CONSERVATION OF AQUATIC AND FISHERY RESOURCES IN THE PACIFIC NORTHWEST:

Implications of New Science for the Aquatic Conservation Strategy of the Northwest Forest Plan

Thank You!

We thank the generous members and supporters of the Coast Range Association for making the science review panel and this report possible. We also thank Doug Bevington at Environment Now for a grant of $5,000 in support of the science review panel.

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Design and typesetting by
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THE CRA SPONSORED AQUATIC CONSERVATION STRATEGY SCIENCE REVIEW PROCESS

Background

For the past ten years a series of agency and political proposals have been offered to change federal forest management under the Northwest Forest Plan (the Plan or NFP). The goal of all proposals is to achieve a substantial increase in timber production. All proposals to date have sought to weaken elements of the Plan's conservation provisions including the Aquatic Conservation Strategy (ACS). While attempts to change the NFP have occurred since 1994, recent initiatives are often associated with a claim that new science warrants change to the Plan's standards and guidelines or the allocation of land base for conservation and restoration purposes (late-successional and riparian reserves).

A number of federal laws guide the NFP's implementation and administration. These laws require agencies to follow the **best available science** when proposing actions. The BLM's 2008 WOPR initiative substantially departed from the NFP. At the time, the agency made representations that new science warranted the departure. Yet upon taking office, the Obama administration withdrew the WOPR knowing that it would not hold up in federal court. Its weakness was the adequacy of its science representations as required under federal law.

Preparing for a science review panel

The Northwest Forest Plan is twenty years old and its effects clearly show on the landscape in fewer timber cuts, larger areas of intact forest, and cleaner water flowing in streams and rivers. Achieving intact, complex, older forest structure was a key goal of the Plan. The other major goal of the Plan is to conserve and restore watershed functions through an Aquatic Conservation Strategy. Over the course of the Plan's twenty year history many new studies and scientific findings were published having relevance to the core assumptions of the Plan– including the ACS.

No less than five large, front-line Oregon-based conservation organizations prioritize the protection of federal forests. These groups work closely with scientists and have staff experts able to assess complex forest issues. In the summer of 2012, we sensed an expertise gap in the ability of the conservation community to adequately address proposed changes to the ACS. That's when the Coast Range Association began to explore how science-based expertise could be brought to bear on assessing political and agency proposals and clarify what the new science actually warrants. In January of 2013 we contracted Dr. Chris Frissell to advise the CRA on federal land management issues related to the ACS. In April of 2013, Dr. Frissell proposed convening an independent science review panel to assess the ACS in light of new science.

In May, 2013 Dr. Frissell produced a paper to help frame questions that might be addressed by a science review panel. The paper, *Evaluating Proposed Reductions of Riparian Reserve Protection in the Northwest Forest Plan: Potential Consequences for Clean Water, Streams and Fish*, offered that new science indeed had much to say. What the new science pointed to was that the federal ACS should not be weakened. At the same time it was becoming increasingly clear that a thorough review of the literature and writing a rigorous statement of science findings would be a sizable task.

The Independent Science Review Panel

Over the summer and fall of 2013, Dr. Frissell and Mary Scurlock of M. Scurlock & Associates prepared for and recruited the science review panel. For our part, the Coast Range Association sought guidance on the new science and a report to help us and the public assess proposals by political leaders and agency managers. On December 2nd and 3rd, 2013 the independent science review panel met in Portland. The panel was made up of nine scientists with Mary Scurlock providing policy expertise.

At the start of the panel's deliberations senior BLM staff briefed the panel on the guiding framework of their current Western Oregon Plans Revision process. In addition, a branch chief at the National Marine Fisheries Service briefed the panel on endangered salmon consultations occurring under the Northwest Forest Plan and the Endangered Species Act. Lastly, senior staff from the Environmental Protection Agency-Region 10 briefed the panel on relevant water quality issues in the area of the Northwest Forest Plan.

The Coast Range Association's role in the panel process was to cover the costs which included travel, food, lodging and meeting room expenses. Panel members understood they were volunteering their time and under no obligation to reach any outcome.

The panel finished its science review discussion on December 3rd. Extensive notes were taken. The panel agreed that Chris would author an initial draft report capturing the panel's consensus views on the implications of new science for the ACS.

Of the ten panel members, several individuals had direct experience developing the original Northwest Forest Plan. All panel member's professional careers had spanned the twenty years of the NFP's existence. Panel members knew the goals of the ACS and how it applied to federal forests under the NFP. In addition, panel members were thoroughly aware of land management practices on adjoining non-federal lands.

Members of the Independent Science Review Panel

Rowan. J. Baker Independent environmental consultant (Formerly US Fish and Wildlife Service)

Kelly Burnett Research Fish Biologist (Emeritus) Pacific Northwest Research Station-Corvallis Forestry Sciences Lab

Robert Beschta Professor Emeritus at the College of Forestry, Oregon State University.

Dominick A. DellaSella President and Chief Scientist of the Geos Institute and President of the Society for Conservation Biology, North America Section.

Christopher A. Frissell Consulting Research Ecologist and Freshwater Conservation Biologist, and Affiliate Research Professor, Flathead Lake Biological Station, The University of Montana.

Robert M. Hughes Courtesy Associate Professor in the Department of Fisheries and Wildlife at Oregon State University. Senior Scientist at Amis Opes Institute, and 2013-2014 President of the American Fisheries Society.

Dale A. McCullough Senior Fisheries Scientist at the Columbia River Inter-Tribal Fish Commission.

Jon Rhodes Senior Conservation Hydrologist with Planeto Azul Hydrologic Consultants.

Mary Scurlock Principal Policy Analyst, M. Scurlock & Associates freshwater policy consultants.

Robert C. Wissmar Professor, Aquatic & Fishery Sciences at University of Washington

The Final Report

Following the panel's Portland meeting members forwarded to Dr. Frissell a large number of published studies relevant to the many topics discussed. Over the next three months Chris worked to produce a draft report. During this period, additional review and input was received from two scientists unable to attend the Portland meeting: aquatic scientist James Karr of the University of Washington and Rich Nawa staff ecologist at the non-governmental organization KS Wild.

On March 2nd a draft report was sent to panel members. The draft triggered a large number of revisions and the consideration of still more scientific studies. Between March 2nd and March 30th an initial report was prepared for the CRA. The CRA submitted this version of the report to the BLM as public comment on March 31st. However, work continued for four additional months resulting in hundreds of corrections, changes and the addition of new studies.

On July 30th the CRA received the final report. The report is titled–***Conservation of Aquatic and Fishery resources in the Pacific Northwest: Implications of New Science for the Aquatic Conservation Strategy of the Northwest Forest Plan***. The document is authored by nine scientists and policy expert Scurlock. Collectively, the report's authors and science panel members not only represent the best available science but had developed much of the relevant science over the course of their professional careers.

The final report is the best synthesis of aquatic science related to the NFP since the development of the Plan in 1993. Federal land management agencies and Oregon's political leaders now have a document that clarifies many aquatic issues heretofore unaddressed in policy discussions. We consider the report to be a major achievement by the scientists involved and a highly significant contribution to public understanding of a vital federal land management issue.

Collectively, the report's authors and science panel members not only represent the best available science but had developed much of the relevant science over the course of their professional careers. The final report is the best synthesis of aquatic science related to the NFP since the development of the Plan in 1993.

KEY FINDINGS

Management after Wildfire, Disease, and Other Disturbances

For maintenance of forest ecosystem integrity, *post-disturbance logging should be prohibited in Riparian Reserves, Key Watersheds, Late Successional Reserves, and other areas where conservation is a dominant emphasis. Post-disturbance actions should prioritize road decommissioning or systemic road drainage improvements, and suspension of livestock grazing to reduce harm under the increased hydrological stresses expected in post-fire forests and their aquatic and riparian habitats and biota.*

Forest Thinning Intended to Reduce Tree Density or Wildfire Fuels

Thinning and fuels reduction by means of mechanized equipment or for commercial log removal purposes should be generally prohibited in Riparian Reserves and Key Watersheds. Any thinning or fuels treatment that does occur as a restorative treatment in Riparian Reserves (e.g., to remove non-native tree species from a site) should retain all downed wood debris on the ground. Thinning projects that involve road and landing (including those deemed "temporary") construction and/or reconstruction of road segments that have undergone significant recovery through non-use should also be prohibited, due to their long term impacts on critical watershed elements and processes.

Road Networks and Their Management

The authors suggest six policy changes to achieve needed road reductions: 1) *Prohibit the construction of new permanent and "temporary" roads*, except in limited instances were construction of a short segment of new road is coupled with and necessary for the decommissioning of longer and more damaging segments of existing road. 2) *Allow no net increase in road density in any watershed*. 3) *Strengthen road density restrictions for Key Watersheds and establish unambiguous standards and metrics for net road density reduction, which include adequate accounting for landings and the impacts of so-called "temporary" and decommissioned roads and landings*. 4) *Improve the system of classification (e.g., road type, use) and inventory (e.g., whether a road is active or decommissioned), and mapping (i.e., update maps to reflect current conditions)* to ensure that agency bookkeeping corresponds with actual field conditions. 5) *Require each proposed forestry and other development project to meet a target of incremental reduction of the road system* in all watersheds affected by the project. 6) *roads for which there are not adequate funds for maintenance and upkeep should be decommissioned*.

Riparian Reserves for Protecting Stream Temperature

We find no sufficient scientific support for reducing current ACS Riparian Reserve default widths for any stream type. In many watersheds and stream segments, larger areas of forest protection are warranted to prevent warming of shallow groundwater, particularly given likely trends future climate change, and the expectation of increased influence of wildfire and other "unmanaged" forest disturbances (Westerling et al. 2006).

