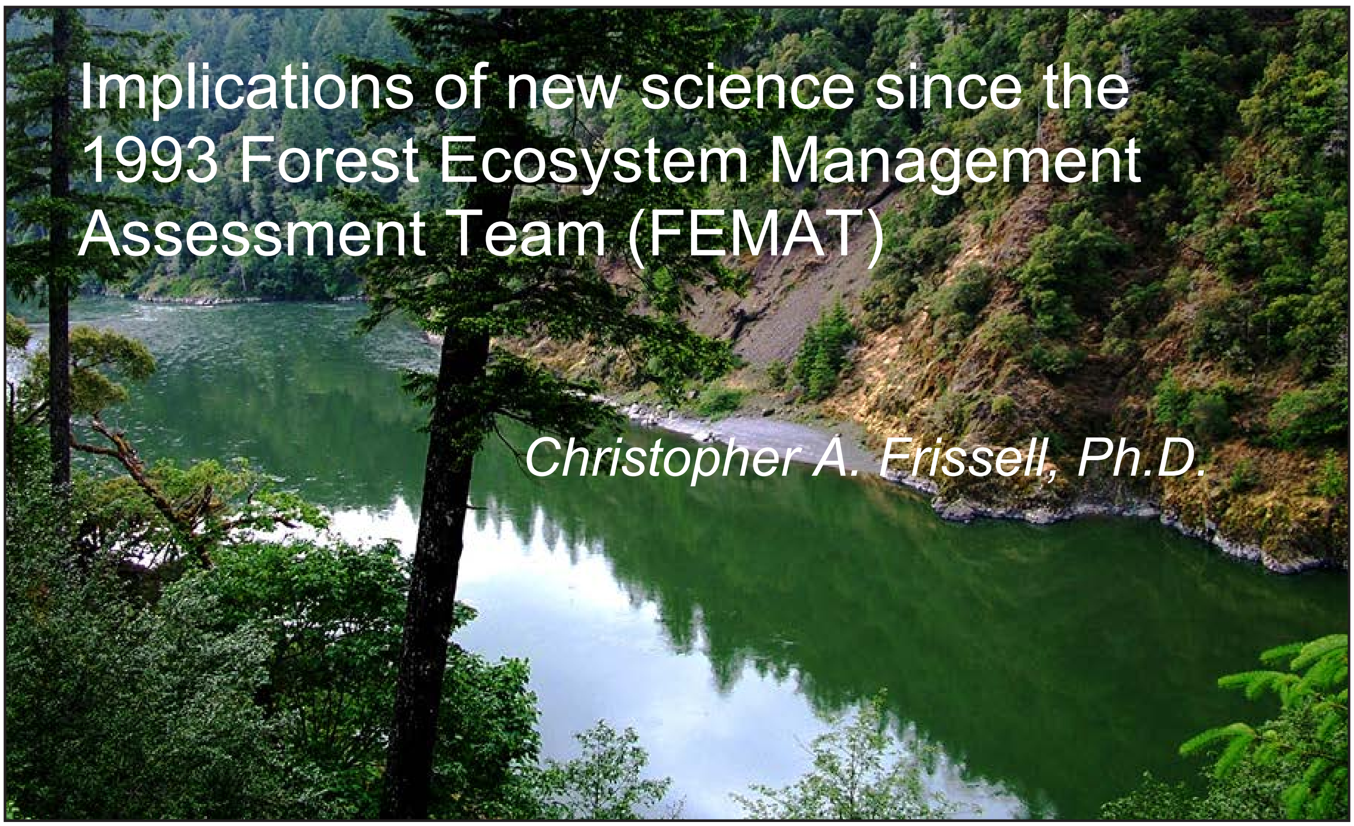
Aquatic Resource Protections in the Northwest Forest Plan: Evaluating Potential Consequences of Proposed Riparian Reserve Reductions for Clean Water, Streams and Fish



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EXECUTIVE SUMMARY

This report is a summary intended to steer interested parties to the scientific literature most pertinent to understanding the potential environmental consequences of altering riparian reserve protections on federal lands in the Northwest Forest Plan (NWFP) area of Oregon, Washington and California. The report emphasizes the implications of "new science" published since the 1993 publication of The Forest Ecosystem Management Assessment Team's synthesis (FEMAT 1993), in part because "new science" is frequently cited as the rationale for altering or replacing the water and watershed protections that have prevailed under NWFP rules since 1994.

The NWFP originated by Presidential directive in response to litigation and political conflict resulting from management failures on the National Forests and Bureau of Land Management (BLM) forest lands within the range of the northern spotted owl in western Oregon, Washington and northern California. FEMAT recognized the multitude of ecological links between terrestrial forest and wildlife and aquatic ecosystems and the many ways by which those linkages are influence by forest management. The outcome was an Aquatic Conservation Strategy (ACS) as a key design element within the NWFP. Critical ACS components include Riparian Reserves, Key Watersheds, Riparian Management Objectives and operative Standards and Guidelines, and an ecological assessment process called Watershed Analysis, the means by which site-specific departures from "default" regional protection rules could be justified.

This report focuses on the science pertinent to recent efforts by the US Forest Service, BLM, political leaders, and others to fundamentally alter the Northwest Forest Plan by reducing the area of Riparian Reserves, while also increasing the basis for commercial logging from near-stream and potentially unstable lands. Various alternatives to the existing ACS and NWFP have been proposed by the BLM in its Western Oregon Plan Revisions EIS, by Region 6 of the Forest Service in its 2008 Aquatic Resources Conservation Strategy, by Representatives DeFazio, Schrader, and Walden of Oregon in federal legislation, and by Gordon Reeves and colleagues in an unpublished white paper in 2013. While a federal review of monitoring data in 2006 reported that the ACS has been somewhat effective in setting streams across the region on a course toward restoration, no public scientific review equivalent to FEMAT has occurred to evaluate the basis for that success, and whether or how it might be affected by recent proposals to scale back stream Riparian Reserve protection. Meanwhile, the BLM and Forest Service have moved in recent years toward more systematic and aggressive logging within Riparian Reserves (this is most evident as commercial thinning). Riparian logging now contributes a substantial portion of the commercial timber counted by the agencies toward their annual timber production targets, raising concerns about their recent and future management commitment to restoration of water quality and watersheds, streams and rivers, and their fish and wildlife habitat.

This report examines some of the potential and likely environmental consequences of narrower Riparian Reserves, or increased logging within current or modified Riparian Reserves by the aforementioned proposals for the NWFP region. This review is needed because federal agencies and other proponents of increased logging and reduced riparian protections have failed to systematically evaluate and disclose potential environmental consequences of their proposals.

Reduced Riparian Reserves could alter thermal regimes and increase summer stream temperatures in a wide variety of streams through several known mechanisms, including warming of near-surface groundwater in logged areas, reduced redundancy and increased vulnerability of riparian forests and stream surface shade to natural disturbance events and anticipated climate change.

Narrower Riparian Reserves increase the proximity of logging and other vegetation and ground disturbing actions to stream channels, materially increasing the likelihood of erosion and sediment delivery to streams. Proposals to reduce Riparian Reserve widths do not account for the potential impact of reduced protection for unstable slopes and reduced buffering of streams from the erosional impact of roads, and skid trails, even though logging roads and skid trails are necessary to cost-effectively extract timber from near-stream areas. Reduced Riparian Reserve area measurably increases the chance that erosion sources will increase the duration and concentration of suspended sediment in streams, impairing water quality, biological productivity and habitat conditions. Other regional scientific assessments have identified the need for larger areas of riparian protection for headwater streams than provided for on the NW Forest Plan ACS, largely on the basis of reducing erosion and sediment delivery originating from up-slope logging disturbances.

Reduced Riparian Reserve widths would diminish the capacity of riparian forests to filter nutrients that are the inevitable result of logging and other vegetation and oil disturbances. Nutrient loads are presently a threat to water quality and salmon habitat in numerous coastal lakes and rivers. Logging within Riparian Reserves creates new nutrient source areas close to streams, at the same time it directly compromises the effectiveness of riparian forests to filter nutrients sources originating upslope. Emerging science suggests for steep headwater streams, Riparian Reserves substantially wider than current ACS defaults are necessary to fully protect streams from nutrient increases caused by logging.

Angling and recreation by present and future generations are among the many human values dependent on Northwest Forest Plan stream protections. Author photo.

Logging within Riparian Reserves directly alters natural riparian forest successional pathways, and impairs the recruitment of woody debris to streams, even while wood loadings remain decimated relative to historic levels; wood in all categories remains in very short supply in the vast majority of Pacific Northwest streams. Reducing riparian reserve width increases the likelihood of catastrophic windfall of remaining trees, truncating the steady or sustained recruitment of trees expected from natural mortality and disturbance processes in streamside forests. Effectively maintaining or restoring natural levels and rates of wood recruitment to streams on a comprehensive, landscape-wide basis will very likely require substantially wider buffers along headwater streams than provided for under the NWFP ACS. Mitigation measures like "tree tipping" are site specific mitigation measures with limited ecological benefit, and they represent a clear tradeoff between presumed near-term benefits and the inexorable process of natural debris recruitment, which is measurably comprised by thinning.

Other significant categories of ecological impact, including effects on terrestrial and avian wildlife, and effects on habitat connectivity across regional landscapes may be equally important, but are not considered in this paper.

