

Science

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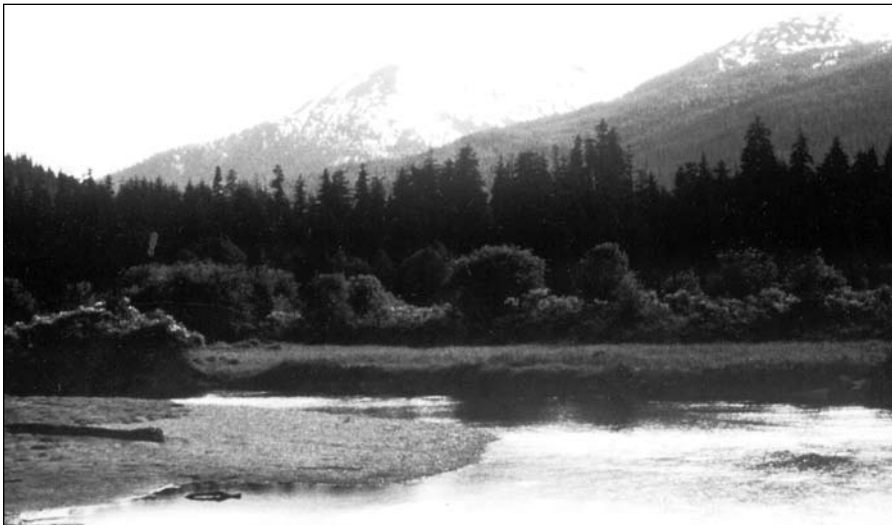
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“Science affects the way we think together.”

Lewis Thomas

DOES IT WORK? MONITORING THE EFFECTIVENESS OF STREAM MANAGEMENT PRACTICES IN ALASKA



Pristine landscape is abundant in southeast Alaska.

*“However far the stream flows,
it never forgets its source.”*

—Nigerian proverb

Ecological monitoring doesn't receive the attention it deserves. It is an endurance sport that requires careful planning and long-term commitment. Nonetheless, monitoring is critical.

The Forest Service goes to great lengths designing sensible management strategies. And sure, planning is important. So is the careful implementation of the plan. But that's not the end of the process. There is still one key question: Does it work? This is the domain of effectiveness monitoring. It tests that management goals are being met, and, if they're not, it points the way toward successful adaptation.

“Effectiveness monitoring can provide early warning to land managers, triggering further investigation that may lead to identification of a habitat-degrading disturbance,” says Richard Woodsmith, a research hydrologist at the PNW Research Station in Wenatchee, Washington. “It's fundamental to adaptive management.” He defines effectiveness monitoring as “quantitative monitoring of the effectiveness of a suite of land management practices at achieving stated goals.”

For several years while at the PNW Research Station Juneau, Alaska, lab and now from Wenatchee, Woodsmith has been working with managers and natural resource specialists for the Tongass National Forest (NF) in southeastern Alaska, to develop an approach for monitoring the effectiveness of their land management plan, as it relates to

IN SUMMARY

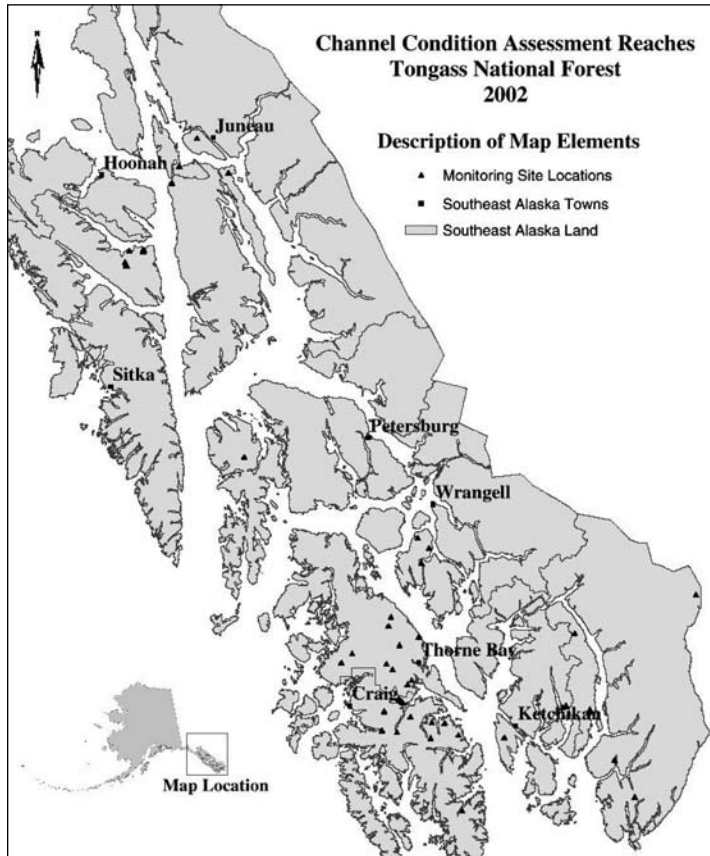
The condition of aquatic habitat and the health of aquatic species, particularly salmon, are a significant concern in the Pacific Northwest. Land management agencies use fish and riparian guidelines intended to maintain or improve aquatic habitat. Gauging whether or not those guidelines are effectively meeting their objectives requires careful monitoring of stream conditions. A defensible monitoring program needs to be based on procedures that allow the existing state and changes in stream channel condition to be objectively and precisely measured over time.