Riparian Reserves and Nutrient Retention

Although more research is needed in the Pacific Northwest on nutrient retention, current scientific knowledge is sufficient to justify three recommendations. 1) *Continuous, no-cut Riparian Reserves exceeding 50 m (160 feet)* *along all streams and wetlands are generally needed to mitigate the effects of up-slope logging on nutrient loading to both freshwater ecosystems and downstream marine environments.* 2) *Cessation of livestock grazing in Riparian Reserves, road network reduction, and reconfiguration of remaining roads to reduce their hydrologic connectivity to surface waters are needed to reduce downstream nutrient loading*. 3) *Analysis of the effects of management actions on nutrient loading to immediate downstream receiving waters, including lakes, wetlands, reservoirs, mainstream rivers, estuaries, and the nearshore marine, are needed in environmental assessments, environmental impact statements, watershed analyses, and ESA consultations for aquatic species*.

Livestock Grazing

We conclude that *livestock grazing should be excluded from Riparian Reserves, Key Watersheds, and other lands where conservation is the primary management objective*.

Chemical Use in Forests

While the science on toxic chemicals is certainly advancing, we have five interim recommendations based on existing knowledge: 1) *Minimize application of chemicals for forest management purposes in time and space;* for example, hand-application should be favored over aerial application when there is no feasible alternative to pesticide use. 2) *Weigh the full range of environmental trade-offs between the perceived benefits of chemical use and its possible harms in each case before a decision is made to use chemicals in forest management*. 3) *Implement wide, un-thinned forested buffers in Riparian Reserves to help reduce exposure of fish and aquatic life to toxic chemicals*. Thinned or narrow buffers can allow greatly increased aerosol penetration (chemical) from slopes to streams, and narrower buffers may also allow more transport of toxins in runoff. 4) *Reduce road density and the hydrologic connectivity of roads to surface waters to help control toxins* that originate from road use and maintenance, as well as those that are applied up-slope but find their way to streams via surface runoff. 5) *Analyze the possible effects of management actions in affecting the delivery of toxic chemicals to streams in every NEPA document and ESA consultation*.

Climate Change: Consequences and Adaptation

Our overall recommendation is that 1) *ACS protections for Riparian Reserves should be sustained and strengthened to better protect and restore natural ecosystem processes that confer resilience to climate change*, as detailed in our other recommendations. In addition, 2) *an interagency scientific conservation design effort is needed to expand and reconfigure some present Key Watersheds to ensure they better encompass specific areas that are likely to be topographic and hydrologic buffers to future climate change impacts.* Finally, we recommend that 3) *the direct and indirect effects of management actions on the integrity and capacity of stream and watershed ecosystems for resilience to climate change be analyzed in every environmental assessment, environmental impact statement, watershed analysis, and ESA consultation.*

Monitoring and Adaptive Management

We recommend three policy shifts in how monitoring is employed under the ACS. First, as a standard management practice, require *some form of effectiveness monitoring and expert review of stream and watershed responses for every forestry, range, mining, recreation development, or active management project*. Secondly, *agencies should review existing programs of comprehensive regional and watershed-scale effectiveness monitoring programs, and develop comprehensive monitoring strategies to optimize return on the capital investment in monitoring*. We call for an *interagency scientific* *panel to review the status and effectiveness of trend monitoring efforts, and identify data sets that could be useful in drawing inferences for improved monitoring programs*. Third, agency-driven improvements in monitoring programs should include *increased emphasis on tracking ecological conditions, including explicit biological condition measures, and the ability to establish with some certainty that trends in Key Watersheds result from specific management actions or choices (which may include deferral of active management)*.

Conclusion

We conclude that attempts to reduce protections to watershed, riparian, and freshwater ecosystems by weakening major components of the ACS and other related conservation elements of the Northwest Forest Plan are not justified by new and emerging science. Improved ecosystem protections–and better monitoring of outcomes–are warranted across all land ownerships, including federal forest lands, if freshwater ecosystems and their biota, including salmon and other sensitive species are to be effectively conserved in an era of increased ecological stress and changing climate.

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What follows on pages 10 through 45 is the final report as received by the Coast Range Association

CONSERVATION OF AQUATIC AND FISHERY RESOURCES IN THE PACIFIC NORTHWEST:

Implications of New Science for the Aquatic Conservation Strategy of the Northwest Forest Plan

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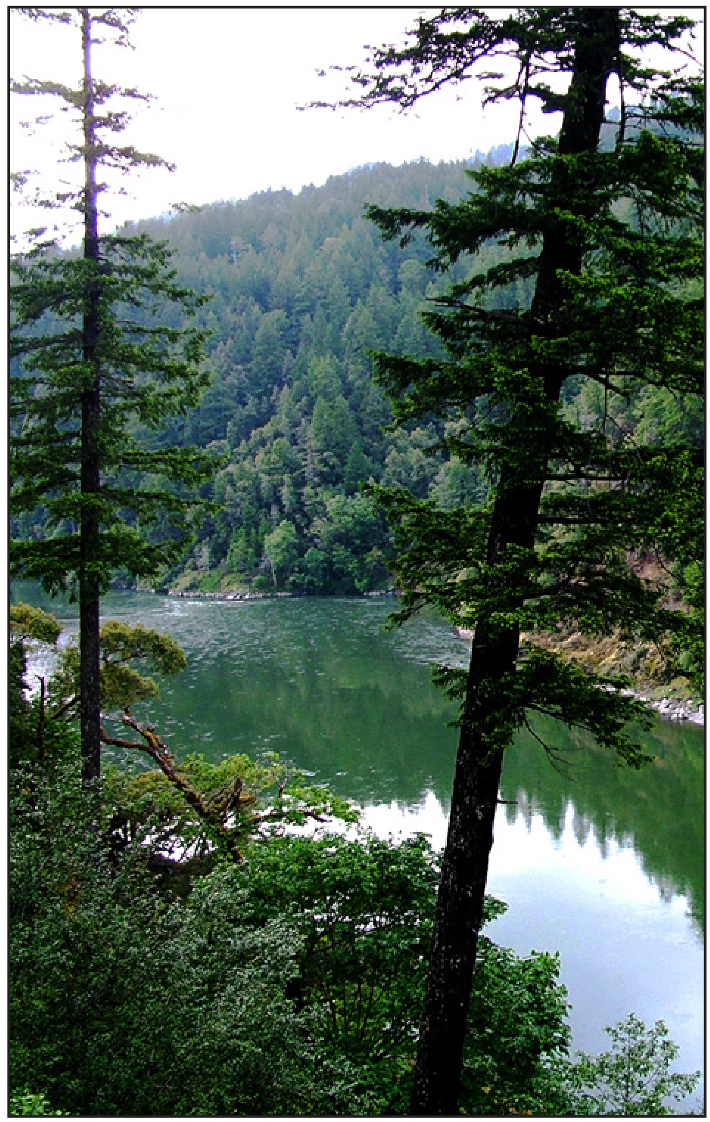

FINAL REPORT
July 30, 2014

CONSERVATION OF AQUATIC AND FISHERY RESOURCES IN THE PACIFIC NORTHWEST:

Implications of New Science for the Aquatic Conservation Strategy of the Northwest Forest Plan

ABSTRACT

Twenty years have elapsed since a major science synthesis and planning effort led to adoption of the Aquatic Conservation Strategy (ACS) of the Northwest Forest Plan (NFP) in 1994. Their purpose was to protect and restore riparian and aquatic ecosystems on Pacific Northwest federal forest lands and to ensure that forest management plans achieved legally required and socially desired multiple use objectives, including water quality, aquatic and wildlife resources. In this paper, we review relevant science emerging since 1993 to assess whether proposed changes to the ACS, including reduced riparian reserve protections and a substantially lowered burden of proof for watershed-disturbing activities, are scientifically justified. Observed and anticipated effects of climate change, and of cumulative anthropogenic stressors operating in the nonfederal lands surrounding NFP lands strongly indicate the need to strengthen, not weaken key ACS protections. Roads and ground disturbance associated with mechanical thinning and fuels reduction activities, especially within Riparian Reserves, cause adverse environmental impacts that generally offset or exceed presumed restorative benefits. Headwater streams warrant wider riparian forest buffers than current ACS provisions to ensure effective retention of sediment and nutrients derived from upslope logging, fire, and landslides. Widespread and sustained ecological harm caused by roads is now widely recognized, and ACS measures should be strengthened to more effectively arrest and reduce road impacts in all catchments. Grazing, mining, post-disturbance logging (e.g., fire salvage), water withdrawal, and aerial application of toxic chemicals can cause both acute and chronic harm to aquatic ecosystems. Existing ACS standards and guidelines would need to be strengthened to more effectively control these impacts. A more thorough and current scientific review and synthesis by federal agencies to inform a future ACS is long overdue. Unfortunately, no such review has occurred, while recent agency and legislative proposals would substantially reduce protective provisions of the ACS and NFP by increasing the extent of logging and other mechanized forest management, such as fuels treatments.

Introduction: Origins of the Aquatic Conservation Strategy

In 1994, region-wide social protest over logging old-growth forests, court injunctions on federal forest timber sales, and a rare presidential "roundtable" summit, led to sweeping changes the management of federal forest lands in the U.S. Pacific Northwest. The federal agencies with primary land management responsibilities, the U.S. Department of Agriculture's Forest Service (USFS) and U.S. Department of Interior's Bureau of Land Management (BLM), jointly adopted a new, regional conservation and management framework now known as the Northwest Forest Plan (hereinafter referred to as the NFP, or the "Plan"). The NFP was designed to meet President Clinton's call for an approach that would (1) satisfy federal courts and lift the injunctions, (2) protect the environment, and (3) help stabilize the regional economy (GAO 1999). The Plan's Record of Decision (USDA and USDI 1994) offered a "scientifically sound, ecologically credible, and legally responsible" long-term management strategy for federal lands within the range of the northern spotted owl (*Strix occidentalis cauria*). The NWP region encompasses over 99,000 square km (24.5 million acres) within the highly productive forest zones of western Washington and Oregon and northern California. In addition to spotted owls and other wildlife species dependent on late seral forests, these federal lands also harbor sensitive, declining, and federally listed salmon species (FEMAT 1993; USDA and USDI 1994). Declines in once-abundant salmon and other fish assemblages, amphibians and invertebrates (e.g., river mussels) indicate substantial and persistent loss of aquatic ecosystem integrity (Hughes et al. 2004; Kaufmann and Hughes 2006).

