PNW
Pacific Northwest Research Station

Science FINDINGS

INSIDE

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"Science affects the way we think together."
Lewis Thomas

LANDSLIDES THROUGH THE FISH-EYE LENS

If it is true that revolutions can be born in small moments, then the 1981 meeting of the American Fisheries Society provided one of those moments. Fred Everest, a research fish biologist for the Pacific Northwest (PNW) Research Station, was presenting a paper about landslide effects on stream channels.

When he said something about the value of landslides to stream channels, the room erupted, according to Gordie Reeves, a graduate student at the time.

"They wanted to know what on earth he could be thinking," Reeves recalls. "Are you saying there's such a thing as a good landslide?!" He was accused of setting back fisheries research 20 years.

But the fuss hit Reeves at a new angle. "I figured if the landslide's affecting the channel that way, then it must be affecting fish, too. We needed to take a closer look."

This eruption–miniscule in the grand scheme of things–began successfully to change a broad way of thinking.

Landslides and debris flows bring a combination of large woody debris and sediment into streams. Under natural disturbance regimes, streams and fish recover and benefit over time from these pulses of material.

Appreciating that landslides were part of a natural disturbance regime was not such a stretch. Understanding that they played a crucial and beneficial role in flushing and rebuilding channels was another thing.

And good for fish? What about those massive slides that filled the channel with trees and dirt and rocks and stumps?

"The general understanding at the time was that such events made channels too messy to be productive for fish," explains Reeves, now a research fish biologist at the PNW Research Station. "But the question it raised for me was, if we're going to accept that these ecosystems are dynamic, in other words with really big disturbances as a regular part of the plan, shouldn't the fish be telling us that with their behavior and adaptations?"

Indeed, closer inspection by Reeves and others, the fish had a great deal to tell us about how they view "natural catastrophe."

All the world knows
that revolutions
never go backward.
(William Seward, 1801-1872)

Forest Service
USDA United States Department of Agriculture

EDITOR'S NOTE

*The **PACIFIC NORTHWEST RESEARCH STATION** serves society by improving the understanding, use, and management of natural resources. This monthly publication presents science findings for people who make and influence decisions about managing land.*

This issue examines research the Station has been conducting on how catastrophic disturbances affect fish habitat. Whereas our February issue discussed the physical dynamics of a flood on a landscape, here we expand to major disturbances in general while narrowing in on fish habitat – still at a landscape scale.

Our work in this area is unfolding new knowledge about very complex ecological processes. We are beginning to understand how fish are weed-like opportunists as they take advantage of natural cycling over long-time scales and large areas.

As scientists, one conclusion we have made about the restoration of the fish habitat so vital to the people of the Pacific Northwest, is that great consideration must be given to the role and legacy of natural disturbance. The implications for management and policy from our work are at a larger scale and more complex than we would have dreamed of only a few decades ago.

We encourage you to continue with us on a journey of knowledge so that you may have a clear understanding of scientific information as you make decisions that affect fish habitat or are in response to disturbance events. To learn more, please see our "For Further Reading" section.

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SALMONIDS ARE ADAPTED TO DISTURBANCE

Life history adaptations of salmon include adult straying and high fecundity rates, and early migration of juveniles. Together, they suggest survival tactics that would do credit to any weed. Straying by adults on their famous journey home is not uncommon, though statistically minor. The reasons for straying are not well understood, although it seems to be genetically controlled, directly or indirectly. Strays are likely to be most successful reproductively where local populations have been reduced or eliminated, just as happens typically after a major disturbance.

Disturbances completely change habitat in some areas which "wink out." Other areas become productive over time and "wink on" to support fish populations.

"The analogy with weeds is quite striking; salmon are definitely opportunistic in similar ways. They require suitable habitat, but they take maximum advantage of it," Reeves notes.

New populations also are helped by the migration of juveniles from birth streams to other areas before they head for the ocean. Furthermore, salmon are prolific reproducers: high fecundity and large eggs are particular advantages for species whose young must thrive in gravel for extended periods. So what do these adaptations suggest to the prepared mind?

