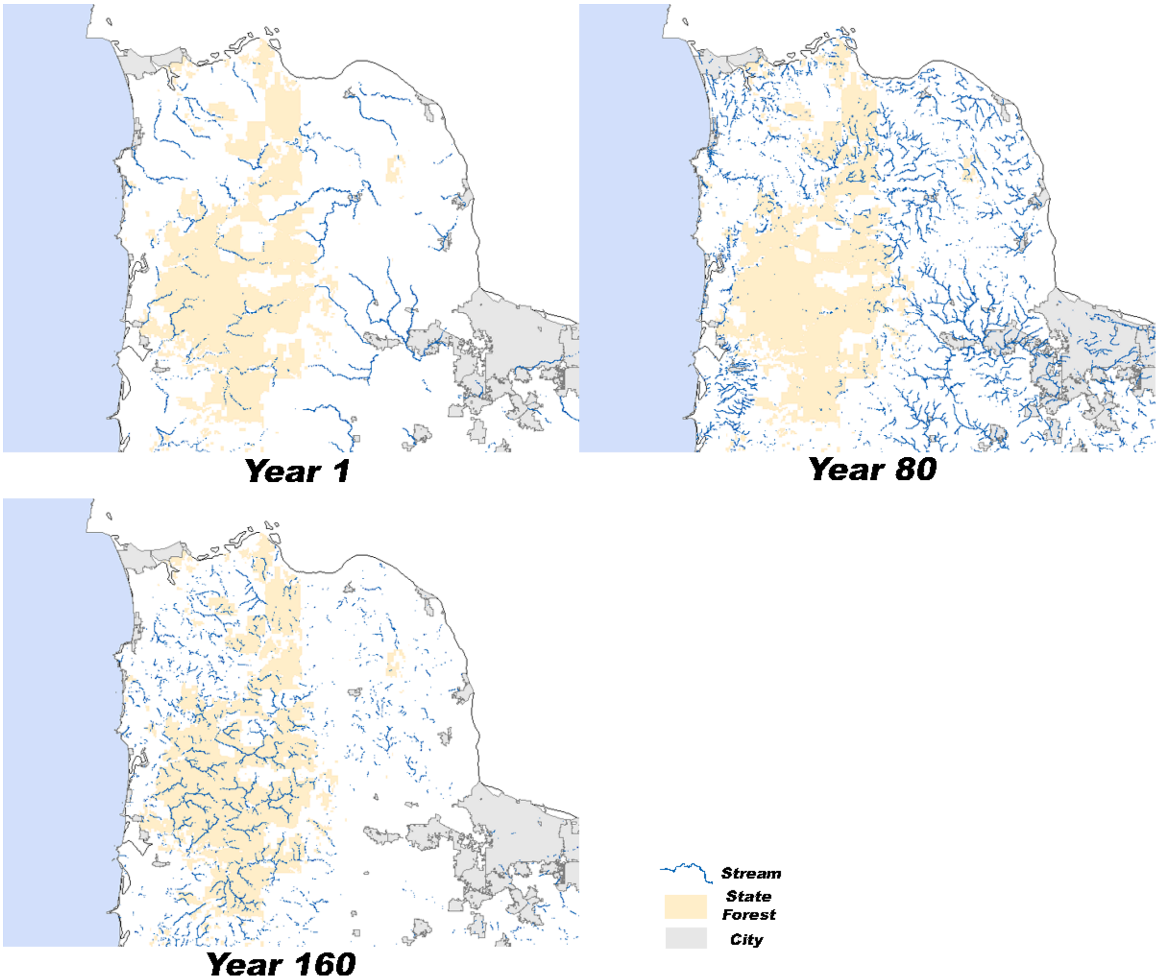

Figure 1. Hypothetical (not based on empirical data or modeling) distribution of good salmon habitat (large amounts of large wood, gravel and pools, and low summer temperatures) through time in and around the Tillamook State Forest. Variation in the distribution of good salmon habitat is driven by disturbance dynamics, including intense and interacting events like large forest fires, storms, landslides, and floods.