To ensure that the new plan had the sound scientific basis necessary to withstand legal scrutiny, the federal agencies convened an interagency and interdisciplinary panel of scientists (Forest Ecosystem Management Assessment Team, FEMAT 1993) to develop the rationale and options for conservation provisions of the Plan. Recognizing that terrestrial and freshwater species fundamentally share the same landscape, FEMAT scientists developed a system of terrestrial reserves and conservation provisions and a separate but overlapping Aquatic Conservation Strategy ("ACS").

Since the NFP was adopted, social and political pressure have mounted to significantly recast or eliminate the Plan (e.g., Johnson and Franklin 2012), including key elements of its ACS. In late 2013, two bills were introduced in Congress (S.1784 and H.R.1526) that would substantially reshape management on approximately 8000 square km (roughly 2 million acres) managed by the BLM in western Oregon. Separately, the BLM has initiated an administrative planning process intended to result in a decision to replace the NFP policies. These efforts appear principally motivated by the goal of increasing commercial timber production (Blumm and Wigington 2013, DellaSala et al. 2014). Meanwhile, the Forest Service has adopted guidance that would permit substantial alteration of key elements of the ACS in future revisions of its National Forest Management Plans in the Pacific Northwest.

Both agency and congressional proponents of significant alterations of the NFP and its ACS have referred generally to "new science" as a basis for many proposed changes. However, we find that post-1993 scientific findings relevant to the ACS have not been synthesized and addressed in a systematic manner. In this paper we review the key ACS elements, briefly discuss several proposed modifications, and identify concerns about the likely consequences of proposed modifications. Finally we identify needed improvements in the protective measures in the ACS as indicated by new and emerging scientific knowledge, and suggest the form future revisions of ACS provisions might take if they are to be responsive and robust to recent scientific advances.

Core Design Elements of the Aquatic Conservation Strategy

FEMAT (1993) articulated the ACS with two spatial and two programmatic components for managing watersheds and riparian areas: (1) *Key Watersheds,* a land allocation comprising hydrologically discrete areas that putatively contain much of the remaining higher-quality aquatic habitat and offer the greatest potential protection for recovering at-risk fish species. These watersheds are priorities for active restoration, ARE subject to a “no net increase” mandate for road density and watershed analysis mandate for major land use activites.

TABLE 1.
The nine narrative ACS Objectives describing watershed functions and processes and which apply landscape-wide (USDA and USDI. 1994. Record of Decision, p.B-11).

Forest Service and BLM-administered lands within the range of the northern spotted owl will be managed to:

1. *Maintain and restore the distribution, diversity, and complexity of watershed and landscape-scale features to ensure protection of the aquatic systems to which species, populations and communities are uniquely adapted.*
2. *Maintain and restore spatial and temporal connectivity within and between watersheds. Lateral, longitudinal, and drainage network connections include floodplains, wetlands, upslope areas, headwater tributaries, and intact refugia. These network connections must provide chemically and physically unobstructed routes to areas critical for fulfilling life history requirements of aquatic and riparian-dependent species.*
3. *Maintain and restore the physical integrity of the aquatic system, including shorelines, banks, and bottom configurations.*
4. *Maintain and restore water quality necessary to support healthy riparian, aquatic, and wetland ecosystems. Water quality must remain within the range that maintains the biological, physical, and chemical integrity of the system and benefits survival, growth, reproduction, and migration of individuals composing aquatic and riparian communities.*
5. *Maintain and restore the sediment regime under which aquatic ecosystems evolved. Elements of the sediment regime include the timing, volume, rate, and character of sediment input, storage, and transport.*
6. *Maintain and restore in-stream flows sufficient to create and sustain riparian, aquatic, and wetland habitats and to retain patterns of sediment, nutrient, and wood routing. The timing, magnitude, duration, and spatial distribution of peak, high, and low flows must be protected.*
7. *Maintain and restore the timing, variability, and duration of floodplain inundation and water table elevation in meadows and wetlands.*
8. *Maintain and restore the species composition and structural diversity of plant communities in riparian areas and wetlands to provide adequate summer and winter thermal regulation, nutrient filtering, appropriate rates of surface erosion, bank erosion, and channel migration and to supply amounts and distributions of coarse woody debris sufficient to sustain physical complexity and stability.*
9. *Maintain and restore habitat to support well-distributed populations of native plant, invertebrate, and vertebrate riparian-dependent species.*

(2) Riparian Reserves, a land allocation of varying widths along streams and lakes where aquatic and riparian objectives receive primary emphasis and where management is constrained according to activity-specific standards and guidelines. (3) *Watershed Analysis* is an assessment procedure designed to recommend how to tailor management priorities and actions to the biophysical limitations and perceived restoration needs of individual watersheds. (4) *Watershed Restoration*, a long-term program of somewhat unspecified scope and content, but which may include such wide-ranging provisions as road decommissioning, instream habitat alterations, and other measures (ROD 1994).

Late Successional [forest] Reserves, Congressionally designated reserves, and administratively withdrawn areas are land allocations outside of the specific components of the ACS, but they provide additional protection for portions of watersheds, riparian and aquatic ecosystems, particularly in terms of how they regulate landscape-wide management disturbances. In turn, aspects of the ACS also help provide habitat and connectivity for terrestrial wildlife species (ROD 1994, p.7). Many birds, mammals, amphibians, and invertebrates benefit from roadless areas (Trombulak and Frissell 2000); require large trees or wood debris for nesting or other uses; or rely on riparian forests for refuge, foraging, or dispersal (Pollock and Beechie 2014).

Beyond land allocations, the ACS imposes constraints on habitat-degrading management activities in two other ways: 1) It provides binding *standards and guidelines* that explicitly constrain numerous potential management activities within riparian reserves and key watersheds. 2) It requires all management activities on surrounding federal forestlands to be consistent with maintaining and restoring watershed functions and processes that are described in nine narrative ACS objectives (Table 1). The activity-specific standards and guidelines were intended to "prohibit and regulate activities in Riparian Reserves that retard or prevent attainment of the [ACS] objectives" (USDA and USDI 1994). The precaution that management activities may not retard recovery is a potent requirement. In order to ensure an action does not retard or prevent attainment of recovery, managers must ascertain the net effects of any proposed action on natural recovery processes at site-specific areas and larger spatial scales. This requirement addresses the observation (FEMAT, 1993) that past ecological degradation caused by numerous incremental harms often is not recognized. Cumulative effects across the landscape commonly offset gains from those passive or active management measures claimed to benefit ecological conditions and aquatic resource values.

Although it is beyond the scope of this paper to enumerate the many activity-specific standards and guidelines that comprise the ACS, some specific examples will be discussed because they are conspicuously affected by new or emerging scientific knowledge. The nine over arching ACS objectives also have binding force and constitute forest-wide standards and guidelines themselves (ROD 1994). This approach was explicitly intended to constrain activities in geomorphically, hydrologically, and ecologically sensitive areas and to limit the cumulative impacts of activities throughout a watershed (FEMAT 1993, V-29). The identified goal was to maintain conditions within a broadly conceived "range of variability" across multiple spatial and temporal scales, by evaluating, avoiding, or reversing ecologically harmful management at watershed and site-specific scales. The science of ecological restoration broadly recognizes that avoidance of adverse impacts is far more effective than post-hoc remediation of impacts (Kauffman et al. 1997, Karr et al. 2004, Roni et al. 2008), and this principle is codified in the Plan's Standards and Guidelines for watershed restoration (guideline WR-3 clearly states: "*Do* *not use mitigation or planned restoration as a substitute for preventing habitat degradation.")* During the mid-1990s, some federal agencies argued that site-specific failure to meet ACS objectives was broadly acceptable if unacceptable outcomes were not expected to be observed at larger scales. However, courts have validated that the conservation burdens delineated in the ACS apply to both site- or project-specific as well as larger scales, such as a watershed, planning area, or national forest.[1] The guiding language in the nine narrative objectives directs managers to "maintain and restore" specifically identified ecological conditions and functions. Hence management activities that will affect aquatic ecosystems may be pursued only under a reasonable assurance that they are restorative or protective in nature. It is not sufficient that management activities produce acceptably small adverse impacts, or cause harms that might potentially be mitigated by other measures.

Courts have ruled that FEMAT (1994) embodies the best available scientific information pertaining to the impacts of forestry activities on salmon and their habitat in the Pacific Northwest federal forests and that the Plan adequately integrates FEMAT's scientific representations[2]. Several scientific reviews (e.g., Spence et al. 1996, DellaSala and Williams 2006, Reeves et al. 2006a, Everest and Reeves 2006) have broadly concluded that while a great deal of new information has been published, the fundamentals and rationale of FEMAT and the ACS remain consistent with available scientific information. However, no interagency scientific panel comparable to the scope of FEMAT has been reconvened to formally address the broad question of how new scientific information may affect the validity of the ACS and how that might in turn affect Endangered Species Act (ESA) consultations, Clean Water Act (CWA) compliance, or NEPA, NFMA, and other relevant project level planning processes.