Taken as a whole, the scientific literature indicates that proposed curtailment of ACS Riparian Reserve protections is certain to cause harm—potentially vital harm-- to water quality, stream habitat, stream organisms like salmon and other fish and wildlife. The nature and extent of these risks and harms should be carefully evaluated and fully disclosed before public policy decisions are made that will change the course of management in Pacific Northwest forests. Proponents of reduced Riparian Reserve protection, including the US Forest Service, the BLM, and certain Congressional and state officeholders, have so far failed their duty to ensure such disclosure.

Beyond the direct and indirect environmental impacts and mounting costs to water, salmon, and fish and wildlife resources, alterations of the NWFP and ACS are nearly certain to trigger reinitiated Endangered Species Act consultations on virtually all ongoing and planned BLM and Forest Service actions, region wide, given that past consultations were based on the undiminished protective standards of the NWFP. All things taken into account, proposals to reduce Riparian Reserve protections appear highly unlikely to increase efficiency and productivity in federal forest management and alleviate political tensions, and economic stress, but rather risk exactly the opposite outcomes.

INTRODUCTION

The Northwest Forest Plan (NWFP) is a unique, powerful, and formative regional conservation planning effort initiated by several federal land management and regulatory agencies in 1993 (and adopted in 1994). The NWFP was given impetus by Presidential directive in response to litigation and political conflict stemming from logging practices and related management failures in the National Forests and Bureau of Land Management (BLM) forest lands within the range of the northern spotted owl in western Oregon, Washington and northern California. A multi-disciplinary team of scientists, charged with taking a comprehensive approach to ecosystem management and conservation design, established the scientific, and conservation landscape design framework for the NWFP. They recognized the systematic and intimate ecological links between terrestrial forest and wildlife management and the conservation of riparian and aquatic ecosystems in the landscape of the Pacific Northwest. With this in mind, they developed the architecture of what is now the Aquatic Conservation Strategy (ACS), a key component of the NWFP.

Young coho salmon in the Oregon Coast Range. Once widespread and abundant, the coho is now federally listed as a threatened species throughout the Northwest Forest Plan area in Oregon and Washington. Steve Trask photo.

The ACS was devised as a robust approach for linking terrestrial and aquatic ecosystem management, with several articulated parts. The first is a comprehensive system of Riparian Reserves, protecting riparian forest ecosystems adjacent to streams of all sizes. Somewhat wider Reserves are designated for larger, fish-bearing streams and somewhat narrower ones for non-fish-bearing headwater streams. Coupled to Riparian Reserves, the ACS provides a list of Riparian Management Objectives and Standards and Guidelines. This list was designed to provide direction and sideboards for how the areas should be managed to ensure protection and restoration of riparian and aquatic resources. The second component is a network of Key Watersheds. These are larger, hydrologicaly contiguous areas of high ecological value where restoration of watershed and riparian conditions is to be prioritized by the agencies. The third component is a process of Watershed Analysis, which furnishes a framework and procedure for detailed analysis to establish restoration objectives and priorities for Key Watersheds and Riparian Reserves. It also provides a procedural means of adjusting default Riparian Reserve widths, if warranted, and for establishing site-specific priorities and sideboards for restoration. Critically, the NWFP decreed that any logging, or other active management activity, within Riparian Reserves can only be justified if it can be shown to be a necessary intervention to restore riparian and aquatic ecological functions and values. Management activities within Riparian Reserves, including logging, must be determined to be restorative to riparian resource values and functions. According to several key Ninth Circuit court decisions, it is NOT sufficient to show that logging in Riparian Reserves would "do no harm." Accordingly, Riparian Reserves were mapped, or their extent across the region estimated, and these acres removed from the timber base used for modeling of the annual quantity of potential commercial timber production from all National Forests and BLM management areas.

The distinguished multidisciplinary science team that developed the ACS has never been reconvened. However, in 2006 a 15-year agency review of NWFP implementation reported that the ACS has been somewhat successful in attaining its goals of improving riparian habitat conditions. In-stream habitat measures reportedly showed measured improvement in selected Key Watersheds where active road remediation substanstially reduced logging road densities. Despite some preliminary indications of success of the NWFP and ACS as a conservation framework, since around 2006 there has been mounting pressure from some Oregon counties, Oregon political leaders, and the BLM and US Forest Service to reduce protection for streams and watersheds. This would dramatically alter the design and function of the ACS and NWFP.

In western Oregon stream densities are particularly high and site-potential trees are tall. As a result, Riparian Reserves as defined under the "default requirements of the ACS occupy a large fraction of the federally-owned landscape (as much as ca. 40 percent, see FEMAT [1993], but in effect nearer 20-30% in most planning areas). Therefore, any means of transferring land out of Riparian Reserve status into adjacent Matrix status, where most commercial logging is slated to occur, could increase the land area on which intensive commercial logging operations are conducted. Such proposed changes in watershed, stream and riparian protection would put considerable regional resources at risk. In western Oregon, for example, about 1.2 million acres of BLM lands occur within 79 Surface Water Source Areas (SWSA) that provide clean drinking water for 1.5 million people from Medford to Portland. Virtually every acre of Forest Service and BLM land in the NWFP area contributes to the health of watersheds and riparian habitat critical for the future survival and recovery of salmon or trout, frogs and salamanders, and numerous other wildlife species.

Several sources can be consulted to describe the apparent rationale for proposed changes in

BLM and the US Forest Service conduct a variety of forestry activities in addition commercial logging within the Northwest Forest Plan area. Riparian Reserves and other conservation measures are critical to safeguard water, fish and wildlife from forestry practices intended to benefit timber supply. Author photo.

the ACS, particularly wholesale reductions of Riparian Reserve areas, on federal forest lands. Emphasizing scientific information that has emerged since 1993, this memo assesses the likely environmental consequences of proposed or in-process reductions in ACS protections for water and fishery resources in Oregon. Importantly, many or most of the potential environmental consequences identified below have received grossly inadequate recognition and analytic consideration by the proponents of ACS diminution, including the BLM and the Forest Service. As a result, both agency-originated and legislative governmental proposals—have not been informed by a rigorous assessment of the likely magnitude of harm they may pose to aquatic resources in Oregon. Thus the public and decision-makers remain unaware of crucial information and implications.

Key References

FEMAT (1993), Montgomery et al. (1995), Naiman et al. (2000), Olson et al. (2007), Reeves et al. (2006b), Carroll et al. (2009), Blum and Wigington (2013), Heiken 2013, Dellasala et al. (2013)

The Northwest Forest Plan landscape remains strongly imprinted by extensive forest roads and clearcut logging from the previous century. The legacy of past watershed damage renders these ecosystems and their resources more vulnerable to disturbances today. Author photo.

PROPOSED CHANGES IN THE NWFP AQUATIC CONSERVATION STRATEGY

Who has proposed changes in the NWFP Aquatic Conservation Strategy (ACS)?

After an abortive early attempt to reduce aquatic protections in 2003, the BLM in 2005 announced its intention to pursue an Environmental Impact Statement for Western Oregon Plan Revisions, or "WOPR," to substantially revise the management of BLM's lands under the Northwest Forest Plan.

Each of three alternatives in the EIS were designed to increase timber harvest from BLM lands. They accomplished this, in part, by invoking large reductions of Riparian Reserve areas and proposing increased logging activity within the reduced boundaries. The three alternatives reduced Riparian Reserve widths from the Northwest Forest Plan typical default standard of 340 feet for fish-bearing streams to 100 or 170 feet. Two of the alternatives would have provided for extensive logging in "other than mature or structurally complex stands" to within 25 feet of fish-bearing streams. For non-fish-bearing streams with perennial flow, one alternative would have maintained existing 170-foot-wide Riparian Reserves, but two others would have reduced those to 25 to 100 feet width, depending on stand conditions. Protection for intermittent flow, non-fish-bearing streams would have been halved from 170 to 85 feet, or chopped to 25 feet, depending on the alternative. While the NWFP allows occasional salvage, thinning and "feathering" within Riparian Reserves under specific circumstances, the WOPR would have also allowed commercial timber harvesting for pervasive "safety and operational" reasons.

While the WOPR Final EIS was officially withdrawn by Department of Interior in 2009 (citing scientific shortcomings), presently BLM is proceeding again with a revision of its Resource Management Plans. All indications are these plans will be premised on the same perceived agency desire to replace Riparian Reserves with weaker protections and cut more trees near streams.

In early 2013, Reeves, Pickard and Johnson, in a white paper with the somewhat misleading title "Alternative Riparian Buffer Strategies for Matrix Lands of BLM Western Oregon Forests That Maintain Aquatic Ecosystem Values" described a means by which they believed default Riparian Reserve widths for non-fish-bearing streams could be systematically narrowed to provide for increased timber production from "Matrix" lands. Despite the fact that, in some cases, Watershed Analysis has established scientific and environmental grounds for expanded, rather than contracted, Riparian Reserve boundaries—see Heiken [2013] and Pacific Rivers Council Comments on WOPR DEIS (Jan. 11, 2008,pp11-12]). Reeves et al. (2013) stated that the NWFP mechanism for adjusting Riparian Reserve boundaries (Watershed Analysis) has, for reasons the authors did not specify or describe, failed. Reeves et al. (2013) proposed that a new, automated procedure, based on analysis of digital elevation models and related GIS technology, can be employed to systematically narrow Riparian Reserves in many streams. Land near streams would therefore be systematically reallocated to Matrix category where commercial logging could occur without establishing any ecological restoration basis for cutting trees.