Researchers at the PNW Research Station laboratories in Juneau, Alaska, and Wenatchee, Washington, have been collaborating with the Tongass National Forest, in southeast Alaska, to design a stream channel monitoring protocol. Their results indicate that measures of channel geometry, pool frequency, pool size, and potentially streambed surface grain size distribution all are viable indicator variables for effectiveness monitoring.

Using these measures, they found high variability in stream channel conditions within pristine watersheds as well as those subject to heavy logging and roading. Nevertheless, well-trained personnel following carefully developed procedures will be able to efficiently collect field data characterizing selected monitoring variables. And, following a sufficient period of data collection, they will be able to analyze change in channel condition, as reflected by these variables, and develop conclusions regarding the relative magnitude of effects of various land use practices on channel condition.

streams and aquatic habitat. The Tongass is, by far, the country's largest national forest. Indeed, it's roughly the same size as Ireland. It contains more than 26,000 square miles of temperate rain forest, within which flows approximately 17,000 miles of salmon-bearing streams. The Tongass is an angler's or a hungry bear's delight.

Throughout much of the Pacific Northwest, salmon populations are in decline and stream habitat alteration is widely regarded as one of the major causes. Alaska is one of the few regions left with healthy populations. That's why the Tongass NF puts a heavy emphasis on stream protection. Their land management plan calls for the maintenance or restoration of aquatic habitat and stream channel and bank condition. To that end, the plan dictates a variety of stream conservation policies, such as the retention of stream-side buffers during logging and restrictions on road building.



Streams were monitored over a large area in the Tongass National Forest in southeast Alaska.

But who's to say if these policies are sufficient to meet their objectives?

"The Tongass Forest Plan poses the question: Are fish and riparian standards and guidelines effective in maintaining or improving fish habitat?" explains Woodsmith, who has been working closely with local resource managers to develop a strategy for answering this question. "Finding an answer will require an effectiveness monitoring program that allows the existing state and the variability of stream channel conditions to be objectively and precisely measured over time," he adds.

You might ask, if the main concern is declining salmon populations, then why not just monitor the fish? According to Woodsmith, "there are just too many 'out of basin' impacts on salmon that the Forest Service has no control over. If we only monitored fish numbers, we wouldn't know if a change in the population was a result of commercial fishing, conditions in the ocean, such as food sources or disease, or if they were related to changes in the stream channel due to land management, which is a factor we have some control over."

KEY FINDINGS	
▶	<ul style="list-style-type: none"> Variability in stream channel condition is large within all land use categories examined in this study, owing to differences in watershed condition, climate, and the effects of background and anthropogenic disturbance. This makes detection of land use effects difficult without long-term monitoring and large sample sizes.
▶	<ul style="list-style-type: none"> An important step in enhancing change detection capability, despite large variability in channel condition, is limiting selection of monitoring variables to those that are sensitive to disturbance and can be measured objectively, precisely, and efficiently. This research found that measures of channel geometry, pool frequency, and pool size are viable indicator variables for effectiveness monitoring. Bed surface grain size distribution is responsive to watershed disturbance, but it is difficult to measure efficiently with reasonable precision.
▶	<ul style="list-style-type: none"> Well-trained personnel following carefully developed monitoring procedures can (1) efficiently collect field data characterizing selected monitoring variables; (2) following a sufficient period of data collection, analyze change in channel condition, as reflected by these variables; and (3) develop conclusions regarding the relative magnitude of effects of various land use practices on channel condition.