Because the ACS is incorporated into agency land use management plans, it is directly enforceable by third parties pursuant to the over arching resource planning statutes of the USFS and BLM. While the majority of distribution of salmon species in the Pacific Northwest lies downstream of federal forest watersheds, the federal lands provide important high-quality refugia for many populations (Burnett et al. 2006), and federal forests confer regional hydrologic benefit to water quality and ecosystem integrity downstream. Implementation of the ACS on federal forests has become a foundational baseline component for attainment of salmonid recovery under the Endangered Species Act and of water quality standards under the Clean Water Act. For example, federal ESA salmon recovery plans in Oregon and California rely heavily on Plan implementation (e.g., NMFS 2007, pp. 402-403, NMFS 2012, pp. 3-48, 49). Furthermore, because of the extent to which ACS implementation is widely assumed to represent the federal contribution to aquatic ecosystem conservation, changes have regulatory implications for nonfederal lands. For example, the underlying analyses of Habitat Conservation Plans granted to nonfederal landowners in the Pacific Northwest under the ESA, with assurances extending 40-50 years, explicitly rest on full ACS implementation on surrounding federal lands. (See e.g. WA DNR 2005). Similar expectations

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1 See e.g. Pac. Fed'n of Fishermen's Ass'ns et. al. v. Nat'l Marine Fisheries Serv., 71 F. Supp. 2d 1063 (W.D. Wash. 1999) ("PCFFA II")(finding that the Plan requires a determination of consistency with the ACS objectives at the project scale); Pac. Fed'n of Fishermen's Ass'ns et. al. v. Nat'l Marine Fisheries Serv. 265 F.3d 1028 (9th Cir. 2001) ("PCFFA III") (finding NMFS' biological opinions on 23 timber sales affecting then-listed Umpqua cutthroat trout and Oregon Coast coho salmon failed to assess site-level impacts).

2 See e.g. Seattle Audubon Soc'y v. Lyons, 871 F. Supp 1291, 1303 (W.D. Wash. 1994), aff'd sub nom., Seattle Audubon Soc'y v. Moseley, 80 F.3d 1401 9th Cir. 1996) (finding adequate scientific support in the plan's decision record and "unprecedented thoroughness" of the agencies' effort to meet "the legal and scientific needs of forest management").

undergird the state of Oregon's restoration plan for salmon and water quality.[3] In basins where water quality standards are not being met, state and federal regulators routinely consider the ACS to be an adequate implementation plan for BLM and Forest Service managers. Substantive alteration and weakening of the ACS threatens to upset a complicated web of region-wide conservation planning that is explicitly and implicitly dependent on the future habitat quality and recovery rate that the ACS is designed to achieve.

3 http://www.oregon.gov/OPSW/archives/ocsri_mar1997/ocsri_mar1997ex.pdf (identifying NFP implementation as a critical element of Oregon's salmon recovery plan)

Changes to the ACS Proposed by Administrative and Legislative Efforts

ACS Riparian Reserves. Based on the nested set of ecological rationales considered in FEMAT (1993), the ACS specified a set of "default" widths of the Riparian Reserve land allocation to be a) at least two site-potential tree heights (*ca*. 100 m or 330ft) on either side of fish-bearing streams, and b) at least one tree height (*ca*. 50 m or 160 feet) on non-fish bearing streams. Within these reserves, the conservation of aquatic and riparian-dependent terrestrial resources receives primary emphasis. Beyond these default delineations, Riparian Reserves must be drawn to protect areas susceptible to channel erosion and mass wasting. The Riparian Reserve widths were based on ecosystem process considerations (FEMAT 1993, Olson et al. 2007) and broadly specified population viability and habitat considerations for seven groups of salmonids and many terrestrial and avian species. Various sources (e.g., Johnson et al. 2012) have estimated that based on the high stream densities prevailing over much of the region, roughly 40% of total acres within the Plan area are located within the "default" Riparian Reserve system. However, only about 11% of the Plan area lies in Riparian Reserves associated with those areas (often referred to as "Matrix lands") where commercial logging is expected to be concentrated, and where the Riparian Reserve allocation most directly restricts potential logging activity and other management-related disturbances. Very few of the many completed watershed analyses offered a scientific rationale for reducing default Riparian Reserve areas in any location; a larger number identified site-specific reasons to expand Riparian Reserves beyond the specified default widths (Pacific Rivers Council 2008).

<u>*Proposed Changes to the ACS and Riparian Reserves*</u>. The BLM's 2008 Western Oregon Plan Revisions (WOPR) proposed a new regime of management for the "Oregon and California (O&C) Lands, distributed widely across western Oregon (Blumm and Wigington 2013). The WOPR proposed greatly reducing default Riparian Reserve widths, primarily arguing that ACS default delineations include some upland or "non-riparian" vegetation and that summer stream shade and large wood recruitment to fish-bearing streams could be maintained with narrower reserve widths. Narrative objectives- and standards and guidelines were also reduced or eliminated, allowing commercial timber harvest in Riparian Reserves for pervasive "safety and operational" reasons. The analyses and rationale underlying the WOPR were withdrawn by BLM in 2009 in significant part because they were deemed unlikely to survive consultations with ESA enforcement agencies (the National Marine Fisheries Service and US Fish and Wildlife Service). In a recent regional planning document, BLM (2013) argued again that "Riparian Reserve boundaries extend out beyond the water influence zone and are wider than necessary for water quality protection" but provided few or no specific scientific citations to support these claims. BLM has provided little scientific rationale or empiri-

cal validation for their decision to selectively focus on hydrophilic vegetation, proximate stream shade, and large wood recruitment as the only ecological considerations dictating riparian reserve delineation—in contrast to the much more comprehensive set of biophysical functions considered in FEMAT and the NFP ACS. (Note, as detailed later in this text, we also disagree with BLM's specific simplifying assumptions about effect of Riparian Reserve width on maintenance of shade and wood recruitment, and further conclude that other functions, such as nutrient retention, implicate much wider and less-disturbed reserves.)

A similar extremely constricted perspective on riparian ecological functions appears to underlie two Congressional bills for BLM lands in western Oregon (the "O&C" Lands), one of which (H.R. 1526, http://defazio.house.gov/issues/bipartisan-oc-forests-plan) would reallocate some 675,000 ha (1,667,000 acres) to an "O&C Trust"," the primary purpose of which is timber management (Blumm and Wigington 2013). Areas equivalent to Riparian reserves in the Trust would be designated at about half the width of the current ACS default requirement for steams (with extremely limited buffers for springs, seeps, wetlands, and unstable landscapes). A U.S. Senate bill introduced in 2013 (S.1786) would allocate about 50% of O&C lands to so-called "forestry emphasis areas," cut default Riparian Reserve areas by half across all stream types, with further narrowing if watershed analysis deems them "not ecologically important." The bill would provide for potentially extensive commercial logging in the rubric of thinning riparian areas where stands are younger than 80 years of age; only stands older than 120 years would be protected from logging. These older stands remain in scattered small patches across O&C lands but are important ecologically given high levels of timber cutting on surrounding nonfederal lands (DellaSala et al. 2013). Environmental review at the project level would also be curtailed from current requirements, including but not limited to eliminating the requirement for project-level determinations of consistency with ACS objectives.

Meanwhile the USFS—which manages the majority of federal forestlands in the three state NWP area, has focused on incrementally replacing the ACS with new provisions in upcoming revisions of individual National Forest Plans. In 2008 the Forest Service adopted new regional planning guidance (USDA 2008) that generally mirrors the NFP default riparian area widths and key watersheds allocations, but altered the narrative ACS Objectives, Watershed Analysis, and other NFP direction for management within reserve areas. This guidance stakes a claim for expanded agency discretion to undertake a broader range of vegetation and ground-disturbing management activities within riparian reserves, including but not limited to thinning and other commercial logging and livestock grazing. The 2008 Forest Service regional guidance, if implemented in future revised Forest Plans, would allow actions that alter riparian reserve resources and goals, as long as managers can present a general argument that impacts would be offset by other, beneficial actions or naturally-occurring improvements dispersed or averaged across time or space. The apparent intent of these changes is to reduce the burden for analysis of environmental impacts associated with such projects, which would, for example, streamline approval of more aggressive implementation of mechanized and commercial thinning and other vegetation- and ground-disturbing actions within Riparian Reserves. We are concerned that the 2008 USFS planning guidance has not been subject to rigorous external or scientific review, and if implemented could have harmful consequences for riparian and aquatic resources that have not been adequately evaluated or disclosed.

Weakening of the Northwest Forest Plan ACS will impact numerous listed fish, wildlife and plant species by changing the range of acceptable on-the-ground outcomes from management actions. Across the Pacific Northwest, reduced protections for listed species and water quality via changes in the ACS would likely necessitate reconsideration of many existing agency programs and initiatives that have been premised on implementation of the 1994 ACS measures.

ACS Watershed Restoration. The ACS intended watershed restoration to be strategically identified and prioritized through *Watershed Analysis*, with particular emphasis on improving ecological conditions in *Key Watersheds*. Protection through passive restoration (Kauffman et al. 1997) of existing high-quality habitat is explicitly prioritized over active instream rehabilitation. To be effective, instream habitat-improvement projects rely on concurrent long-term riparian and catchment-scale protection and rehabilitation measures, and these must be programmatically tiered to management plans affecting each watershed. Hence site-specific active measure, such as instream habitat structures or riparian tree planting, should not be claimed to mitigate for ongoing or future harmful and degrading management actions (Frissell and Nawa 1992, Frissell and Bayles 1996, Roni et al. 2008).

Proposed Changes in Watershed Restoration Policy. In contrast, the current Senate Bill would simply allocate $1 million annually for instream wood placement and $5 million for road removal or "improvement" across the BLM's O&C land area, and apparently exclude such activities from environmental analysis under NEPA. In doing so this bill would decouple active restoration measures from land management decisions. The bill would also alter the programmatic approach to watershed restoration, as discussed in the next section.