"First, let's check for mistaken notions," Reeves says. "We have lived with an expectation that all natural streams maintain a consistent, highly productive state for fish, and while we believed this it helped us to perceive disturbances such as wildfire and landslides as negative events."

In reality, the productive state of streams with regard to fish is hugely variable. Says Kelly Burnett, fish biologist, with the PNW Research Station. "The variation, or cycling, in stream states operates over large and small scales of space and time, from the valley segment or reach to whole watersheds, and from single years to decades and even centuries. The natural cycling over long time scales and large areas results in high-quality habitat at a particular place degrading and then rebuilding over time. A mosaic of habitat conditions is created across the landscape."

To illustrate the concept of natural cycling, these biologists refer to habitats "winking out" and "winking on." As disturbances eliminate or completely change habitat in one area, which "winks out," other areas - ideally - have become more productive over time. They "wink on" and can take over the support and maintenance of fish populations.

The problem, to simplify it comes when too many habitats have winked out, and not enough have winked on to replace them, which is where we currently find ourselves.

FOR FURTHER READING

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KNOW WHAT YOU'RE MIMICKING FIRST

How easy will it be to get more habitat to wink back on? Surely if we understand that major disturbance events are part of the natural dynamics, then we can just mimic them?

"Well, you'd better know what you're mimicking before you take that on," says Reeves, and Burnett adds, "We don't know as much as we need to, so I believe we need to preserve our options by excluding areas that are currently providing high-quality habitat from any landscape-scale experimentation."

Human activities are creating a new disturbance regime... a "press" versus a "pulse" disturbance of natural systems.

Having stated these clear qualifications and underlined the need for continuing research, Reeves and Burnett emphasize that the focus for management needs to be on preserving ecosystem processes. The crucial recovery processes include cycling supplies of large wood from the forest through the streams, channel adjustments to wood, varying waves of sediment--sequences of events that can take decades to centuries to complete their work.

For example, in an area such as the Oregon Coast Range, the natural disturbance regime includes infrequent stand-resetting wildfires that reduce soil-binding strength until the forest begins to regenerate. More frequent disturbances come from intense, soil-saturating winter rainstorms. The result during the periods of low root strength? Concentrated landsliding into channels and debris flows. A "pulse" of activity through the system.

The immediate impacts, the researchers explain, look pretty bad: direct fish mortality, habitat destruction, elimination of access to spawning and rearing sites, and temporary reduction or elimination of food resources. But wait--literally. Wait. Over time, landslides and debris flows provide large wood and sediment of all sizes from silt through larger gravels for the channel, and affect storage of these materials.

But what happens when the disturbances come in another form? What happens when we suppress wildfire? When more sediment and less large wood pours into the stream in harvest-related hillslope failures? When disturbances recur in the 40- to 50-year range rather than the 150-year-plus intervals of natural disturbances?

"Human activities are creating a new disturbance regime, and we refer to this as a 'press' rather than a 'pulse' disturbance," explains Reeves. "Rather than episodic delivery of wood and sediment, with hundreds of years available for denuded areas to recharge, what we have now is more like chronic, frequent delivery, from smaller areas over shorter timespans."

Simply put, a pulse disturbance does not push an ecosystem beyond its normal limits of resilience, and allows it to recover the conditions present before the disturbance. Indeed, pulse disturbances are thought to be essential components of many natural systems. A press disturbance forces an ecosystem to a fundamentally different set of conditions, such as when intensive, short-rotation timber harvesting or urbanization leads to a "cleaned-up" version of a stream.

Intermittent streams play a crucial role in bringing large wood into streams, where it helps create the complex habitat preferred by salmonids.

"What may be just as important to note are the changes in the legacy of disturbance, the conditions immediately following a disturbance," Reeves adds. "Changes in the legacy will influence a stream's resiliency for rapid recovery, as well as altering future conditions."