DETECTING THE SIGNAL OVER THE NOISE

With so much year-to-year variability in stream channel condition, even in pristine streams, isolating changes that are the result of land use is a thorny task. But if it is done carefully, assessments of channel condition can also contribute to the evaluation of restoration needs and success of restoration activities.

One of the first challenges Woodsmith and his colleagues faced was uncovering the best combination of stream channel variables to monitor. "To detect change, despite the natural variability in channel conditions, we sought monitoring variables that are biologically important and sensitive to disturbance and

also can be measured objectively, precisely, and efficiently," he says.

Meeting this standard meant weighing the merits of several monitoring protocols that have been used elsewhere. "We knew that visual stream measurements are often not objective or precise, even if they are efficient.

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For instance, if, this year, you looked at the composition of the entire streambed and assessed it as 50 percent sand and 50 percent gravel, then I came back next year and assessed it as 75 percent gravel, how would we know if that was a real change in substrate or just measurement slop?”

On the other end of the spectrum, Woodsmith had to remain realistic with regard to practical efficiency. This meant, for example, that not every foot of every stream could be carefully measured and many variables are inherently too imprecise to be useful. Similarly, some high-tech but expensive tools such as LIDAR (laser imaging detection and ranging technology), which is a very precise and objective way to measure stream channels using an airborne laser, were not viable options, because of cost considerations.

Ultimately, based on his previous research and a review of the literature, Woodsmith selected a small number of channel condition variables

that seemed to have good potential. They included detailed surveys of stream channel topography, pool frequency, pool depth, substrate grain size, and the amount and size of large wood in the stream. Photos and sketches were used to document the general condition of the study sites.

Woodsmith then put the variables to the test. Working with land managers and resource professionals from the Tongass NF, he surveyed an assortment of streams that represented the range of conditions seen on the forest. Three intensities of land use were classified. Streams in watersheds with no history of logging or road building were considered pristine. Streams with an intermediate amount of logging and roading within the watershed were classed as moderate use. And streams in heavily logged and roaded basins were considered heavy use. Most surveys were conducted over a 5-year period from 1996 through 2000, and compatible surveys dating as far back as 1989 were included.

“The stream channels were tremendously variable, even in basins with no history of logging,” says Woodsmith. “It’s easy to fall into the trap of thinking that there is one ‘right’ condition for a healthy stream. And if we went out and measured some pristine streams, we’d then have the magic number that all other streams could be gauged against. That view simply doesn’t recognize the natural dynamics of stream systems.”

For most of the variables they measured, large variance and limited data caused most of the land use contrasts to be inconclusive. Nonetheless, they were able to whittle down the list of potential variables to a manageable number. Woodsmith is confident that, given sufficient data, they will be able to determine with reasonable certainty if management effects exceed the natural variability. This will allow an effectiveness monitoring program to inform future management plans.

INDICATORS OF CHANGE

“We found that measures of channel geometry, pool frequency, and pool size are viable indicator variables for effectiveness monitoring,” says Woodsmith. “In addition, streambed grain size distribution is responsive to watershed disturbance. Although it is difficult to measure efficiently with reasonable precision, it remains a promising indicator variable, given sufficient data.”

Channel geometry includes measures such as width-to-depth ratio and stream gradient, or

slope. These are important attributes to monitor because various land management activities have the potential to alter streamflow, sediment load, or loading of large woody debris in the channels. This can simplify channel geometry through bank erosion and sedimentation. What may result is a straighter, wider stream, with lower habitat quality for salmon and other aquatic organisms.

Similarly, pool frequency and pool size are sensitive to disturbance and are biologically important indicators of complex habitat, which is beneficial to fish. Deeper pools provide more high-quality habitat and a wider array of hydraulic and temperature conditions. Pools can be affected by land use if the number of large trees falling into streams is reduced or if sedimentation is increased. These logs can trap sediment, stabilize banks, and form pools. Obviously, removing onsite construction material will, in time, reduce the frequency of pools. “We could have just as easily used large wood frequency rather than pool frequency as a variable—they are essentially redundant,” Woodsmith explains. “But, for statistical analyses, we can’t use both. We chose pool frequency because it is a more direct measure of habitat.”

Woodsmith is a little less enthusiastic about the merits of monitoring streambed grain size, at least in terms of precision and objectivity. Nonetheless, he suggests it be considered in the Tongass’ effectiveness monitoring program.