Proposed changes to ACS Key Watershed allocations. The Senate and the House bills and the BLM (2013) call for revising Key Watershed allocations in place for the past 20 years under the NFP and ACS. Many current Key Watersheds would apparently be dropped from the allocation under the House bill, with the consequences for conservation planning and species at risk unevaluated; the Senate Bill calls for a revised watershed classification to accommodate new land allocations.

Certain revised Key Watershed delineations might in theory benefit particular populations of species such as ESA-listed coho salmon. However, the concept of prioritizing conservation efforts in Key Watersheds is undermined when watershed-scale priorities are upended and reshuffled on a time frame that is decades shorter than the amount of time expected for significant watershed restoration to occur. Effective watershed restoration requires a sustained commitment to aquatic resource protection and restoration, coupled with appropriately conditioned and scaled land management and effectiveness monitoring extending for decades to centuries (FEMAT 1993). Critical components of the ROD for the ACS include requirements for no road construction within inventoried roadless areas within Key Watersheds, and no net increase in road density within each Key Watershed. These protections for Key Watersheds would apparently be lost under the Congressional proposals, at least for those Key Watersheds that would be de-designated. Although the 2013 Senate bill would retain a process it refers to as "Watershed Analysis" its purpose appears to be inverted: it would not focus on watershed restoration, but on identifying ecological changes due to increase commercial logging over that which might occur under the default prescriptions specified in the bill.

CHANGES IN TERRESTRIAL LAND ALLOCATIONS ALSO AFFECT WATERSHED INTEGRITY

Land allocations within the NFP and other authorities, but outside of the ACS, including Late Successional Reserves, Wilderness, other congressionally designated or "administratively withdrawn" lands, and inventoried roadless areas, can confer additional protection to watersheds. These land allocations can prevent or retard road network expansion, and other disturbances, allowing natural ecosystem maintenance and natural recovery processes to proceed. They limit the spatial extent of disturbances across watershed and stream networks, and reduce the incidence or likelihood of adverse cumulative impacts. Many Key Watersheds are closely associated with such specially designated lands, though unfortunately few are largely or entirely nested such within such conservation delineations (Frissell and Bayles 1996). As a consequence, when new proposals strip away the protection conferred by Late Successional Reserves, roadless areas, or other administrative designations, watersheds are placed at greater risk of impact from forestry activities. Land disturbance from roads, logging, grazing, or other actions can undermine the benefits of restoration and land protection elsewhere in the same watershed (Espinosa et al. 1997), depending on the geography of the watershed in question. The trade-offs of cumulative risk and potential harm to watersheds and sensitive or listed aquatic species from changes in land allocation have not been rigorously assessed in the Congressional and administrative proposals. Such trade-offs amount to a wholesale re-casting of NFP land allocations for the region that includes and surrounds the O&C lands. Each of the 2013 Congressional bills proposes to substantially re-allocate protection of older forests, generally by focusing protection on older stands rather than the more expansive Late Successional Reserves of the present NFP. Moreover the Congressional bills make special provision for thinning under nearly all land allocations, with guidelines allowing for agency-determined findings of need and some minimal requirements for tree retention. Although the NFP did not prohibit thinning or salvage logging in these areas, the legislative bills favor more extensive and intense logging and increasing fragmentation by logging roads than have previously occurred in areas now classified as Late Successional Reserves.

NEW SCIENCE THAT INFORMS AQUATIC CONSERVATION STRATEGY AND PRACTICES

In the following section we discuss some relevant new science published since the convening of FEMAT (1993). We provide selected citations and briefly summarize our view of major implications for the purpose of developing and improving an effective aquatic conservation framework. While our interpretations and recommendations focus on the ACS, many of the citation sources and their implications are derived from studies of other regions and ecosystem types out of necessity because of limited research done in the Pacific Northwest. Just as in FEMAT (1993), relevant scientific information that is critical to define and frame topics of crucial conservation concern sometimes originates from other similar regions, and often spans a variety of disciplines.

In this paper we were not able to comprehensively address all areas of scientific advancement concerning forest management, water quality and aquatic conservation. Some topics await further elaboration. For example, we do not comprehensively discuss the literature on impacts of logging and roads on streamflow patterns (e.g., Moore and Wondzell 2005), and subsequent effects on stream geomorphology, habitat, and biota. However, we do consider known effects of forest management and climate change on streamflows as a contributing concern under several topic headings. Most importantly, we also do not assess new science pertinent to non-aquatic and amphibian wildlife species in this report. This important work remains to be done.

Management after Wildfire, Disease, and Other Disturbances. Salvage logging of dead or dying trees after fires, insect outbreaks, and other disturbances in Pacific Northwest forests continues to be undertaken in the region, and its effects are a recurring ecological concern (see review by Lindenmayer and Noss 2006). Soon after the NFP was adopted in 1994, the scientific community began to weigh in on the inadvisability of post-disturbance logging. Scientists have catalogued the critical importance of large standing live trees, snags, and downed wood from fallen trees in the post-disturbance recovery of natural forests, including stand successional pathways, watershed processes, and wildlife and fish habitat (e.g., Gresswell 1999, Minshall 2003). Numerous scientific syntheses provided precautionary advice against post-fire logging on a wide range of causal grounds (e.g., Beschta et al. 2004, Karr et al. 2004, Lindenmayer et al. 2004, Lindenmayer and Noss 2006, Donato et al. 2006, Noss et al. 2006). More recent work has identified the potential importance of pulses in trophic energy following high-severity wildfire (Malison and Baxter 2010) for persistence and recovery of aquatic and riparian species. This new information builds on a more longstanding recognition that wildfire, that among its many other effects, plays an important long-term role in the generation of complex wood debris structures in streams (Minshall 2003). Other reviews focused on plant and landscape ecology broadly call into question the effectiveness of salvage logging insect-infested trees to control insect outbreaks (e.g., Black et al. 2013, Six et al. 2014). Similar concerns about the consequences of salvage logging curtailing natural ecosystem recovery processes pertain to salvaging of stands affected by any natural mortality agent, such as windthrow or volcanism.

However, post-disturbance logging was not expressly ruled out in the NFP and ACS, and the political demand for salvage logging remains high, so large post-fire salvage logging projects have been pursued by the USFS and BLM in many areas, including on occasion within Key Watersheds, Riparian Reserves, Late Successional Forest Reserves, and designated critical habitat of listed species (see DellaSala et al. 2014). Scientific consensus on the inadvisability of post-disturbance logging largely emerged in the years just after FEMAT, hence the ACS should be strengthened to reflect such sources as the recommendations in Beschta et al. (2004), Karr et al. (2004), and Black et al. (2013).

We conclude that for maintenance of forest ecosystem integrity, *post-disturbance logging should be prohibited in Riparian Reserves, Key Watersheds, Late Successional Reserves, and other areas where conservation is a dominant emphasis. Post-disturbance actions should prioritize road decommissioning or systemic road drainage improvements, and suspension of livestock grazing to reduce harm under the increased hydrological stresses expected in post-fire forests and their aquatic and riparian habitats and biota.*

Forest Thinning Intended to Reduce Tree Density or Wildfire Fuels. Current ACS language allows the agencies to "apply silvicultural practices for Riparian Reserves to control stocking, reestablish and manage stands, and acquire desired vegetation characteristics needed to attain…objectives." The agencies carry a project-specific burden to establish the need for thinning and that outcomes are ecologically restorative. Recently the USFS and BLM have pressed to increase in the average size of thinning projects apparently to reduce the number and cost of site-specific environmental analyses by broadening their scope. Agency initiatives presume extensive use of mechanical harvesting methods in conjunction with commercial timber sales to thin trees in Riparian Reserves and other areas where conservation values are given highest priority. In wetter forest types, the primary claim that thinning is restorative rests on the assumption that the growth rate and vigor of those trees left alive after thinning will likely improve, thereby hastening the future development of larger-sized trees in the stand. In drier forests, the primary rationale is that thinning is needed to promote a generalized reduction in fuel loads, thereby presumably reducing the risk, or severity, or rate of spread, of wildfire and that thinning can increase fire resistance of selected individual trees.

Regardless of silvicultural intent, mechanized treatments in Riparian Reserves can disturb vegetation and soils in close proximity to surface waters, where the risk of sediment delivery and other impacts is demonstrably high (Rashin et al. 2006, Dwire et al. 2010). Logging activity that disturbs soils within riparian buffers can also reduce the buffer's effectiveness to retain sediment and nutrients delivered from upslope sources. Thinning or other disturbance of coniferous or deciduous trees and shrubs within riparian and wetland areas can cause decades of diminished summer low flows (after an initial few years during which low flows may increase), as a consequence of increased water demand by rapidly re-growing vegetation (Hicks et al. 1991, Moore and Wondzell 2005). In addition, thinning and yarding of logs from near-stream areas requires or encourages the construction of roads in close vicinity to streams, where the likelihood of sediment delivery and other impact from roads is increased (Luce et al. 2001). Bryce et al. (2010) found that for sediment-sensitive aquatic vertebrates and macroinvertebrates, minimum-effect levels for percentage fines were 5% and 3%, respectively, meaning that even small increases in fines can adversely affect salmonids and their prey.

Mechanized thinning and fuels operations usually require higher-density road access to be feasibly implemented. Mechanical treatments for fuels reduction are particularly problematic because recurring entries at roughly 10-year intervals are necessary to sustain the desired conditions (Martinson and Omi 2013); such a forest management regime strongly favors, if not requires, a permanent, high-density road network. Many thinning projects involve road and landing construction and reconstruction, as well as elevated haul and other use of existing roads, all of which significantly contribute to watershed and aquatic degradation. Even if constructed roads and landings are deemed "temporary," their consequent impacts to watersheds and water bodies are long lasting or permanent. The hydrological and ecological disruptions of road systems and their use (Jones et al. 2000, Trombulak and Frissell 2000, Gucinski et al. 2001, Black et al. 2013), exacerbated by other effects of vehicle traffic, will likely outweigh any presumed restorative benefit to streams and wetlands accruing from thinning and fuels reduction. In recent years, the prospect of future thinning or fuels reduction projects often has become the basis for the USFS or BLM to avoid or delay decommissioning environmentally harmful roads, even when fiscal resources were available for the work. Prescribed fire without extensive mechanical treatment is of much less concern, as it is more feasible to apply in sparsely-roaded wildlands, entails far less soil disturbance, and if conducted in proper times and places it can more adequately mimic the ecological effects of natural wildfire.