Reeves et al. (2013) claim that their GIS-based method, without any testing or field validation, could be implemented to "maintain aquatic ecosystem values," but their white paper includes only very limited and generalized analysis of a small subset of the values and functions provided by Riparian Reserves. The remainder of the present document includes an overview of a range of aquatic resources, conditions, and functions that could and would likely be affected by systematic narrowing of Riparian Reserves on federal lands, or by changes of management direction that allow vegetation and ground-disturbing actions to be taken more routinely within Riparian Reserves. Neither Reeves et al. (2013) nor the present paper address terrestrial wildlife habitat needs, although that continues to be a major conservation purpose of Riparian Reserves, and one of the principle reasons why Northwest Forest Plan default Riparian Reserve boundaries were (see Heiken [2013] for an analysis of wildlife concerns, and TWS [2013] for comments some of the shortcomings of Riparian Reserve reduction for wildlife conservation).

While Reeves et al. (2013) remains an unpublished white paper that has not undergone formal or documented peer review and lacks the official blessing of any federal agency, it is of great concern that, in a letter dated 6 February 2013, the Oregon Governor's office, apparently referring to the Reeves et al. report (draft at that time), admonished the Oregon Congressional delegation that "evolving science concludes" that federal land Riparian Reserves can and should be reduced through legislation. (See Heiken [2013] for more details.) A recent letter signed by 180 scientists nationally challenges the assertion that scientific information substantiates a move to reduce Riparian Reserve protections among other conservation elements of the NWFP (Dellasala et al. 2013).

The political desire for increased timber harvest from BLM lands is, on its surface, driven by the expectation that increased logging on the Oregon and California Railroad lands and Coos Bay Wagon Road lands under BLM management might financially benefit Oregon counties that are struggling with longstanding fiscal issues. Franklin and Johnson (2012) accordingly provide a silvicultural recipe for increased commercial logging and presumably revenues from BLM lands in western Oregon. They explicitly did not consider management of Riparian Reserves or the consequences of their forest management recommendations on aquatic and riparian ecosystems. However, through well-known pathways that include increased road systems and increased area of vegetation and ground disturbance across large catchments, increased logging will directly affect water quality, and aquatic habitat and biota.

This push for increased logging on BLM land received additional impetus in mid 2013 when a federal court in Washington, DC ruled that present cutting levels in southern Oregon BLM O&C lands should be increased to accord with projections established in existing BLM plans. The court did not rule on or consider the full weight of environmental consequences of such a decision, other than relying on BLM's present plans to establish this. The timber industry appears to read this decision as a mandate for BLM to cut more trees. However, others view it as a mandate for more accurate analysis and decisions as BLM revises its management plans for O&C lands, so that prevailing conservation needs are met and whatever projected timber volume the agency projects are reliably offered.

Although Reeves et al.'s (2013) alternatives for systematic Riparian Reserve reduction were intended to apply to BLM forests only, it is only logical that if they were scientifically defensible as described, they could eventually be extended to National Forest Matrix lands as well (a much larger area), hence they could set regional precedent.

Notably, the *Aquatic Resource Conservation Strategy* (ARCS, see USDA 2008) is a "Regional Framework" document developed in 2008 by the USDA Forest Service Pacific Northwest Region to guide ongoing revision of National Forest Plans in Oregon and Washington. The ARCS generally retains the default riparian area widths and key watersheds, as in the NWFP, as the primary spatial footprint of aquatic conservation. However, subtle changes in the wording of Riparian Reserve Management Objectives, Watershed Analysis, and other guidance for management within reserve areas within ARCS would provide the agency with greatly expanded discretion to undertake a broader range of vegetation and ground-disturbing management activities within Riparian Reserves. These activities include thinning and other commercial logging. ARCS does this by relaxing the NWFP requirement that each management action be justified by site-specific analysis showing the action is beneficial or necessary to attain ecological restoration goals for Riparian Reserves—that is, protection and recovery of water quality fish or wildlife habitat. The ARCS would allow actions that are individually not beneficial or outright harmful to riparian reserve resources and goals, if a general argument can be made that harms are offset or balanced by additional ecologically beneficial actions or effects. These offsetting benefits may be dispersed or averaged across time or space. On its face, this approach would explicitly allow natural ecosystem recovery could be slowed to an imperceptible rate, in clear contradiction to FEMAT's (1993) clear conclusions about the need for widespread aquatic recovery restoration if numerous natural resource goals and legal mandates are to be met.

Among the management actions that would be routinely allowed by the change of wording in ARCS is riparian reserve logging---which the agency commonly justifies by the generic (for the most part without justification with site-specific data or direct experimental evidence from comparable sites) argument that thinning trees today "should result" in larger trees in future years (see section on woody debris below). While the Forest Service argues that ARCS requirements "should" provide for ecological improvement at the scale of large watersheds, no analysis is provided by the Forest Service to substantiate this assumption.

Further, nothing in the ARCS ties vegetation- and ground-disturbing actions to large-scale improvements or restoration. In effect, with ARCS it appears the Forest Service intends to allow logging and other site-disturbing actions to proceed programmatically, without clear and quantified analysis and justification that they are restorative of riparian resource conditions. This approach has been ruled illegal under the NWFP Record of Decision, but by adopting ARCS changes in forest plan revisions, the Forest Service would, forest by forest, administratively revoke and replace current core NWFP conservation rules and alter these legal criteria. Because this would be a major departure from the NWFS ACS, it would almost certainly trigger reinitiated Endangered Species Act consultations with the US Fish and Wildlife Service and National Marine Fisheries Service (NOAA Fisheries) for numerous listed fish, wildlife and plant species on all projects, plans, and policies that guide logging actions by the Forest Service.

What is the intent of proposed changes in the NWFP ACS?

Narrowing the existing ACS Riparian Reserve widths and other changes proposed in the BLM WOPR and other recent legislative and administrative efforts appear to be intended justify recent actions and proposed actions, as well as to further expand logging of timber from near-stream areas, by relaxing the need for environmental review and avoiding site-specific, project-by project public disclosure of the potential consequences of riparian logging. Because of good growing conditions that commonly prevail in riparian forests and related factors, in many cases riparian trees are faster-growing, larger and more valuable as saw logs than trees in adjacent upland forests. Therefore, logging trees from near-stream areas can make some timber sales, or portions of sales, more financially profitable. There is a long history of recurring resource damage when the agencies, faced with vague standards, cut corners in the interest of meeting timber targets. The ACS was designed to head off this problem by adopting clear standards requiring that ecological objectives become the driving criteria within Riparian Reserves, with timber production a secondary by-product of necessary restoration actions. To further reinforce this change in priority, Riparian Reserves were removed from the land base used to estimate the projected possible timber sale volume for each management unit of the BLM and Forest Service.

In the past decade or so, both the Forest Service and BLM have relied on various premises in order to rationalize increased logging of trees from inside riparian forest areas. Under current management, between 15 and 20 percent of the timber volume offered by BLM in recent years was slated to be cut from inside Riparian Reserves (on those districts where reporting allowed the number to be estimated, namely Salem District; and Roseburg District. The Eugene District of BLM reported that from 2008 through 2010, more than half of all acres in its extensive commercial thinning program was carried out in Riparian Reserves.

The NWFP removed Riparian Reserves from the timber base upon which it made calculations to project "Probable Timber Sale Quantity," commonly interpreted today by political interests as a timber "target," because this was in keeping with plan's requirement that logging inside Riparian Reserves be conducted only when it was incidental to and necessary for ecological restoration of riparian resources. Hence, to the extent reports are true when they claim that BLM and Forest Service units are "not selling enough timber" to satisfy expectations created by the Northwest Forest Plan, it appears that timber production from upland forests in the "Matrix" land allocation (dedicated to a combination of commercial forest production and ecological objectives) is the source of shortfall. (Some of this shortfall relates to the difficulty the agencies have had in justifying clearcut logging of late successional forests within the matrix land base.) Most important for purposes of this paper, it suggests that the agencies have to a surprisingly large degree compensated by systematically accelerating thinning and salvage logging inside Riparian Reserves to help their attempts to meet perceived "targets."

Reeves et al. (2013) claim, without attribution, that the Riparian Reserve allocations made in the original Northwest Forest Plan Record of Decision (ROD) were expected to be narrowed over time. Other FEMAT participants disagree that there was a scientists' consensus on this matter. Though these buffers were termed "interim" designations pending Watershed Analysis, there was no explicit presumption that Watershed Analysis would either increase or decrease the net area allocated to, or the median width of, Riparian Reserves. It is illuminating that in the final ROD default Riparian Reserve areas were widened for headwater streams in response to lingering concerns about adequate protection for wildlife habitat and water quality. Moreover, expert science panel ratings for viability of fish species across the main alternatives developed for the NWFP reflect substantially increased probability of persistence with the increased protection for headwater streams across plan alternatives. Obviously, FEMAT panel scientists determined that wider Riparian Reserves conveyed real accumulative conservation benefit compared to alternatives relying on narrower riparian buffers. Since FEMAT, several other scientific assessments have concluded that larger zones of riparian and adjacent slope protection than those provided in the NWFP are necessary for headwater streams.

While the limited and qualified opportunity for some logging was allowed inside Riparian Reserves under the Northwest Forest Plan, it is highly questionable whether either the current levels of commercial logging occurring in Riparian Reserves, or the expanded incidence of logging anticipated in agency and congressional proposals to change the Northwest Forest Plan requirements for BLM O&C and Coos Wagon Road lands, were anticipated by scientists and the courts that evaluated the biological and environmental outcomes of the Northwest Forest Plan. Later in this report some of the potential environmental consequences of logging within Riparian Reserves will be discussed—many or most of which have for the greater part not been addressed, or have been addressed with outdated and insufficient analysis, in environmental review of these projects.