“The channel geometry and pool data are collected with professional surveying equipment, which means our measures are quite precise from year to year and across different field crews. Grain size, on the other hand, is estimated by hand sampling and measurement across a grid placed along the streambed,” says Woodsmith. “Unfortunately, we find a great deal of variation among observers in particle sampling and measurement—there are so many ambiguities.”

Nonetheless, most stream monitoring protocols include a measure of streambed grain size. This attests to the importance of substrate as an indicator of habitat quality and disturbance history. Moreover, sudden changes in substrate can indicate a land use effect through changes in hydrology, erosion, or sedimentation.



Pools and large woody debris are closely associated regardless of the land use history.

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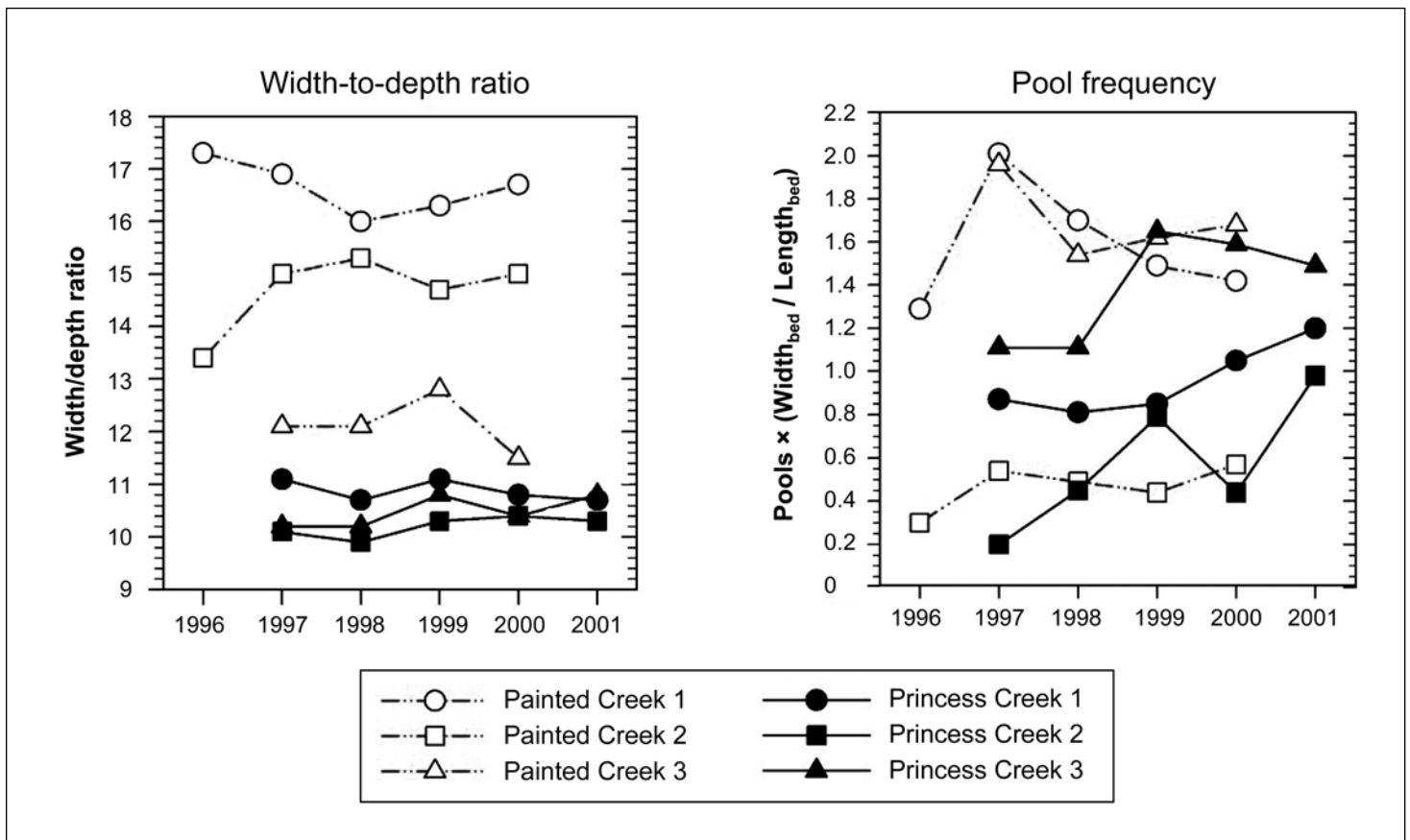
THE POWER OF MONITORING

For each monitoring variable, Woodsmith calculated something called statistical power, which gives managers an idea of what kind of changes can be detected for a given amount of monitoring. “The power of a statistical test is simply a measure of its ability to give you the right answer,” he explains.