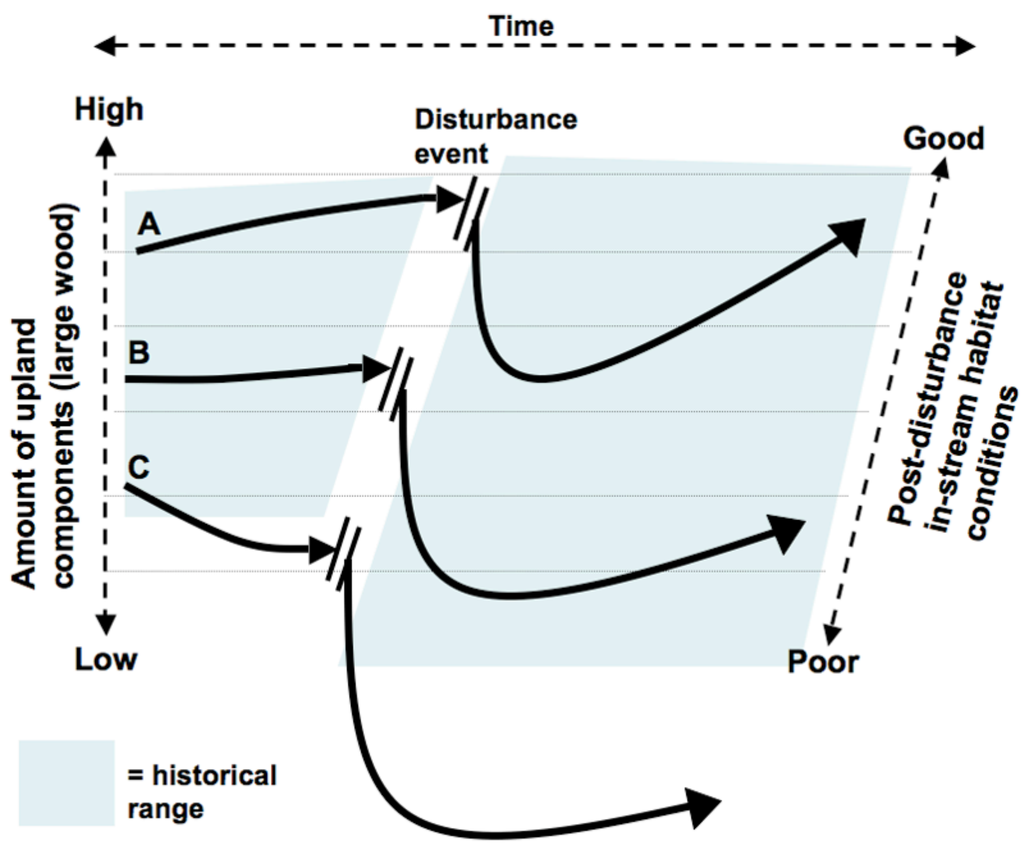

Figure 2. Hypothetical (not based on empirical data or modeling) interactions in western Oregon between disturbance events and amounts of large wood, an important in-stream habitat component. In Pathway A, a disturbance event interacts with large accumulations of large wood. Large wood currently in a stream reach is flushed through the system, but is replaced by debris torrents containing large amounts of large wood from upslope locations. In Pathway B, debris torrents interact with moderate amounts of upslope large wood, and there is less large wood accumulated in streams as a result. In Pathway C, debris torrents interact with little large wood. In this case, little large wood is accumulated in streams. Without the structural contributions of large wood, debris flow in this scenario may contribute large amounts of fine sediment and scour stream banks with little long-term benefit to salmon.