KEY FINDINGS

- Aquatic ecosystems are highly dynamic. Failure to consider the role and legacy of natural disturbance has limited the effectiveness of restoration programs.
- The streamscape (of the central Oregon coast) is a mosaic of habitat conditions at any point in time. Conditions ranged from very good to very poor, depending to a large extent on the time since the last major disturbance.
- "Key watersheds" and reserves are a vital short-term tool for protecting best and most ecologically intact habitats. Reserves must be large enough to allow natural disturbance events to play out their effects.

So how do these ideas relate to restoration efforts? Oregonian news articles in July 1997 bemoaned the expenditure of $3 billion on salmon restoration to no apparent effect. The articles did not delve into the phenomena of natural disturbances. But a significant body of research now suggests that failure to consider the highly dynamic nature of aquatic ecosystems has severely limited the effectiveness of restoration programs, according to Reeves and Burnett.

Researchers in this arena are promoting new approaches to restoration efforts, modifying human disturbance regimes to incorporate dynamism. In this way, they are trying to create and maintain what they call the "historic range of variability."

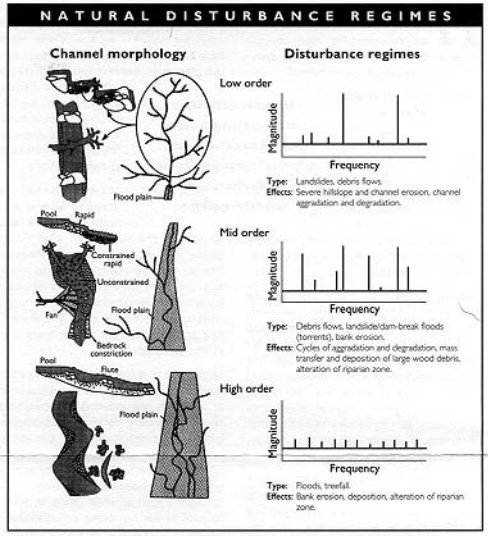
But the focus must be on processes, not just structure, says Burnett. Reeves agrees emphatically.

"We've got to manage to maintain processes. Consider the periodic delivery of wood from upstream areas: this is a small fraction of the landscape, but it's crucial in large wood delivery, so we must leave the big trees up there, in areas where streams are often intermittent." We need to focus and customize these kinds of efforts. Reeves says he's had landowners tell him they could commit to turning 10 percent of their land over to habitat restoration.

Reserves are vital short-term tools for protecting the best and most ecologically intact habitats.

A strong recommendation coming out of this research is establishing watershed reserves that contain the best existing habitats and include the most ecologically intact watersheds: the "key watersheds" approach. But if the landscape is constantly in a state of flux, with a mosaic of different conditions, how can reserves help?

"Of course we can't hold the line on the dynamics of ecosystems. Therefore existing reserves are a short-term but essential strategy, and the challenge to management lies in creating the next generation of reserves," says Reeves.



Natural disturbance regimes have specific and beneficial effects on stream channel morphology.

Part of the way to do this is to identify watersheds that have the best potential for being restored, then prevent further degradation and restore ecological processes that create and maintain instream habitats. Reserves should be large enough to allow natural disturbance regimes to play out their effects, thus supporting a mosaic of patches with different biological and physical conditions.

Under the Northwest Forest Plan, Reeves notes, the reserves are relatively small, and not much attention has been paid to maintaining processes within and around them. Thus they could easily become vulnerable to press disturbances.

Reeves and Burnett are both concerned that the details of their work be fully understood before overall concepts are widely adopted and applied. "There is an incentive to embrace this work that I'm uncomfortable with unless there is strong commitment to continuing research, and until we have had the opportunity to evaluate results of future work," says Burnett. "With the wrong spin, it can give 'permission' for landslides, for active management, without full understanding. We must beware the winking off without the winking on."