What kinds of specific changes in aquatic and riparian habitat protection are called for in the current proposals?

Reeves et al. Riparian Reserve "Variable Buffer Approach"

Reeves et al. (2013) described a "variable buffer approach" for systematically narrowing Riparian Reserves on streams passing through Matrix lands (a large proportion of the stream network, which is dominated by its arterial system of headwater streams too steep or variable in flow to support fish) in western Oregon BLM lands. The approach is based on GIS analysis using a nested set of Digital Elevation Models as "screens," coupled with a priori classification criteria for assigning each stream segment 1) potential "importance" for fish production, 2) risk of impact from debris flows or certain other slope erosion sources, 3) a topographic orientation and shade model that predicts risk of summer stream warming from forest cover removal (the analysis lacks any information on groundwater, a well-known determinant of actual stream temperature and sensitivity to thermal change). Summing these three factors, the procedure appears to classify all streams simply into three categories: 1) "high-priority fishbearing" streams, which would receive fill-NWFP buffer protection (two tree heights, or ca. 340 feet Riparian Reserves), 2) "low-priority fishbearing streams," that would receive an "inner buffer" of 100 feet, and 3) "low-priority nonfishbearing streams," that would receive a 50-foot "inner buffer." Outside of these "inner buffer" distances, extensive logging would be allowed (under Franklin and Johnson's [2013] so-called "ecological forestry" guidelines, which includes clear-cut treatments, see DellaSala et al. [in press]), and all areas outside the "inner buffers" would be added to the timber base to increase the areal basis for the calculation of potential commercial timber production.

Hence in sum, under the Reeves et al. (2013) alternative, the actual area devoted to ecological protection and restoration of streams and riparian systems would be reduced by half to two-thirds along a large proportion of the stream network. As a result, between 18 to 23 percent of NWFP Riparian Reserve area would be carved off and reallocated to Matrix for commercial logging purposes. Most of this acreage reallocation would come from greatly narrowed buffers along those fish-bearing streams deemed by the procedure to be of "lesser importance," (although the biological features that verify and quantify their "lesser importance" category are not clearly specified). That is, based on the example basins modeling in the report, Reeves et al. (2013) estimate that somewhere around 7 and 9 percent of the federal land area that now falls within Riparian Reserves, hence is now dedicated to protection and restoration of complex natural forest, would be reallocated to timber production as its management priority. Reeves et al. (2013) do not address the impact of logging roads and many other environmental factors that their alternatives to the NWFP ACS would directly or indirectly affect.

Although actual gains to timber production from the changes proposed by Reeves et al. (2013) are uncertain, they may be much lower than the land area involved. In recent years, the BLM has routinely applied extensive, high-volume-removal thinning prescriptions within Riparian Reserves outside of the nearest 50 feet to stream channel edges. Hence, while the transfer of acres to "Matrix" may inflate the apparent productive potential of the timber base for planning purposes, it will likely elevate actual timber yield by a much lower proportion (if at all). Concerns about current BLM and Forest Service logging practices within Riparian Reserves are reflected in the sections below.

DeFazio-Schrader-Walden Forest Legislation

A recent legislative proposal by Representatives DeFazio (D-Oregon), Schrader (D-Oregon), and Walden (R-Oregon), included in a federal forests bill (the so-called Restoring Healthy Forests for Healthy Communities Act, H.R. 1526) passed out of the U.S. House Natural Resources Committee on 1 July 1013, would effectively privatize and allocate to industrial forest management approximately 1.5 million acres of O&C federal lands in a timber trust. These lands would then be managed exclusively to maximize timber revenues for the 18 counties that include O&C lands. Northwest Forest Plan protections would be suspended from this large area. Dramatically weaker Oregon Forest Practices Rules for private industrial forest lands would apply there. This would result in much narrower streamside buffers with more extensive logging within them than present NWFP ACS requirements, including along fish-bearing streams. The difference would be akin to the more draconian alternatives that appeared in the BLM WOPR EIS—that is, protected areas along all streams would be diminished by half to two-thirds. Greatly increased logging would be allowed within the buffers, particularly on federal lands where presently more medium-and-larger-size trees exist near streams than on privately owned forest lands. The language also fails to identify for protection from logging the many thousands of acres of potentially unstable lands and highly erodible soils where retaining natural forest is critical to both guard against accelerated sediment delivery to streams and protect natural sources of large wood for long-term habitat formation.

Forest Service Region 6 ARCS

The changes on the ground associated with the Forest Service ARCS remain unclear. The overall intended or expected effect of ARCS on the extent of logging within riparian areas has not been disclosed by the Forest Service. The ARCS by design clearly intends to rationalize routine and widespread commercial thinning program within Riparian Reserves, which the Forest Service has been implementing or trying to implement in recent years.

Have the potential effects and conservation effectiveness of proposed ACS changes, including those for default widths and management direction for Riparian Reserves, been scientifically evaluated?

Conservation organizations challenged the flawed and inadequate analysis of environmental effects in the BLM WOPR EIS in federal court. This challenge included the effects of proposed reductions in Riparian Reserve protections. The EIS was later withdrawn by the BLM because of this litigation and related concerns that rollbacks in stream protections, among other factors, would force NMFS to rule that stream protection rollbacks would jeopardize recovery of ESA-listed salmon in western Oregon.

Other than privately funded or unfunded review and public comment on the BLM WOPR EIS, and a limited formal peer review of some of the EIS content by individual federal scientists, there has been no comprehensive, regional scientific review of whether such efforts to increase logging in riparian areas by changing default reserve boundaries and relaxing the requirement to establish the ecological need for reserves are scientifically justified. Nor has there been any comprehensive independent analysis or peer review of their potential ecological impact. (The BLM's WOPR FEIS was criticized by independent scientists, government science reviewers, and other agencies as grossly inadequate in this regard.)

Of recent concern is the 2010 BLM and Forest Service's commission of an interagency "Science Review Team" (SRT) to investigate riparian reserve thinning under the NWFP and its implications and consequences for riparian and aquatic ecosystems, which had remained a highly controversial topic among the various federal agencies. In its final report (Spies et al. 2013), the SRT panel concluded that, among previously unreported adverse affects, thinning commonly leads to depletion of large wood in riparian areas and streams. This finding strongly indicates that the routine prescription of thinning for the outer areas of Riparian Reserves in BLM and Forest Service timber sales is inappropriate under the Northwest Forest Plan, is harmful to ecosystem and species recovery under many or most prevailing circumstances, and has been inaccurately described and disclosed in most NEPA analyses to date. BLM and the Forest Service have appeared to limit circulation of the report and to date have announced no policy changes pursuant to its content, although in summer if 2013 it became apparent the agencies were at last planning a series of internal meetings on the matter. This internal interagency review process to date unfortunately inspires little confidence US Forest Service and BLM are presently amenable to improving their decisions and policies for environmental protection in the face of new scientific information, if the changes are thought to result in reduced logging.

Key References

FEMAT (1993), Rhodes et al. (1994) Erman et al. (1996), Moyle et al. (1996), Olson et al. (2002), Reeves et al. (2006b), Olson et al. (2007), USDI-BLM (2007), Carroll et al. (2009), Franklin and Johnson (2012), Johnson and Franklin (2013), Bumm and Wigington (2013), Reeves et al. (2013), DellaSala, et al. (2013), DellaSala et al. (in press), Spies et al. (2013), Heiken (2013).

CONSEQUENCES FOR WATER TEMPERATURE PROTECTION

What factors determine the temperature of forest streams?

Stream temperature at headwaters sources is initially established by the ambient temperature of groundwater that feed source springs—generally a function of average annual temperature (hence also ground temperature) at a given latitude and elevation. As surface water flows downstream, exposure to climatic influences tends to warm streams above their ambient groundwater temperature in summer, or cool it in winter. Streamflow itself plays a role in determining the vulnerability of streams to climate influences; smaller and shallower flows are more vulnerable to warming in summer, for example, than larger and deeper flows.

Riparian vegetation is important in regulating stream temperature in numerous ways: 1) it shades soils and shallow groundwater before it is discharged to surface streams; 2) it shades the water surface from solar insolation, and reduces wind penetration and air mass mixing over the water surface, buffering microclimate and insulating the stream from summer daytime warming or winter night time cooling, and 3) it stabilizes streambanks and floodplain surfaces and provides a supply of downed wood that helps keep channels narrow and in, some cases, many-branched, and establishes internal hydrologic complexity—namely, vertical and lateral flow exchange between surface water and hyporheic (shallow subsurface waters) that buffers streams against the effect of solar insolation and airmass mixing. Hence, stream temperature can be changed by either altering riparian vegetation and other features that externally buffer streams from climatic temperature stress, or by altering the internal features, such as channel complexity and subsurface flow exchange which moderate the potential influence of climatic stress.

Because of extensive spring flows and shallow subsurface, or hyporheic, flow exchange, some natural streams and some larger rivers are substantially colder than could be predicted based strictly on climate drivers. Further, extensive late successional forest cover within Riparian Reserves typically creates an extensive area of highly buffered microclimate that keeps surface waters comparatively cool in summer and warmer in winter, as well as stabilizing streamflow, in the face of macrocli-

Stream temperature is influenced by the shade provided by multiple layers forest trees and shrubs both near and farther away from the stream, coupled with complex factors like groundwater temperature of springs, and the flux of water between surface streams and the shallow alluvial aquifers of mountain valleys. All of these factors are strongly influenced by how we manage riparian ecosystems. Author photo.

mate and weather variability. Projected future climate change renders hydrologic and thermal buffering from both hyporheic sources and late-successional forests even more critical in the future than they are today.