Substantial questions remain about the putative ecological benefits of thinning and fuels reduction. This is critical because agency proponents commonly argue that the desired ecological benefits outweigh the adverse environmental effects of logging and fuels treatments. Dispute among federal agencies about claimed ecological benefits of thinning in moister, Douglas-fir-dominated forest types (widespread in the Pacific Northwest) led to an interagency scientific review in 2012-2013 (Spies et al. 2013). That panel concluded that increased tree growth might be better obtained from thinning very young, high-density stands--which very seldom produces commercially saleable logs. They further concluded that thinning produces unusually low-stem-density forests and causes long–term depletion of snag and wood recruitment that is likely detrimental in most Riparian Reserves (Spies et al. 2013, and see Pollock et al. 2012, Pollock and Beechie 2013). Further depletion of wood recruitment in headwater streams can adversely affect the behavior of debris flows in Pacific Northwest watersheds in ways that further reduce residual wood debris and its important functions over extensive portions of streams and rivers (May and Gresswell 2002), where present-day wood abundance is decimated compared to historical conditions (Sedell et al. 1988, Pollock and Beechie 2014). Finally, recent reviews also raise compelling, unanswered questions about the effectiveness of thinning forests for attempted control of insect outbreaks (Black et al. 2013, Six et al. 2014).

The effect of thinning on fire behavior and effects within riparian areas has been little studied. For western North American forests in uplands the literature is replete with ambiguous and conflicting results regarding the effects of thinning and other mechanical fuels treatments on fire severity, rate of spread, and recurrence. Moreover, the probability of a fire burning through a treated stand within the limited time window of potential effectiveness of a fuels treatment has been shown to be very small (Lydersen et al. 2014, Rhodes and Baker 2008). Any presumed benefit is even less persistent in Riparian Reserve areas where woody vegetation regrows rapidly after treatment, and where in moister forest types fire tends to recur with lower frequency. Equally important, we question whether managers should be striving to reduce fire severity in riparian areas as a rule, considering that high-severity fire plays a natural and historical role in shaping riparian and stream ecosystems (Gresswell 1999, Minshall 2003, Benda et al. 2003, Malison and Baxter 2010). Other natural forest disturbances, including windthrow, insect outbreaks, and landslides on forested slopes, appear to play a similarly important role in generating pulses of wood debris recruitment to streams, establishing a long-lasting source of ecological and habitat complexity.

Considering the difficult-to-justify costs and recognized inherent risks of adverse impact associated with such operations in sensitive areas, balanced against the uncertainty in intended benefits, we conclude the following: *Thinning and fuels reduction by means of mechanized equipment or for commercial log removal purposes should be generally prohibited in Riparian Reserves and Key Watersheds. Any thinning or fuels treatment that does occur as a restorative treatment in Riparian Reserves (e.g., to remove non-native tree species from a site) should retain all downed wood debris on the ground. Thinning projects that involve road and landing (including those deemed "temporary") construction and/or reconstruction of road segments that have undergone significant recovery through non-use should also be prohibited, due to their long term impacts on critical watershed elements and processes.*

Road Networks and Their Management. Roads are ecologically problematic in any environment because they affect biota, water quality, and a suite of biophysical processes through many physical, chemical, and biological pathways (Trombulak and Frissell 2000, Jones et al. 2000, Al-Chokhachy et al. 2010).

The magnitude of existing road impacts on watersheds and streams in the Plan may equal or exceed the effect of all other activities combined. Firman et al. (2012) reported that density of spawning coho salmon across coastal Oregon streams was negatively associated with road density. Kaufmann and Hughes (2006) found that road density in Coast Range streams was associated negatively with 25-50% of the variability in condition of aquatic vertebrate assemblages. More recently, Meredith et al. (2014) showed that the abundance of habitat-forming wood in Columbia Basin streams declined with proximity to roads, and the effect was roughly the same magnitude as that of natural climate and vegetation differences or long-term livestock grazing.

Roads are necessary to support logging, mining, grazing, and motorized recreation, but the existing federal forest road system far outstrips the extent of those demands. The number and poor condition of USFS and BLM roads, the agencies' inability to prevent current roads from deteriorating and harming streams, and the pervasive effects of roads on the physical and biological environments were recognized in FEMAT (1993). In addition, forest roads have been the subject of high-profile national dialogue and policy reviews since the development of the Plan (Gucinski et al. 2001, Pacific Rivers Council 2008). The ACS's primary means of protecting streams from roads and encouraging effective restoration are twofold: First, ASC objectives discouraged locating roads within Riparian Reserves, and second, roadless areas were to be maintained and overall road density reduced in Key Watersheds. For a small number of Key Watersheds where road network reduction has been pursued, agency monitoring efforts have reported improvements of certain instream habitat conditions, a response not detected elsewhere (Gallo et al. 2005, Reeves et al. 2006a). Often overlooked is that proposals to reduce the size of Riparian Reserves could provide more free rein for the construction of roads and landings in closer proximity to streams, markedly increasing the likelihood of sediment delivery and alteration of near-stream hydrology.

How to substantially reduce road density in critical watersheds and improve road drainage, stream crossings, and other factors that affect streams and aquatic biota, while maintaining sufficient roads for other forest uses, remain central challenges to forest planning and management. The ACS and other operative policies have lacked sufficient means and impetus to accomplish this in the past 20 years. We therefore suggest five policy changes to achieve needed road reductions: 1) *Prohibit the construction of new permanent and "temporary" roads*, except in limited instances were construction of a short segment of new road is coupled with and necessary for the decommissioning of longer and more damaging segments of existing road. 2) *Allow no net increase in road density in any watershed*. New "temporary" roads and landings should be considered to be roads and counted towards road density levels for at least several decades after decommissioning. 3) *Strengthen road density restrictions for Key Watersheds and establish unambiguous standards and metrics for net road density reduction, which include adequate accounting for landings and the impacts of so-called "temporary" and decommissioned roads and landings*. 4) *Improve the system of classification (e.g., road type, use) and inventory (e.g., whether a road is active or decommissioned), and mapping (i.e., update maps to reflect current conditions)* to ensure that agency bookkeeping of road miles corresponds with actual field conditions. This provision is necessary because at present many roads "disappear" when dropped from the inventory, but they in fact remain on the landscape causing watershed impacts. Also, lax road mapping programs and narrow definitions of what constitutes a road can significantly under represent the actual road densities. 5) *Require each proposed forestry and other development project to meet a target of incremental reduction of the road system* in all watersheds affected by the project. Road density redution should be required until road density in the affected watershed is lower than the target established on the basis of biological response.[4] Finally, 6) *roads for which there are not adequate funds for maintenance and upkeep should be decommissioned*.

Riparian Reserves for Protecting Stream Temperature. Conservation (including restoration) of natural thermal regimes of streams and rivers was but one of many factors considered when ACS default riparian reserve widths were determined in the initial design of the ACS. In recent years the land management agencies and others have commonly assumed shade from riparian vegetation is the predominant proximate control on stream temperature, and some research has suggested that trees within 30 m or so of the stream margin contribute over 90 percent of the effective shade (e.g., Reeves et al. 2013). Furthermore, it has been suggested that headwater streams that do not carry water in summer should presumably not need shade to conserve summer thermal maxima in downstream waters. These two premises have become a primary rationale for proposals by BLM and in congressional bills to reduce default Riparian Reserve widths for some stream types, with the intent of increasing the area of Matrix land or equivalent that is subject to commercial logging. From the perspective of temperature protection, we have four concerns with this rationale for shrinking Riparian Reserves.

4 E.g., 1 mile per square mile (0.62 km per square km) for watersheds with Pacific salmon, steelhead and cutthroat trout (Lee et al. 1997, Thompson and Lee 2000, Carnefix and Frissell 2009), and 0.5 miles per square mile for watersheds supporting bull trout (USFWS 1999; Baxter et al. 2000, see Fig 5 and Appendix, showing that population growth remained negligible in streams with higher road densities; and Ripley et al. 2005, Fig. 5 showing that probability of bull trout occurrence in Alberta tributary streams dropped by half where road densities exceeded about 0.6 miles per square mile).

First, *redundancy*: most current analyses rest on a static view of riparian stand structure and function—that is, shade is modeled as a nearest single layer function of the existing standing trees only. The tree nearest to the stream margin is attributed as the contributor to shade, even though one or more trees standing behind it, slightly farther from the stream, may contribute shade as well. But when trees fall or die in the so-called "inner zone," then the "outer zone" trees become a replacement source of shade. Obviously, if the outer zone trees have been logged, that functional redundancy is lost and any riparian disturbance, man-made or natural, may lead to incrementally reduced stream surface shade—and an increase in stream temperatures.

Second, *density*: whereas we measure canopy shade with fixed-resolution instruments, little is known about how measurements of shade translate to actual solar penetration. In the coarsest sense, a canopy densiometer is used to visually estimate canopy cover with only 17 sample points that are irrespective of solar path. Even more quantitative instruments, such as the Solar Pathfinder or SunEye have the tendency to overlook the value of small canopy gaps or multiple canopy thickness in reducing light intensity reaching the stream, as does the densiometer. "Redundant" tree canopies create a shade structure that is dense compared to that of a single tree, and this may substantially affect the actual solar energy reaching the water surface in ways that we that we seldom adequately measure.