WRITER'S PROFILE

Sally Duncan is a science communications planner and writer specializing in Forest resource issues. She lives in Corvallis, Oregon.

CAN HUMAN DISTURBANCE MAINTAIN THE PARTS OF A NATURAL REGIME?

How can we combine the realities of managed forest resources with the requirements of rambunctious ecosystems? Can human-influenced disturbance maintain components of the natural regime?

First, the legacy of human and natural disturbances is quite different. Press versus pulse. After a wildfire, large amounts of standing and downed wood were frequently delivered to the channel along with sediment in storm-generated landslides. As sediment was transported through the system, the wood was left behind as foundation for high-quality fish habitat. Timber harvest, as typically practiced, more often reduces the amount of large wood available to the stream, thus leaving sediment as the primary material delivered to the channel during and after a storm.

Put another way, channels may be simpler following timber harvest than they are after wildfires, and less able to develop the complex habitat preferred by fish.

A second major difference lies in the interval between events: wildfires in the Oregon Coast Range, for example, occurred on average every 300 years, with recovery and development of the most diverse stream conditions taking up to 150 years. By contrast, timber harvest generally occurs every 60-to-80 years on public lands, and every 40-to-50 years on private timberlands.

Other differences relate to the amount of the landscape affected by disturbance at any one time, and the size of each disturbed area.

Management, then, should look at specifics such as the need for more large wood. Those first- and second-order intermittent streams in particular need careful consideration, Reeves says. Extending rotations is another obvious direction. Ideal intervals will differ, researchers say, according to the size and impact of the natural disturbance regime, and the time it naturally takes for habitat to repair with adequate large wood and sediment.

LAND MANAGEMENT IMPLICATIONS

- **Timber management offers some opportunities for maintaining components of the natural disturbance regime. Wherever possible, human disturbance needs to preserve the processes of natural disturbance, such as episodic delivery of large wood to streams.**
- **Consider concentrating management activities in areas already under stress, to allow other areas longer periods of recovery time. Restoration efforts can then be more focused.**
- **To create and maintain high-quality habitat, think in very long timeframes and in very large areas. Periodic disturbance of aquatic ecosystems is necessary to maintain productivity.**

Another idea, quite controversial, that has grown out of these research findings is that of concentrating rather than dispersing management activities.

"The notion of further managing an area where fish populations are already in trouble seems hugely counterproductive, not to say politically incorrect," Reeves admits. "But if an area has no viable habitat for fish, then concentrate management there -- with a plan for subsequently restoring processes. Leave other areas that are marginal but still viable, more time to recover."

Clearly, all such suggestions need careful consideration and further study. As Burnett notes, one of their challenges is that there are so few unaltered watersheds remaining for comparative studies.

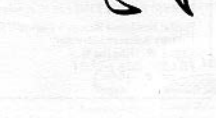
"But we must be willing to step into the lion's den, throw out some ideas, listen to the criticisms, and learn ourselves to adapt our scientific inquiries," says Reeves. Burnett adds, "It is also our obligation as scientists to try to shepherd how the research is used, to keep it consistent with what the research actually supports."

The recommendations that resonate through this research are about perspectives on time and space. Thinking in longer timeframes is essential. A regional perspective is essential. Acknowledging through all management practices that ecosystems are dynamic is likewise essential.

Finally, disturbance must be recognized as an integral component of any long-term management or recovery strategy. Reeves and Burnett are the first to admit this will not come easily. It will take time for resource managers, politicians, other scientists, administrators and, of course, the general public, to understand how periodic disturbance is not necessarily negative.

Turns out there is such a thing as a good landslide. The revolution will not go backwards.

Human ("press") and natural ("pulse") disturbances differ in intensity, timing, and size of disturbed area.



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SCIENTIST'S PROFILES

KELLY BURNETT, a fish biologist with the PNW Research Station has been studying the relations between salmonids and their habitat for 10 years. Her research currently focused on examining the effects of landform and land use on fish habitat and salmonid status at basin and provincial scales.

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