For example, in the contrasts among three land use intensity categories mentioned earlier, statistical power analyses indicate that 20 to 30 stream reaches per category can provide 80 percent power to distinguish heavy land use from moderate use or pristine conditions for selected channel geometry and pool variables. In other words, let’s say we are monitoring watersheds for indications that stream channel conditions differ among categories (this would imply, but not prove, a land use effect). Assuming that 20 to 30 streams were monitored in each category, then, if there were differences, they would correctly be detected 80 percent of the time. Conversely, 20 percent of the time, we would draw the wrong conclusion.



The delivery of large wood and sediment is essential for high-quality habitat.



Change from year to year in width-to-depth ratio and pool frequency in Painted Creek (moderate to heavy land use) and Princess Creek (pristine). There is high year-to-year variation in monitoring variables, which makes it difficult to generalize about differences between pristine streams and those influenced by land management.



- Monitoring change in channel condition by using variables that are sensitive to geomorphic processes will improve understanding of habitat sensitivity to disturbances, including land use practices. Effectiveness monitoring procedures provide methods of data collection and analysis that can help determine the rate and direction of change in channel condition across multiple types and intensities of land use.
- Effectiveness monitoring of stream channel conditions can provide early warnings to land managers, triggering further investigation that may lead to identification of, and management response to, a habitat-degrading disturbance.

As another example, Woodsmith found, based on power analyses of six stream reaches, a 3 percent per year decrease in pool frequency could be detected with 80 percent power with 7 to 38 years of data. The number of years required depends in part on the number of surveys per year. “Adding more stream samples to the design or increasing measurement frequency at each stream generally increases power,” he says.

“Whether 80 percent power is enough certainty is a question for the managers, not the researchers or statisticians. It depends on just how sure they need to be, and whether they are comfortable being wrong 20 percent of the time,” says Woodsmith.

“The role for researchers and statisticians is to develop methods for data collection and analysis that are statistically defensible and allow for the evaluation of management strategies,” says Woodsmith.

THE KEYS TO SUCCESS

“One of the hardest parts of designing an effectiveness monitoring strategy is settling on the exact information needs of the land managers,” says Woodsmith. “Sometimes the local managers have very broad expectations for monitoring—they may be interested only in a general sense if current standards are successful. Nevertheless if a monitoring program is going to be defensible, it must target specific questions.”

“Close collaboration among land managers, resource professionals, researchers, and statisticians will be critically important for plan development,” he adds. This is the approach they are taking on the Tongass.

Details of an effectiveness monitoring program will differ depending on local needs, the land use scenario, and the commitment to long-term funding. And before any monitoring program begins, managers will want to ask themselves several questions. For example, is it only the effectiveness of the most recent guidelines that we need to monitor? What about the legacy of past management practices? What is the availability of sites affected by the land use scenarios of interest?

On the Tongass, managers have committed to a long-term effectiveness monitoring program that assesses the cumulative effects of

land use and restoration. The procedures and analysis techniques that Woodsmith and his colleagues developed will be an important part of this plan, and the streams they sampled will provide the baseline data to build on in the future.

“Given what we’ve accomplished on the Tongass, I believe that well-trained personnel following carefully developed procedures will be able to efficiently collect field data characterizing selected monitoring variables. In addition, following a sufficient period of data collection, they will be able to analyze change in channel condition, as reflected by these variables, and develop conclusions regarding the relative magnitude of effects of various land use practices on channel condition,” says Woodsmith.

A sound monitoring plan will help the Tongass NF to adapt future management plans with the confidence that their actions meet their goals for fish and aquatic habitat conservation.

“A stream is music and motion: smooth glides, fast, turbulent riffles and deep pools, each posing a special challenge.”

—Nelson Bryant



Measuring streambeds with professional surveying equipment increasing precision and the ability to detect changes in stream channel conditions.

FOR FURTHER READING

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of Oregon. He worked as a professional geologist for the Forest Service and the National Park Service, and he was a research associate at Clemson University before joining the Station. Woodsmith has specialized in the geomorphology of streams in forest environments, particularly with respect to implications for aquatic habitat. His current research interests have expanded to include the effects of land management, fire, and other disturbance on watershed hydrology and water quality in semi-arid environments.

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