Third, *groundwater*: thermal response is affected in numerous ways by near-surface groundwater, which affects both surface streamflow rate and the temperature of water at the point of delivery. After initial increases in base flow following logging, summer base flow can decline for many years as a consequence of rapidly re-growing second-growth vegetation and its evapotranspiration demand (Hicks et al. 1991, Moore and Wondzell 2005). Logging in the outer areas of Riparian Reserves or forested wetlands can contribute to or conceivably magnify this effect. Accordingly, in some Pacific Northwest watersheds, stream temperature is more strongly associated with catchment-wide logging than with streamside vegetation cover (Pollock et al. 2009). Stream warming in such watersheds (often containing gently sloping or hilly terrain and numerous forested wetlands) could be influenced by reduced canopy shade over large areas of near-surface groundwater. Warming also could be influenced by changes in shallow groundwater flux rates and the level of the water table (Poole et al 2008). Hence, stream temperatures in some circumstances can become warmer at their point of origin (in spring, summer and fall) following watershed logging. Other research has established the importance of the hyporheic flow exchange in determining surface water thermal regime (Poole and Berman 2001, Baxter and Hauer 2001, Poole et al. 2008). The hyporheic zone may include extensive areas of shallow subsurface flow within montane alluvial valleys. In summer this subsurface pool may be dominated by spring snowmelt or cool rain runoff that cools surface streams when it discharges in midsummer (Poole and Berman 2001, Wondzell 2011). The extent of hyporheic storage and exchange bears a somewhat uncertain relationship to surface landforms, and until the decades after FEMAT, land management agencies lacked both the methods and incentive to accurately map these critically important areas (Torgersen et al. 1999, Baxter and Hauer 2001, Ebersole et al. 2003, Poole et al. 2004, Poole et al. 2008, Torgersen et al. 2012). Sediment accumulation in streambeds, or loss of step pools and other structures contributing to channel complexity—often formed by stable large wood—is thought to reduce entrainment of surface flows into, hence flow exchange with, the hyporheic zone (Moore and Wondzell 2005, Poole et al. 2008).

Given these uncertainties, and the increased importance of such groundwater source areas under future climate changes, any management change that increases the areal extent of logging in watersheds poses a risk of contributing to undesired stream warming. Notably, winter and spring stream temperatures can be of comparable importance to summer temperatures in meeting the habitat needs of species. In particular, temperatures of seasonably intermittent streams (even though they may be non-fish-bearing in summer or support salmonids only in early summer) can be important for salmon and other species in winter and spring (Wigington et al. 2006), and are directly and indirectly influenced by riparian canopy shade, thermal insulation, and other forest conditions that mediate water temperature fluctuations.

Fourth, *channel migration*: over time, stream channels migrate and even small streams have secondary channels that may flow only during the rainy season. However, existing side channels and backwaters provide important rearing and refuge habitat for salmonids, and they are commonly unmapped or mapped poorly. In addition, if riparian buffers are narrowed, some of these channels may migrate outside the narrowed buffer and be exposed to direct sunlight and substantially warmed. For instance, the sources of LWD are impaired during channel migration where outer zones have been harvested. Washington state and private forest practices rules have included criteria designed to identify and protect channel migration zones for many years (Brummer et al. 2006); in the ACS, explicit rules for their delineation are left to watershed analysis.

Considering the multiple ecological factors and processes that affect stream temperature and considering that temperature conservation is but one of many significant functional factors influenced by streamside forests, we *find no sufficient scientific support for reducing current ACS Riparian Reserve default widths for any stream type. In many watersheds and stream segments, larger areas of forest protection are warranted to prevent warming of* *shallow groundwater, particularly given likely trends future climate change, and the expectation of increased influence of wildfire and other "unmanaged" forest disturbances* (Westerling et al. 2006).

Riparian Reserves and Nutrient Retention. The role of forested riparian buffers in retaining nutrients mobilized by upslope disturbance, or delivered to watersheds in precipitation and fertilization, is globally recognized. Forested buffer zones are commonly prescribed to reduce nutrient delivery to streams in agricultural landscapes (Sweeney and Newbold 2014). Logging and fuels management treatments that disturb green vegetation generate increased nitrogen leaching from forest soils that enters streams and wetlands by both surface and subsurface flow paths (Wenger 1999, Gomi et al. 2002, Kubin et al. 2006). Any ground-disturbing activity or condition (such as a road network) tends to mobilize phosphorus in association with soil erosion. Logging disturbs vegetation and soils over large areas, and scaled over large landscapes or river basins, initial disturbance of forested lands tends to generate larger net increases in nutrient loading than repeat disturbances of already-altered agricultural or urban lands (Wickham et al. 2008; note this observation is from a large population of monitoring sites and remains true even though agricultural lands are commonly more heavily fertilized than forest lands). Over time, nutrient loading to headwater streams transfers downstream, where nutrients accumulate in rivers, lakes, estuaries, and nearshore marine ecosystems (Freeman et al. 2007). For all of these reasons, forestry operations have been identified as a major contributor to nutrient loading, eutrophication, and associated impairment of water quality in Pacific Northwest lakes (Blair 1994, Dagget et al. 1996, Oregon DEQ 2007), rivers and estuaries (Oregon DEQ 2007).

Cumulative nutrient impairment of downstream receiving waters can occur without violation of nutrient standards in headwater streams, simply as a consequence of sustained increases in loading from storm water runoff from forest roads and periodic logging. In effect, logging alters the entire regime of nutrient and sediment export, and nutrient losses to surface waters are endemic and widespread consequences of logging and other disturbance of forested watersheds.

The question of what role Riparian Reserves play in nutrient retention has received insufficient consideration in the Pacific Northwest. Research on the nutrient retention efficiency of various forested buffer widths from the Upper Midwest and other regions (Nieber et al. 2011, Sweeney and Newbold 2014) suggests that average phosphorus and nitrogen retention is around 80% for undisturbed buffer zones of 30 m (100 feet) wide. Extrapolation suggests that buffers of 45 m (150 feet) or greater might be necessary to attain 90-99 percent retention of nutrients mobilized by upslope disturbance. These distances are likely too small for Pacific Northwest forests, where slopes are steeper, soils tend to be more porous, and macropores or channeled flow from uplands are more common than in the Midwest (all factors identified in Nieber et al. [2011] as reducing retention efficiency).

By virtue of their high density of surface channels across most mountainous landscapes, headwater streams with seasonal flow receive a large portion of the nutrients mobilized by up-slope disturbance (Gomi et al. 2002, Freeman et al. 2007). Therefore, full protection of wide Riparian Reserves along even the smallest stream channels (and surface-connected wetlands) is likely necessary for effective nutrient retention when surrounding uplands are disturbed. Channel network expansion from gully erosion (Reid et al. 2010) or roads (Wemple and Jones 2002) and channel simplification through loss of woody debris or sediment increases also reduces retention efficiency of nutrients, sediment, and organic matter in headwater systems. Moreover, thinning or other disturbance of vegetation or soils within the Riparian Reserve could short-circuit the benefit of riparian forest buffers, by creating a near-stream source of nutrients that is not fully mediated by the retention capacity of the default-width riparian zone.

Although more research is needed in the Pacific Northwest on nutrient retention, current scientific knowledge is sufficient to justify three recommendations. 1) *Continuous, no-cut Riparian Reserves exceeding 50 m (160 feet) along all streams and wetlands are generally needed to mitigate the effects of up-slope logging on nutrient loading to both freshwater ecosystems and downstream marine environments.* 2) *Cessation of livestock grazing in Riparian Reserves, road network reduction, and reconfiguration of remaining roads to reduce their hydrologic connectivity to surface waters are needed to reduce downstream nutrient loading.* 3) *Analysis of the effects of management actions on nutrient loading to immediate downstream receiving waters, including lakes, wetlands, reservoirs, mainstem rivers, estuaries, and the nearshore marine, are needed in environmental assessments, environmental impact statements, watershed analyses, and ESA consultations for aquatic species.*

Livestock Grazing. Whereas forestry predominates in the Northwest Forest Plan area, grazing affects a significant portion of the area as well; for example, 22 percent of BLM lands were subject to livestock grazing in the early 2000s (BLM 2008). A larger area was affected by historic grazing, where soil impacts may persist. Livestock grazing has large impacts on streams (Al-Chokhachy et al. 2010) because livestock tend to concentrate in streams, floodplains and alluvial valleys (see Beschta et al. 2013 for a recent synthesis). Besides direct disruption of wetlands and streambeds, and the suppression of woody vegetation, soil compaction by grazing in both riparian and upland areas degrades runoff quality and adversely alters flow regimes and watershed functions such as soil water storage and nutrient retention.

In addition to these direct impacts, new research shows that managing for livestock can indirectly alter ecosystem trophic cascades. For example, livestock depredation on open range led to programs to extirpate large native carnivores. Reduced numbers of carnivores release native ungulates and other herbivores from predation, leading to declines of riparian vegetation and stream conditions even outside of livestock-grazed areas (Beschta and Ripple 2012). Removing livestock grazing from federal lands has high potential to increase the resilience of watersheds and streams to environmental stresses, including climate change (Beschta et al. 2013, 2014). Measures to reduce the ecological impacts of livestock grazing, primarily by fencing streamside areas and moving cattle frequently from site to site, have met with variable success (Rhodes et al. 1994). Implementation of these methods is limited by the high capital cost of building and maintaining extensive fencing, the wages of field personnel to manage herds, and the cost of necessary environmental review and monitoring. Livestock grazing in forests is a commercial use that is not restorative, and often is marginal economically. We conclude that *livestock grazing should be excluded from Riparian Reserves, Key Watersheds, and other lands where conservation is the primary management objective.*

Chemical Use in Forests. Only very recently has science begun to directly tackle the difficult questions of fate, effects, and toxicity of pesticides and other chemicals associated with forestland uses on stream biota. Toxic contaminants come from various sources, including storm water runoff from roads (particularly those that discharge directly to surface waters pipes and ditches) (McCarthy et al. 2008, Feist et al. 2011). Herbicides are applied to tree plantations and roadsides to control unwanted vegetation. Until recently these activities were limited by court order on BLM and USFS lands, but now they are increasing in extent and frequency, as well as continuing on adjacent private forest lands. The NMFS is reviewing the science concerning potential harm to listed species of Pacific salmon from application of commonly used pesticides. For example, use following label restrictions of the herbicide 2,4-D was determined to jeopardize Pacific salmon (NMFS 2011). Forest fire retardants that are aerially dropped in large quantities during wildfire suppression operations often reach surface waters, where they may be toxic to salmonids (Buhl and Hamilton 1998, Gaikowski et al. 1996).