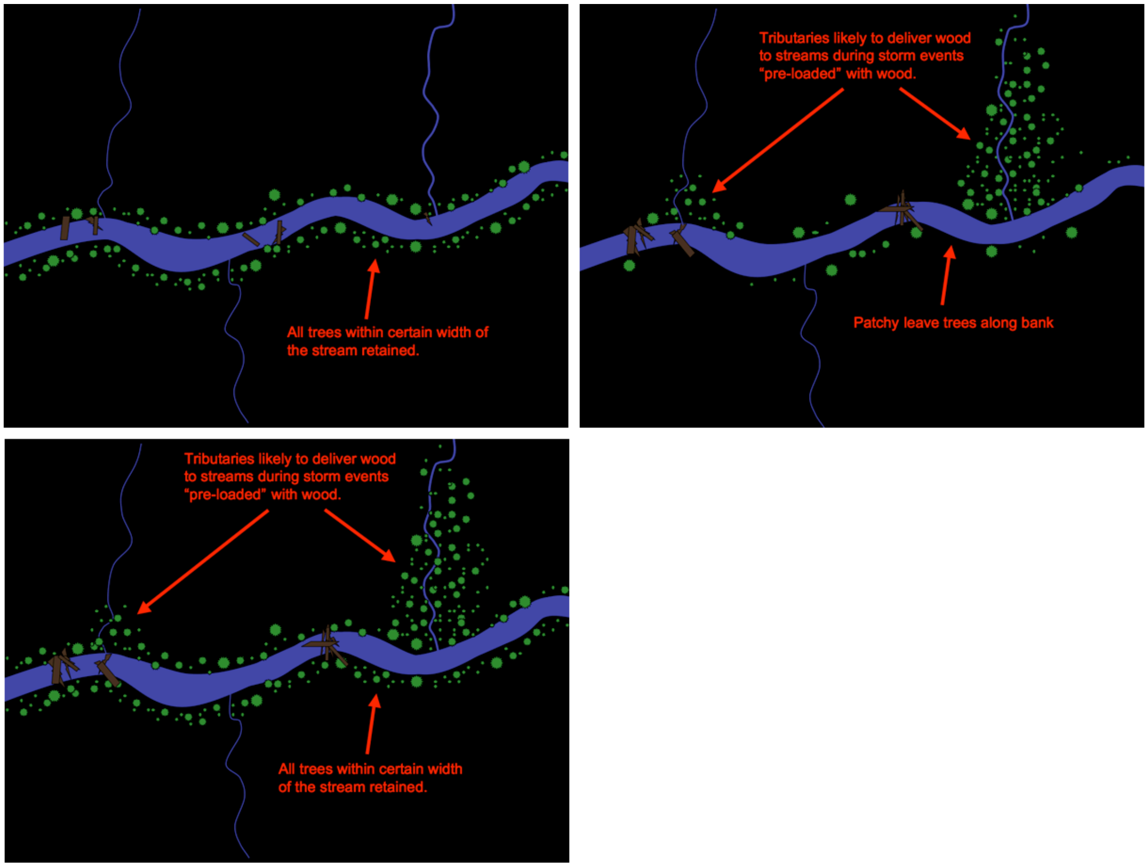

Figure 3. Hypothetical example of how fine-scale landscape analysis could identify key areas for maintaining large wood for future delivery to streams. Future management would maintain large wood in these areas in anticipation of future storm and/or flood events. In the first panel—traditional riparian management—a riparian buffer of standard width is applied to shade the stream and provides future large wood. In the second panel, upland areas are identified for conservation to provide future large wood recruitment with patchy streamside riparian trees maintained. In the final panel, a traditional stream buffer is applied, as well as upland conservation for future wood. In the alternative riparian management scenarios, payments to landowners could incentivize conservation of upland sources of wood.