Extensive riparian shade is a particularly strong influence on stream warming in summer. Over time many streams and rivers have lost a large portion of their natural riparian forest cover as a result of various human actions, including logging, grazing, mining, roads, cropland agriculture, stream diversions, and urbanization. In part because logging of riparian and near-stream trees can be commercially lucrative, forest practices often focus on the question of whether trees in riparian forests should be cut as the primary determinant of water temperature impact in forested areas. In the extensive areas of checkerboard pattern of private and public ownership of forest lands, riparian zones on the privately timberland sections are well-recognized to be extensively depleted and highly ecological impacted by intensive forest management conducted under prevailing Oregon state forest practices. In these checkerboard areas, where better riparian conditions occur on the federal land blocks they can be critical in sustaining better water quality and habitat conditions that support local populations of salmon, trout, amphibians, and other riparian-dependent species.

What is the biological importance of conserving or restoring natural temperature regimes in streams and rivers?

In Oregon, many streams approach or exceed thermal tolerances of native fishes and some amphibians when they reach their thermal maximum in mid to late summer. This is because Oregon and other western USA states have inherited coldwater stream species, like salmon and trout, that dispersed widely during cooler conditions of the Pleistocene era, but are faced with increasing and widespread warming and drying of their habitat in modern times. The vast majority of streams, rivers, and lakes in western Oregon exceed the thermal biological optima of salmon and trout in mid-summer; therefore any additional thermal stress and warming is generally biologically harmful and undesirable. For this reason water quality standards generally call for human activities to maintain, or not deter natural improvement, of stream temperatures.

Many streams in western Oregon show a net passive cooling trend in recent years owing to recovery of riparian vegetation and channel complexity, that were impacted in the previous century of land and water development. In other words, protective forest practices under the Northwest Forest Plan, as well as economic and social changes, have resulted in a trend of many streams improving naturally over time. Yet they remain warmer than their biologically optimal or historical condition, therefore continued recovery through cooling is ideal or, indeed, necessary for the health of some species.

Besides warming of summer maximum temperatures, more subtle alteration of daily and seasonal thermal regimes also results from changes in riparian vegetation or surface-subsurface flow exchange. Cumulative warming during late winter and spring are particularly widespread in the face of human disturbance in forested catchments. These changes, often of magnitude less than a degree F, can nevertheless cause subtle but cumulative effects on behavior, physiological development, and life history of fishes and other stream-dwelling organisms. They also disrupt the carefully timed life histories of locally adapted, native fish populations, and may render them vulnerable to higher mortality at later life stages, or during critical migratory phases.

Some natural events such as very large and intense forest fires and prolonged droughts caused similar disruptions in riparian ecosystems historically, but on a comparatively transient and less-frequent basis. Today human disturbance (by logging, mining, grazing, road constriction, and other uses) is far more frequent than natural fire and other disturbances. This results in more extensive, more extreme, and more sustained prevalence of such altered conditions across time and space that do not resemble natural or historical disturbance regimes.

What are the likely effects of climate change on future stream temperatures?

Climate change can force stream temperatures higher in summer through several mechanisms, including 1) reduced snow storage and earlier season of runoff, resulting in earlier and longer summer baseflow periods, 2) increased vegetation use of water by increased evapotranspiration demand; 3) direct increases in air temperature and wind speed near the water surface, 4) stressing and killing riparian forest trees and shrubs by climate stress, disease, and wildfire. On the other hand, climate warming can also have some offsetting effects, including increased cloud cover in coastal areas reducing solar insolation, and restoration of channel complexity and hyporheic flow exchange by pulsed wood debris recruitment after fire or windstorm events. Perhaps more importantly, climate change is expected to increase weather extremes, which is most likely to be expressed as increased frequency and severity of disturbance events in streams and riparian areas, including windstorms, fire, floods, debris flows, tree disease or pest outbreaks, and wildfire. Through many mechanisms, wider Riparian Reserves with more extensive late successional forest cover buffer streams against summer warming in the face of these anticipated climate trends and disturbance processes.

How does the width and downstream continuity of riparian forest buffer zones affect the temperature of surface waters?

Both wider forest buffers and forest patches that are continuously distributed (rather than patchily distributed) along the stream corridor and stream network are associated with cooler and mores stable summer stream temperatures. In other words, intermittently exposed reaches can result in net energy gain and warming that are not compensated even in shaded reaches downstream (while discontinuous buffers are somewhat better than none, ecologically speaking, they are not sufficient to prevent warming). The appearance of thermal "recovery" downstream may occur if additional cool groundwater sources intervene, but, nevertheless, unshaded reaches generally cause accrued warming that distorts the downstream temperature gradient to a warmer condition than it would have displayed under continuous forested cover.

For example, a study of forest buffer and stream conditions in forested areas of Georgia found that narrowing of forested buffer zones from 100 feet to 50 feet on each side of the stream is predicted to result in average warming of peak summer stream temperatures by about 2 degrees Celsius (3.6 degrees F). This substantially reduced the total estimated area of suitable habitat for native trout in Georgia. Such a magnitude of warming would likely have similar widespread adverse effects on habitat productivity of trout and salmon in Oregon, where many streams also exceed thermal limits for productive salmon and trout populations in summer. This research integrated all sources of stream warming associated with logging and other practices reducing riparian vegetation, hence it accounts for more factors than just canopy shade. Similar empirically-based thermal studies, which are critical for scaling resource impacts against incremental riparian logging actions, have not been done in the Pacific Northwest.

Other studies based on modeling rely on black-box assumptions about subsurface water and generally assume that logging will not impact groundwater temperature. As a result of local groundwater effects, studies validating these modeling efforts in the field frequently show a dramatic departure from model-predicted temperatures. Shade-based simulation models that lack groundwater variability can either over- or under-estimate field-observed maximum stream temperatures.

How does thinning or other logging within Riparian Reserves and riparian areas affect the temperature of surface waters?

Thinning farther than 50-100 feet from stream margins in many (but not all) locations has a measureable but usually small immediate effect on stream shade. However, logging within this area it can cause extensive summer stream warming in landscapes where logging by removing overstory shade from seasonal alluvial wetlands on valley bottoms and from areas of abundant near-surface groundwater on gentle, moderate or benched hillslopes. Warmed groundwater then seeps to adjacent streams, warming surface waters in turn. This is more prevalent in areas of moderate or gentle side slopes and variably porous soils. Groundwater moves more quickly on steeper slopes and through coarse-textured, highly porous soils, and is thus less vulnerable to warming in those locations. Thinning also, by design, reduces the abundance of larger and medium-sized trees. It directly reduces the natural processes of recruitment of dead and downed woody debris, which happens as those trees die and fall, hence limiting hydrologic complexity and thermal resilience of streams and rivers. While effects may vary with thinning prescription and the specific trees taken, any thinning within the nearest 100 feet to a stream can, in some instances, have measureable direct effect on shade reduction. Within 50 feet, it is very highly likely to cause direct measurable shade loss to surface waters.

Logging has continued within the Northwest Forest plan area, but pressure is growing to substantially increase timber harvest by reducing stream protections and other fundamental conservation measures in the Northwest Forest Plan. Author photo.

How does thinning interact with natural disturbance processes to affect stream temperature?

Vegetative shade that keeps streams cool is a "stacked" or redundant function—that is, while near-stream trees play the largest role in shading the water surface, streams in the riparian area outside of 50 feet from stream margins contribute overlapping shade to the stream. Thinning in this "outer zone" does pose a measurable increased risk of stream warming. Even taller vegetation on distant hillslopes can contribute some shade to streams. When near-stream trees are felled or killed by natural events like flood, debris flow, windthrow, disease, or wildfire, then the shade provided by "outer zone" trees becomes the only source of shade to that spot until near-stream trees regrow and gain sufficient height and canopy closure. When Reeves et al. (2013) and others argue that shade can be fully maintained by leaving forest vegetation within 50 feet of the stream channel, they are ignoring the fact that removing trees outside of 50 feet depletes these "stacked" shade functions, rendering streams far more vulnerable to warming whenever natural or human disturbances fell near-stream trees (which they frequently do, given the high incidence and diversity of natural disturbance processes in riparian forests).

It is important to note that thinning in the outer zone (beyond 50 feet) can open the canopy up to wind penetration and in this way can promote increased windfall of trees within the adjacent, narrow no-cut zones. Logging in the riparian area may also disperse tree diseases, such as Port-Orford-cedar root disease and other fungal diseases, which subsequently spread into inner no-cut zone. In these ways, thinning depletes shade redundancy while at the same time increasing riparian disturbance, thus magnifying the potential that outer-zone trees will be needed to provide "backup shade" to streams.

It is also important to recognize that natural events like floods, debris flows and landslides, fire and disease outbreaks are likely to increase, and may already be increasing, in the face of weather extremes associated with climate change. In some valley settings, events like large debris flows can cause stream channel shifts that push stream locations well outside the 50- or 100-foot zone, resulting in sudden new channel locations inside logged forest areas where shade has been dramatically reduced. This is one reason why the NWFP intended to protect the entire floodplain.

Climate change also affects environmental drivers, other than shade, that tend to favor stream warming (such as reduced and earlier season of runoff, reduced groundwater storage and stream base flows, and higher seasonal air temperatures). Human actions other than logging, such as upstream flow storage projects or diversions, can cause streambanks to lose stability, making streamside trees vulnerable to windfall or disease. So, in several ways, thinning restricted to the "outer" zone of Riparian Reserves does contribute materially to future stream warming. All of these sources of impact should be considered, addressed and mitigated if stream ecosystems, waters quality and fish and wildlife habitat are to be adequately protected. It is almost certainty that systematically reducing Riparian Reserve areas will have complex and interacting effects that inexorably move many or most streams toward warmer states during critical summer periods.

What riparian management practices are needed to minimize the adverse impacts of forestry on stream temperature?

Assuring stream temperature conservation and recovery to best feasible biological conditions should be viewed as a complex process that includes protecting and restoring hydrologic and structural complexity of streams and floodplains, as well as the density and continuity of shade and cover from riparian forests. Any practice, such as forest thinning or other logging practices, which disturb forests and reduce forest canopy or remove moderate to large-size trees can, directly or indirectly, adversely impact stream temperature. While in some cases and for the smallest streams, most of the immediate effect on stream shade may be expressed within the 50 feet strip of forest nearest to the stream, in the face of natural disturbances and climate warming, full protection of stream temperature will likely require protection of intact, uncut forest buffers and natural forest successional processes of 150 to 200 feet on either side of the surface waters, stream channels, and incorporating or buffering the possible channel migration zones in alluvial valleys and on alluvial fans. Within this protected Riparian Reserve area, post-fire logging, windthrow or disease and pest outbreaks should be prohibited. In situations where extensive tree plantations with young, very dense trees, exist within a Riparian Reserve area, if forest thinning occurs, it should be accomplished without ground-based machinery, and all stems and larger branches should be left on site. Recent science directly investigating riparian forest thinning effects in the Pacific Northwest (Pollock, et al. 2009, 2012, Pollock and Beechie 2012) finds that in the vast majority of stand conditions, natural forest succession processes will produce riparian forests and functions more closely (and more quickly) matching the patterns of natural forests without thinning than with thinning. In other words, by and large, thinning in Riparian Reserves is not ecologically restorative.

Key References

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CONSEQUENCES FOR EROSION, SEDIMENT DELIVERY, AND SUSPENDED SEDIMENT IN SURFACE WATERS

How does increased erosion caused by logging harm streams and other waters?

Management-caused erosion sources (caused by roads, vegetation removal, soil disturbance, and stream diversion) can trigger debris flows, can result in coarse sediment deposition and channel widening or aggradation, can increase fine sediment deposited on or trapped within gravel stream beds, and can increased suspended sediment and turbidity of waters. These are all variously harmful to reproduction, growth and survival of salmon, trout, and other species.

What is the role of Riparian Reserves in minimizing erosion from logging roads?

Riparian Reserves exert their biggest effects simply by providing an incentive or requirement for roads to be located at a fixed and large minimum distance from streams. Riparian zones are otherwise relatively ineffective at filtering channelized or concentrated sediment-rich flow generated by road surface runoff and road drainage structures. The dominant impact of existing roads in erosion and sedimentation must be addressed by remediation or removal of the roads themselves.

If wide enough, natural riparian forest vegetation and downed wood efficiently filter sediment from dispersed overland runoff before it reaches streams. Vegetation and wood are less effective at protecting streams from sediment in concentrated runoff originating from logging roads, so it is critical for roads to be located well away from Riparian Reserves whenever possible. Author photo.

What is the role of Riparian Reserves in minimizing erosion from landslides?

Primarily, Riparian Reserves drawn properly according to NWFP ACS criteria should incorporate all landslide-prone lands adjacent to streams within the Reserves. This helps protect those sites against the possibility of failure triggered by logging or road disturbance. Secondarily, wider Riparian Reserves can act as a partial buffer against delivery of sediment from adjacent landsides and other slope erosion sources. Larger trees, density of trees, and topography of the terrain, as well as the size and fluidity of the triggering landslide, all influence the effectiveness of Riparian Reserves to mitigate harm and ensure ecological benefit from landslides. Finally, when natural landslides do occur within Riparian Reserves, or landslides from upslope-sources pass through them, a wider natural forest buffer creates the conditions necessary for the natural episodic delivery of large wood to streams that helps shape and restore their long-term hydroecological functions and habitat structure.

What is the role of Riparian Reserves in minimizing ground disturbance from logging?

If logging and other mechanized forms of active management are excluded, Riparian Reserves directly protect land within them from ground disturbance, overland flow, and further erosion and sediment delivery. Each of these sources of impact is more likely to harm aquatic resources if implemented nearer streams than farther away from them.

What is the role of Riparian Reserves in minimizing gullying and channel expansion as a result of logging?

Even when buffer strips are left, logging of upland portions of catchments, creating skid trails, temporary roadways, and felling and yarding scars, typically results in increased runoff, which in turn can cause expansive channel and gully erosion and persistently elevated sedimentation. Expanded channel systems both generate new sediment, and access extant sediment sources that were previously unconnected to surface waters. Sustained elevated turbidity is a primary effect of these changes, and it extends to downstream waters. This impact can be partially but not fully mitigated by riparian buffers. It could potentially by mitigated only by regulating the logging rates and practices within small catchments to minimize the hydrologic effects of logging on soils and stream channels. It is crucial to recognize that natural vegetation disturbance processes like windthrow, fire, disease and major storms will have additional effects on slope and channel erosion regardless of logging impact, but logging creates additional impact and in some cases aggravates or multiplies natural impacts and stresses.

Continuous riparian reserve buffers, particularly in areas of high headwater stream density, can reduce channel expansion and fluvial erosion primarily by limiting the total area available to logging across watersheds. This constraint on landscape-wide logging rates was among the explicit purposes for the establishment of Riparian Reserves in the Northwest Forest Plan. Narrower buffers, particularly along headwater stream channels, place less constraint on the area and rate of logging.

Experimental watershed studies in Oregon, and northern California have demonstrated increases in the duration and overall discharge of suspended sediment load, or turbidity in small streams after logging. In other words, logging causes increased sediment yield and most importantly, a prolonged period of sediment transport and muddy water during the runoff season. Sediment may arise from many sources, but even with riparian zone protection, channel erosion and sediment mobilization are observed as a function of peak flow increases. Once it enters headwater streams, some suspended sediment may be trapped in floodplains and stream bed gravels, but much is exported rapidly downstream where it contributes to increased turbidity of larger streams, rivers, lakes, and coastal waters.

What are the consequences for erosion and sediment delivery of Riparian Reserve widths on headwater streams?

Cutting Riparian Reserve widths would reduce the effectiveness of streamside forests in filtering sediment from up-slope sediment sources and trapping and stabilizing it before it reaches streams. Reduced Riparian Reserve widths also directly increase logging and ground disturbance near to stream channels and other areas of saturated overland flow during wet season conditions. Narrowing riparian buffers or shortening them in headwater areas can increase the frequency with which headwater channels migrate or expand headward to create new channels outside of riparian forest leave areas.

While empirical assessments of the magnitude of these effects are rare in the Pacific Northwest, they have been done elsewhere For example, in a Georgia study, fine sediment accumulation in riffles from a variety of sources increased by an estimated average of about 25 percent when effective riparian forest buffer widths were reduced from 100 ft to 50 ft.

What are the consequences for erosion and sediment delivery of thinning or other logging within Riparian Reserves?

Logging within Riparian Reserves (or with the areas excluded from default Riparian Reserve because of reduced stream buffer widths) can contribute to gully erosion and erosion from channel expansion, and stream sedimentation and turbidity by increasing the total catchment area logged, hence increasing peak flows and channel initiation flows. Morever, commercial removal of larger trees via thinning will deplete the supply of dead and downed wood that helps mitigate against soil and channel erosion and helps retain sediment and nutrients so they do not enter surface waters. Logging within Riparian Reserves is by definition in close proximity to streams, so ground disturbance and other impacts are more likely to result in sediment delivery that harms water quality and habitat conditions in streams.

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CONSEQUENCES FOR NUTRIENT DELIVERY AND EUTROPHICATION

Where do nutrients originate on managed forest landscapes?

Two nutrients are of principle concern in terms of forest management, although they occur in variant forms that can affect or reflect their fate and effects in soil and water: Phosphorus (P) is generally associated with soil disturbance and erosion from forest management activities, including roads, which are a chronic source of erosion and sediment delivery to waters. Nitrogen (N) is broadly generated and freed into soil water, groundwater, and thus into surface water as an inevitable consequence of any kind of vegetation disturbance. Logging of large trees and fire are associated with particularly elevated mobilization of N into runoff. One ACS Riparian Management Objective identifies control of nutrients as one of the functional attributes that need to be sustained or restored in Riparian Reserves.

It is commonly stated, and correct, that on a per-acre basis, forest management mobilizes less N and P than most other land uses. However in western Oregon, because forestry disturbs many more acres of land in a given period of years than other land uses that occur in limited, often low-lying areas, forestry is almost everywhere by far the largest overall source of nutrient runoff from a whole-watershed perspective. Forestry in combination with natural forest vegetation disturbances like wildfire, windstorms, and disease or pest outbreaks in a watershed have cumulative effects on nutrient loading to streams, rivers and lakes.