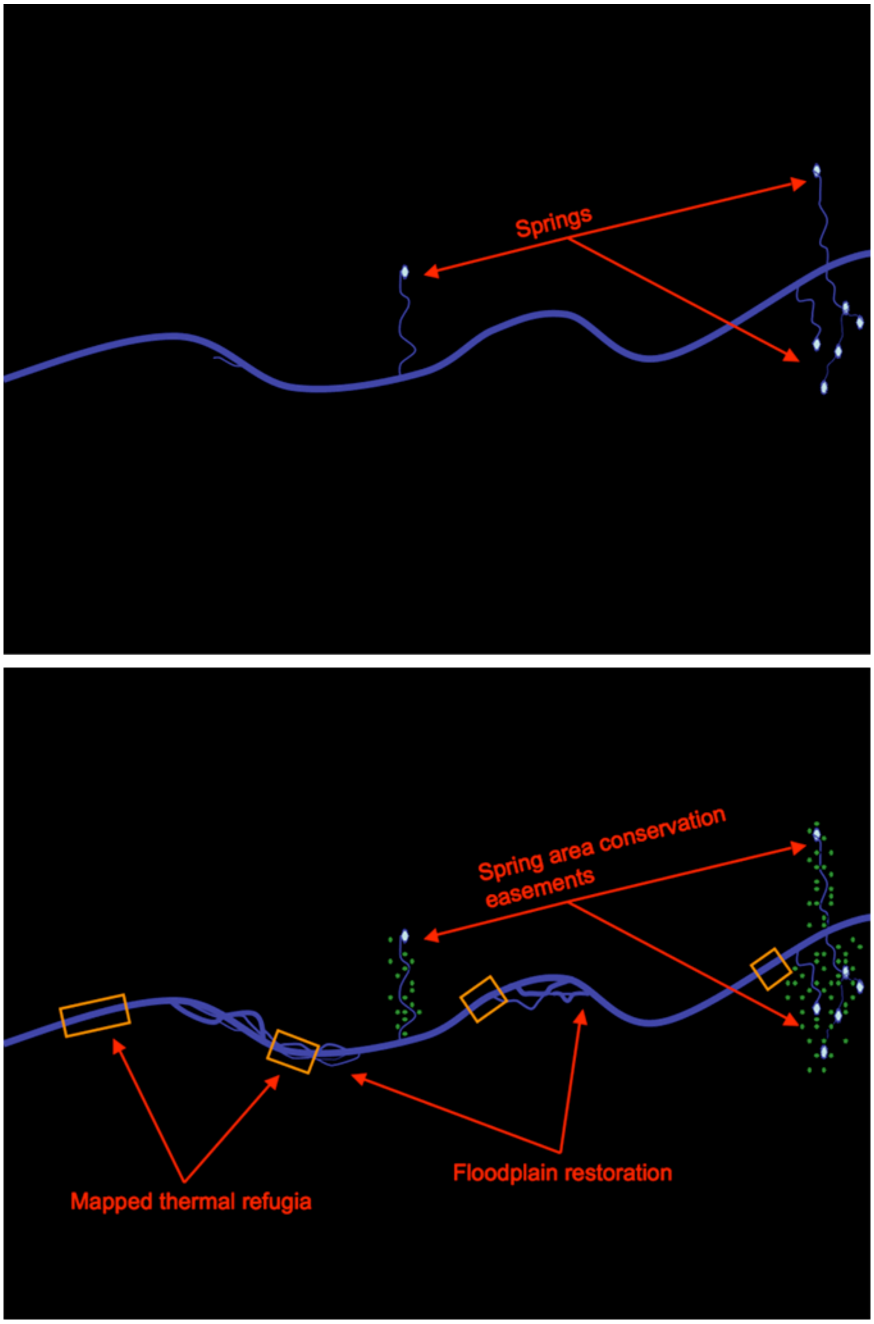

Figure 4 illustrates how spatially explicit analysis could be applied to strategically and effectively conserve fish habitat. In the first panel, a blanket temperature standard is applied across a river reach. In the second panel, landscape analysis identifies springs that provide cold water, which are protected with conservation easements. Key thermal refugia are mapped and monitored. Potential floodplain habitat is identified and restored. Such proactive management activities, identified through spatial analysis and aligned with appropriate incentives, can be expected to achieve species conservation and recovery more effectively than regulatory controls alone.

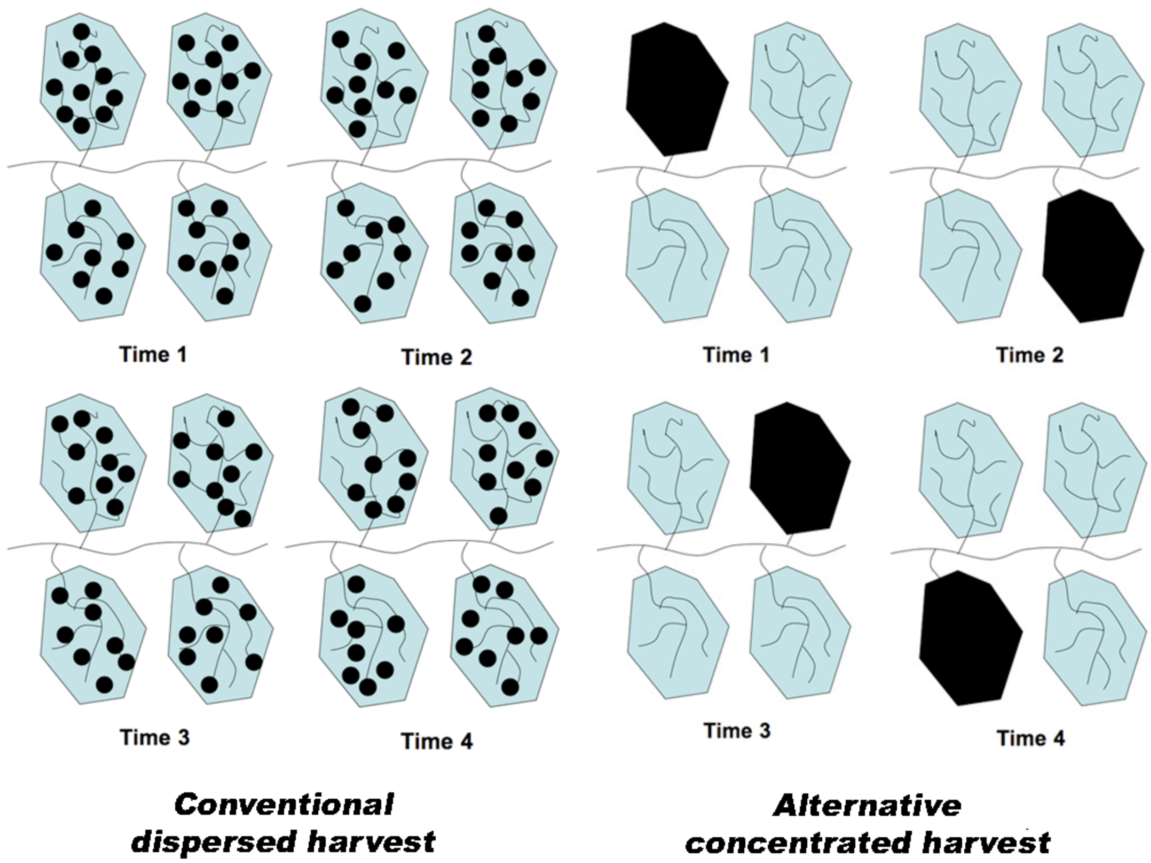

Figure 5. Hypothetical representation of dispersed vs. concentrated harvest strategies. In conventional dispersed harvest, relatively small harvest units are distributed across a hypothetical fifth or sixth field watershed, potentially creating an extensive road system and chronic sedimentation. In the alternative concentrated harvest scenario, large harvest units take place in single watersheds while other watersheds rest.

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