Proportional losses of nutrients into waters are dramatically higher with the initial disturbance of intact natural vegetation—as occurs with logging of even small areas of forest—than when vegetation is further altered in extensively-disturbed ecosystems such as croplands or urbanizing areas. This is because undisturbed natural forest vegetation has exceedingly small baseline nutrient losses (i.e., undisturbed natural forest cover, with its dense and highly biologically integrated subsurface root and microbial systems, is highly retentive of nutrients). As a result, increased area of logging, or other forest disturbance in a watershed, can dramatically increase nutrient loading to downstream waters compared to similar changes of disturbance on other land use types, where background losses area already quite high. For example, clearcut logging increase N loading to an adjacent stream by about 7-fold in one Idaho study, while partial

Small springs and streams reveal the effects of the large flush of nutrients released from soils that always follows vegetation and soil disturbance by logging, here evident as a massive algae bloom in a small stream near a pile of logging slash. Author photo.

cutting caused a more than 5-fold increase. Downstream of the cutting units, cumulative N concentrations increased from pre-logging background levels by about 450-500 percent.

Chronic leaching of N into streams is also observed after fertilization of forestry plantations. Plantations leach supplemental N to streams particularly during winter when plant uptake of nutrients is slow.

What is the consequence of increased nutrient delivery to streams, wetlands, rivers and lakes from forestry operations?

Although it has been relatively little studied in the Pacific Northwest compared to other parts of the world, much is known about the phenomena of eutrophication, which is the ultimate result of increased nutrient delivery to fresh and marine waters. Increased nutrients, particularly when N and P are combined, can cause a host of undesirable effects where they accumulate in downstream waters.

When delivered to steep headwater streams, nutrients commonly move swiftly through them. While traveling downstream, some portion of nutrients leach from stream waters into riparian aquifers where they may be taken up by the roots of riparian plants. Some portion is taken up by in-stream algae and other aquatic plants, cycling the aquatic food web. In anaerobic microhabitats, some nitrate-N may be taken up by denitrifying bacteria and reduced to elemental nitrogen, N_2, and is lost to the atmosphere. P is commonly attached to inorganic or organic particles and can be deposited in overbank areas and cycled back into terrestrial vegetation. But most of these riparian and in-stream cycles of uptake tend to keep much of the N and P in or within close proximity of the stream system. Nutrients uptaken in near-stream vegetation, unless they are consumed by animals and moved away from the stream, tend to return to the stream with leaf drop or litterfall. Nutrients cycled in aquatic plants and animals generally return to solution in the water when the organisms die. Hence the bulk of nutrients that enter headwater streams probably work their way to downstream receiving waters.

Increased algal growth in streams associated with nutrient inputs can result in increased oxygen consumption at night when the expanded plant community is respiring but not producing oxygen through photosynthesis.

Fish in rivers and lakes downstream, like these summer steelhead in Oregon's Umpqua basin, are affected by cumulative changes in water quality that can result from sustained increases of nutrients caused by logging and other watershed disturbances upstream. Author photo.

Large day-to-night swings in oxygen concentration and even pH can result, producing stressful conditions for fishes and other aquatic organisms. When these nutrients eventually work their way downstream to large pools, backwaters, wetlands, and coastal lakes, they can produce acute eutrophic effects. These effects include explosive growth of nuisance algae and aquatic macrophytes, oxygen depletion, high concentrations of plant-derived solutes in the water that result in acidic conditions, discoloration, and unpalatable odor and flavor in drinking water.

Filtration and chemical treatment of water from eutrophied lakes and rivers to make it suitable for municipal or domestic use can be very expensive and often only marginally effective. Increasingly chemically stressful conditions associated with eutrophication could be one reason why extensive areas of habitat in coastal rivers and lakes that appear otherwise suitable for salmon and trout—and were historically productive for those species-- appear to go largely unused by them today. (Some other fishes such as minnows and suckers, and invasive species like carp and smallmouth bass may be more tolerant and favored by eutrophic conditions). N loading can also cause eutrophication in estuaries, and nearshore and offshore marine habitats. More study of nutrient loading and impacts in Oregon waters is strongly needed.

The prospect of incipiently eutrophic conditions in mainstream rivers has been little investigated in western Oregon. However, most western Oregon lakes are listed today as water quality limited, primarily due to nutrient loading from catchment sources and resulting eutrophication and water quality impairment. Source studies for coastal lakes commonly identify forestry as the largest aggregate source of N and P. Coastal lakes are highly efficient nutrient traps and suffer acute symptoms of eutrophication that are impossible to ignore, whereas more chronic, seasonal, or intermittent eutrophication impacts in rivers and marine habitats may be more easily overlooked, if they are not the subject of specific, properly designed studies—and they have not been, for the most part. It should be further noted that increased water temperature exacerbates biological oxygen demand, intensifying the undesirable and ecologically harmful effects of nutrient loading and eutrophication.

Didn't salmon runs in the past contribute large amounts of nutrients to streams?

Historically when salmon died after spawning they contributed nitrogen, phosphorus, carbon, and other nutrients derived from their growth at sea to freshwater ecosystems. However, for several reasons these nutrients affected freshwater ecosystems much differently than does nutrient leaching from logged forests. First, salmon carcasses contributed nutrients at very specific, predictable times of year and locations, which allowed stream organisms to time their life cycles to efficiently capture and process much of their nutrient load. Second, most nutrients in salmon carcasses (and eggs) are bound in large solid form that makes them suitable for capture and transport by terrestrial and avian predators and scavengers, who moved many of the nutrients far upslope from streams and rivers, into terrestrial systems. Third, while some nutrients do leach and escape from carcasses in dissolved form, their predominantly solid form also makes carcasses and eggs easily captured and retained by passive physical processes in streams, where they are subsequently consumed by animals and plants locally. By contrast the dissolved form of nutrients that enter streams after logging through runoff and soil water discharging to streams, and are less easily retained and more rapidly exported downstream. Finally, the large acreages subject to logging in many watersheds, often at rotation intervals much shorter than natural forest disturbance and successional cycles, results in delivery to streams of much larger quantities of nutrients over much more extended time periods, compared to the discrete pulses historically delivered by salmon. In sum, the regime and the form of delivery makes the fate and effects of nutrients delivered by salmon carcasses and eggs potentially much different from those of nitrogen and phosphorus solutes delivered from logged lands.

How do riparian forests mediate nutrient delivery to surface waters?

Roots and rhizomes of forest vegetation can effectively uptake N from soil and groundwater, particularly in riparian areas where phreatic water is often nearer the surface and rooting zone that it sometimes is in upland areas. P, on the other hand, is typically occurs attached to particulate solids, and as a result it is physically entrained by vegetation and by surface roughness and ponding at the soil surface created by downed woody debris or rock fragments. Vegetation and debris is less effective at filtering overland flow as slope steepness increases, hence P delivery to streams is commonly higher with steeper side slopes both because soil disturbance and erosion rates are higher and surface retention of particles is reduced, so that more soil reaches streams. Steep side slopes render riparian forest less effective at N uptake because subsurface, N-laden water flows more quickly through soil pores to surface water channels. Deep surface flow that runs below the forest rooting zone can, such as along the zone of soil-bedrock contact, also reduces the efficiency of uptake of N by forest vegetation.

Of course, in watersheds of mixed ownership, logging activities on intervening private forest land generates increased nutrient loads, and riparian requirements on state lands likely result in exceedingly low retention capacity along most headwater streams on private and state land ownership. Athough in a mixed-ownership situation, it is highly likely that federal forest lands are contributing a much smaller share to total watershed nutrient loads than are other ownerships, as with sediment and temperature, nutrient loading is an additive phenomenon. If other sources are priming the system, it is even more important, not less, to minimize additional nutrient contributions from federal lands.

How do the width and downstream continuity of riparian forest buffer zones affect nutrient delivery to surface waters?

Experimental studies of nutrient uptake as water passes through forested buffer zones have established that wider buffers are needed where slopes are moderate or steep than when they are gentle and subsurface percolation is slow. Research in the Upper Midwest and other regions has established some general information on uptake rates relative to forest buffer widths that were not available 10 or 15 years ago. A recent meta-analysis of multiple field studies showed that, as a general rule, in terrain with gentle side slopes, a 100 foot forest buffer retains about 80% of the N and P passing through in surface and subsurface flow. That is, at 100 feet, about 20 percent of the N mobilized from upslope disturbance filters through and reaches the receiving water. A 50-foot buffer allows about 35% of mobilized N and P to pass through. Although few studies are available for wider buffers, by extrapolation it appears that forest buffers of between 150 and 250 feet width are likely necessary to ensure that *ca.* 90 to 95 percent of nutrient load is scrubbed from the water before it reaches the adjacent stream, wetland, or lake. The effective distances might in fact be be greater (i.e., retention efficiencies lower) for most federal forest lands because side slopes are generally higher and soil porosity is likely greater than those in most available field studies.

In other words, reducing riparian forest reserves from 150ft to 50 feet likely results in almost doubling the nutrient loading to streams resulting from upslope logging disturbance. Expanding Riparian Reserves to ca. 250 feet width from the edges of stream channels would likely be needed to attain nutrient retention efficiency above 90 percent.

Research also shows that continuous buffers are needed to effectively protect receiving waters from retained nutrients; once nutrients reach surface waters in segments by penetrating areas with narrow or no forest buffers, they generally remain in the aquatic system.

How does forest harvesting within riparian areas affect nutrient delivery to surface waters?

Thinning or other logging within the Riparian Reserve or buffer creates pockets of disturbance and sources of nutrients within the buffer. Because nutrients originating at these points can reach streams without passing through the full buffer width, their retention efficiency is greatly reduced. To put it more simply, logging within 150 of stream channels substantially increases the loading of nutrients to surface waters because it is simultaneously creates near-stream nutrient sources at the same time it "punches holes" in the riparian forest functional nutrient filter.

What configuration of riparian area management is needed to minimize delivery of nutrients from forest disturbances?

Taken together, the literature indicates that to effectively minimize nutrient loading to surface waters from up-slope logging would require continuous, not-cut Riparian Reserves of 150 to 250 widths on all streams. This includes headwater channels with intermittent, ephemeral, or seasonal flow, because nutrient releases during winter months are higher as a result of both reduced vegetative uptake from soil water and increased erosion and delivery of soils to streams.

What other practices can help reduce or minimize nutrient delivery associated with forest management?

Reducing the area of forest vegetation disturbed by logging and other activities catchment-wide can reduce the source of mobilized nutrients. Capping the total watershed area logged per decade would be one means of limiting nutrient loading. Riparian Reserves converge in high stream density areas, rendering many small slivers of ground between drainages in upland areas either inaccessible or financially inefficient for commercial logging. Hence wider stream buffers can have double effect on reducing nutrient loadings: they not only increase retention efficiency, they can reduce the source area for nutrient loading by limiting upslope logging.

References:

FEMAT (1993), Spence et al. (1996), Dagget et al. (1996), Wenger (1999), Gomi et al. (2002), Cloern (2003), Compton et al. (2003), Kubin (2006), Wickham et al. (2008), Gravelle et al. (2009), Neiber (2011)

CONSEQUENCES FOR LARGE WOODY DEBRIS

How is woody debris important to stream and other freshwater ecosystems?

Downed woody debris helps provide stable and complex habitat structure on riparian forest floors, streambanks, and in streams and wetlands. Dead and downed wood in riparian areas also serves as a substrate for biological activity and partitions habitat so that more fish & wildlife can co-exist in limited space. Woody debris can help retain moisture and provide microsites to support sensitive species and processes, such as nutrient cycling. Woody debris helps trap sediment and nutrients from overland flow and in-channel flow. It is vital for fluvial processes like stream diversion, and island formation that are critical for overall habitat diversity and biological diversity, including the development and retention of subsurface, or hyporheic, flow paths.

What is the role of riparian forests in determining the availability of wood to freshwater ecosystems?

Photosynthesis of trees grows large wood. Mortality of trees from all sources recruits wood to streams and adjacent riparian areas. The timing and character of wood input is determined by factors including: forest productivity, mortality processes, disturbance regime and episodic disturbance events (large fires, floods, or wind storms), and management interventions.

Federal lands are critical for maintaining and restoring woody debris to stream ecosystems throughout the Pacific Northwest, because as seen here, logging practices on private forests continue to allow the extensive depletion of trees from riparian forests.

Does size matter?

Larger, longer tree boles (commonly, greater than 20 inches diameter and a length that exceeds the active channel width of the stream) may be necessary as stable "key pieces" (or anchoring pieces) against which debris jams are formed in larger, wider streams; but in small and medium sized streams, these functions can be performed by small and intermediate-sized boles. Even in larger streams, smaller wood performs numerous physical and biological functions, such that management actions that trade off small wood recruitment for large wood recruitment can be self-cancelling in their restoration value. Numerous studies have demonstrated the present-day acute shortage of wood *across all size classes* in Pacific Northwest streams within areas affected by logging, roads, dams, and other human influences, relative to wood abundance and functions in natural systems.

What are the effects of narrowing Riparian Reserves on woody debris supply for streams?

Narrowing Riparian Reserve protection areas increases logging activity and substantially reduces long-term woody debris loadings because tree boles are harvested and removed from potential source areas. While most trees that reach streams when they fall originate within the nearest 50 or 100 feet of the stream channel (and most available studies only examined the immediate source of such dead wood pieces), up to a third of trees that fall within this inner zone in a northern California watershed were triggered by trees falling from farther away. Moreover, to maintain a nearly natural incidence of tree fall, one would have to extend one step further to "buffer the buffer." Therefore the sum result to fully protect woody debris source dynamics would be closer to three site potential tree heights, or 450 feet, not one tree height (150 feet) as commonly assumed.

A narrower forested Riparian Reserve would experience reduced treefall from such "domino windfall" sources, but in the short term this might be partly compensated by increased on-site blowdown from wind penetration into the narrow buffer. However, this accelerated windfall can create a near-term pulse of wood that comes at the expense of longer-term wood recruitment (because trees that fall now will not be able to fall again later, and will be replaced by younger and smaller trees less susceptible to windfall during subsequent decades).

How does "tree tipping" thinning affect the supply of woody debris in riparian areas and streams?

Reeves et al. (2013) and Spies et al. (2013) propose "tree tipping" as a means of increasing the efficiency of wood delivery to streams within riparian areas. They reason that if wood delivery to streams can be increased by directional felling of trees within the near-stream buffer zone, then there might be less need to protect the outer riparian area from logging and other disturbances. The primary downfall of "tipping" is the same problem that affects any scheme that trades off near term over long term conservation choices. Every tree that is "tipped" today is a tree that will not remain and get larger for you to tip tomorrow. In other words, wood loadings are increased in the near term, but at the expense of drawing down the pool of wood available for future recruitment. Moreover, not all downed wood "should" enter streams. Downed wood away from stream edges can be of critical importance for wildlife habitat, successful conifer recruitment and forest succession, and floodplain and sediment transport and storage processes.

In sum, tree-tipping is conceived solely as a means of mitigating the commercial extraction of timber from riparian areas for one category of its impact: that of depleting and in-stream downed wood. It only partially and temporarily accomplishes this mitigation objective, while shortchanging all other functions of values of large trees, such as their floodplain, slope stability, and terrestrial wildlife conservation and forest succession functions.

What riparian management practices are needed to minimize the adverse impacts of forestry on woody debris?

While in many cases most of the immediate effect on stream temperatures may be expressed within the 150 feet of forest nearest to the stream, full protection of woody debris recruitment in the face of natural disturbances and climate warming will likely require protection of intact, uncut forest buffers and natural forest successional processes of 250 to 350 feet on either side of the surface waters, stream channels, and the possible channel migration zones in alluvial valleys and on alluvial fans. Post-fire logging, windthrow, or disease and pest outbreaks should be prohibited within Riparian Reserves as it directly removes large wood that is crucial to maintenance and recovery of riparian zone functions and fish and wildlife habitat. In the case of thinning of extensive tree plantations with young, very dense trees, if thinning occurs at all, it should be accomplished without ground-based machinery, with all stems and larger branches left on site. Recent science looking directly at this question (Pollock et al. 2009, 2012; Pollock and Beechie (2012), Spies et al. (2013) concludes that in the vast majority of stand conditions, natural forest succession processes will produce functionally restored riparian forests without thinning, and that thinning of sufficient intensity to stimulate growth release of large leave trees can create forest structural conditions and successional trajectories that are uncommon in nature. In other words, thinning in Riparian Reserves is not ecologically restorative; among other effects, it depletes the supply of future wood faster than it can be replaced through tree regeneration.

Key References

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ABOUT THE COAST RANGE ASSOCIATION

The Oregon Coast Range is one of the great regions in the world. Its natural beauty and its bountiful resources are why we live here. They provide the pillars of the economy, the income brought by retirees, tourism, forestry and fishing. A great many artistic and creative people are attracted to our amazing region, particularly along the coast.

The Coast Range Association was formed in 1991. We work to defend the region's interests, protect its natural and cultural endowments and restore its rivers, wetlands and forests. As such, we are deeply committed to the stewardship of our natural resources.
A balanced concern for people and the land informs our mission: To build just and sustainable communities that provide for people and the natural world.

Coast Range Association (CRA)
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coastrange.org

Key milestones in the Coast Range Association History

1991 - Produced the *Coast Range Biodiversity Conservation Plan* developed by Dr. Reed Noss.

1990-1995 - Worked to secure protection for federal forests with an emphasis on the conservation of remaining native forest and protection for streams and watersheds. Since 1995 we have worked hard to defend and improve the Northwest Forest Plan and it's Aquatic Conservation Strategy.

1997 - Research and published *Coastal Salmon Recovery: An Assessment of Watershed Councils*. The CRA supported the establishment of the Oregon Plan and the development of many watershed councils in the Coast Range region.

1998 - Organized watershed advocates in Coast Range watershed councils and published *Strategically Approaching Salmon Protection in Coastal Watersheds: A Guidance Manual for Watershed Resident*.

2001 - Published *Salmon & Forestry: A Report on Oregons Coastal Watersheds and the Need for Forestry Reform*. This report day lighted hundreds of agency stream habitat surveys documenting deteriorated habitat conditions found in coastal streams. We demonstrated that the higher the percentage of the watershed managed by short rotation forest owners - the worse off were the stream habitat conditions.

2004 - Published *The Economics of Forestry* an article that explains the management drivers of large forestland owners. *The Economics of Forestry* completed a six year program of analysis exploring the difficulties inherent in Wall Street driven financial forestry.

2006 - The CRA became the first organization in the Northwest to use Google Earth to view Forest Service and BLM stand data using KML files. All remaining native forest on BLM lands is identified and viewable using Google Earth. A CRA website with all the KML files is available here: See http://coastrange.org/wordpress/

2006 to 2012 - The CRA embarks on a coastal program highlighting the land-sea connection. We worked to secure a network of marine reserves along Oregon's state owned coastal marine waters. In 2012, the state of Oregon establish a network of five nearshore marine reserves.