While the science on toxic chemicals is certainly advancing, we have five interim recommendations based on existing knowledge: 1) *Minimize application of chemicals for forest management purposes in time and space;* for example, hand-application should be favored over aerial application when there is no feasible alternative to pesticide use. 2) *Weigh the full range of environmental trade-offs between the perceived benefits of chemical use and its possible harms in each case before a decision is made to use chemicals in forest management.* 3) *Implement wide, un-thinned forested buffers in Riparian Reserves to help reduce exposure of fish and aquatic life to toxic chemicals.* Thinned or narrow buffers can allow greatly increased aerosol penetration (chemical) from slopes to streams, and narrower buffers may also allow more transport of toxins in runoff. 4) *Reduce road density and the hydrologic connectivity of roads to surface waters to help control toxins* that originate from road use and maintenance, as well as those that are applied up-slope but find their way to streams via surface runoff. 5) *Analyze the possible effects of management actions in affecting the delivery of toxic chemicals to streams in every NEPA document and ESA consultation.*

Climate Change: Consequences and Adaptation. Anticipated climate change will alter the way we expect ecosystems to respond to forest management actions (Dale et al. 2001, Mote et al. 2003). In general for this region, hydrologic model predictions stepped-down from regional and global circulation models project increased stream and lake warming (varying magnitude across the seasons); more intense winter precipitation events, including flood and wind disturbance of riparian forests; earlier snow pack melting except for the highest elevation watersheds; and likely increased intensity and duration of droughts (Battin et al. 2007, Dalton et al. 2013). In very general terms, most climate change scenarios suggest larger and higher severity wildfires than seen in recent decades, and generally elevated evapotranspiration that could further reduce low summer streamflows. Luce and Holden (2009) documented a widespread pattern of declining summer streamflow over recent decades at gauging stations across the Pacific Northwest.

Climate changes will likely exacerbate existing (ongoing) trends in watershed degradation by affecting key processes or factors (stream thermal regimes, surface flows, groundwater and floodplain connectivity, landslide rates, fuels, fire, invasive species, and post disturbance human responses, to name but a few). Most climate change adaptation strategies call for strategic removal of non-climate stressors, because these will likely be more tractable or remediable than climate stressors (ISAB 2007, Furniss et al. 2010). No formal review of the ACS has apparently been conducted by the USFS or BLM to determine what, if any, science-based changes to the ACS best address future climate scenarios. It seems unlikely, however, that even a cursory review of the climate literature would lend support to proposals to remove or diminish currently protective provisions of the ACS.

The current ACS requirements are integral to assuring streams, wetlands, and other water bodies have the best possible resilience in the face of increasing climate stress. Extensive forested north-facing slopes can moderate some climate influence on watersheds, and localized springs, and extensive shallow alluvial aquifers that store water seasonally can moderate summer streamflows and both summer and winter temperatures (Poole and Berman, 2001, Isaak et al. 2010, Wondzell 2011). Complex natural riparian vegetation communities and natural accumulations of large wood (resulting in concentrations of stored sediment) in and near floodplains are instrumental in creating and maintaining conditions that support hyporheic flow exchange. Wide Riparian Reserves provide not only shade, but essential protection and support for the natural processes that maintain and regenerate the suite of hydrologic and geomorphic elements that help buffer streams against climate forcing.

Intact watersheds are often seen to be less vulnerable to storms, floods, droughts, wildfire, and other extreme events, and are expected to be more resilient to future climate change than highly altered watersheds. Streams and rivers affected by reduced alluvial groundwater storage and diminished hyporheic buffering, fragmentation and loss of biological habitat connectivity, and a less intact native biota, are likely to respond more quickly and with greater volatility to climate change, as are engineered systems such as roads and dams. Watershed resilience in the face of climate change can best be maintained by protecting and restoring the suite of natural processes and conditions that characterize natural forested riparian areas and floodplains (Seavy et al. 2009, Furniss et al., 2010). This is exactly what the ACS was originally designed to accomplish. Whittling away riparian protections on the basis of narrowed, single-factor considerations such as proximate stream shade undermines the comprehensive protection of stream and riparian processes that the ACS was designed to maintain and restore. Finally, under changing climate, some management practices that seemed to produce desirable outcomes in the past may not do so in the future. For example, the putative effectiveness of forest thinning at altering fire behavior could become even more uncertain if weather extremes become more of a top-down driver of fire behavior (see Martinson and Omi 2013) in future climates (Dale et al. 2001, Westerling et al. 2006).

Our overall recommendation is that 1) *ACS protections for Riparian Reserves should be sustained and strengthened to better protect and restore natural ecosystem processes that confer resilience to climate change,* as detailed in our other recommendations. In addition, 2) *an interagency scientific conservation design effort is needed to expand and reconfigure some present Key Watersheds to ensure they better encompass specific areas that are likely to be topographic and hydrologic buffers to future climate change impacts.* Finally, we recommend that 3) *the direct and indirect effects of management actions on the integrity and capacity of stream and watershed ecosystems for resilience to climate change be analyzed in every environmental assessment, environmental impact statement, watershed analysis, and ESA consultation.*

Monitoring and Adaptive Management.

Environmental monitoring data often prove to be useful, but we cannot always anticipate how those data will be useful. Monitoring can be especially valuable when coupled with available data from historical records and time series sampling (such as streamflow gauging and temperature recorder data strings) (Wissmar 1993, Wissmar and Beschta 1988). Substantial progress has been made in the past 20 years on sampling design and methods of data collection for monitoring streams, watersheds and regions of watersheds (Steel et al. 2010). Twenty years after FEMAT, there are greatly expanded technological capabilities for spatially explicit data reporting and analysis, and numerous and increasingly robust methods to integrally evaluate considerations of ecological scale, geographical context, spatial and temporal continuity, and biological connectivity in data design and analysis.

The Northwest Forest Plan designated large

Adaptive Management Areas where alternative means of management and conservation might be implemented and closely monitored. For many reasons this option failed. Public involvement was required, but in most cases the public could not agree on the need for trial and testing of specific management hypotheses (Gray 2000). Managers and scientists also sometimes disagreed on hypotheses to test or what practices should be implemented. Lacking coherent large-scale experimental proposals drawing broad social support, funding never materialized. These failures are by no means endemic to the NFP—they characterize many, if not most aspirational attempts at formalized, large-scale adaptive management (Walters 1997).

We note, however, that ongoing management across multiple ownerships and with a multitude of natural background conditions creates a broad array of natural experiments that already exist on the landscape. Scientists can probably continue to learn much of what we need to know by creative monitoring of extant natural experiments. However imperfect they may be, natural experiments are more beneficial than waiting for planned, large-scale experiments that have proven exceedingly difficult to execute (and are almost always far from ideal themselves in terms of design and resources).

The existing monitoring program for aquatic resources in the Northwest Forest Plan area (Aquatic and Riparian Effectiveness Monitoring Program, AREMP, http://www.reo.gov/monitoring/reports/watershed/aremp/aremp.htm) in our view is constrained by certain design and sampling protocols that limit AREMP's capacity for drawing inferences about changes in habitat condition, living system condition, and biophysical processes over time. Whereas AREMP is intended by design to detect trends in some riparian or stream conditions over large areas, interpreting causal relations for responses requires information about changes in physical conditions and biota at specific locations over time. Further, AREMP design is based on delineated hydrologic units some of which do not represent hydrographically complete watersheds; this confounds identifying linkages between watershed condition and stream biotic and physical responses (Omernik 2003). Considering the scope of natural and man-caused variability in the field, Anlauf et al. (2011) suggested that AREMP incorporates a statistically insufficient number of sites to yield useful confidence intervals needed for reliable assessments of many measures of stream condition.

Effectiveness monitoring generally fails when the design or data preclude process or cause-effect inferences, or when assumed fundamental relationships between habitat indices and biological populations and assemblages remain untested. Outside of the specific confines of AREMP, some useful new understanding has emerged from regionally extensive monitoring programs on federal lands in the Pacific Northwest (e.g., Hough-Snee et al. 2014, Meredith et al. 2014). In our view, these studies, far more specifically than AREMP, focus on iterative explicit hypotheses about cause-and-effect relations to inform the query and analysis of field survey data

We recommend three policy shifts in how monitoring is employed under the ACS. First, as a standard management practice, require *some form of effectiveness monitoring and expert review of stream and watershed responses for every forestry, range, mining, recreation development, or active management project.* Every project that could potentially affect watershed and stream conditions should integrally include collection of a field data set that sheds some light on key post-project biophysical conditions influenced by the project. Agency actions should help to increase the certainty of outcomes at particular sites. Agencies should first engage experts that could check collective awareness of the reliability of conventional assumptions about the effects of management actions. Expert's perspectives would and increase the likelihood of the agencies identifying unanticipated outcomes that warrant broader study and management consideration. Expert review of project outcomes is needed to discourage the institutional habitat of assuming *a priori* that project outcomes are more certain and unequivocally beneficial than they often are.

Secondly, agencies should review existing programs of comprehensive regional and watershed-scale effectiveness monitoring programs, and develop comprehensive monitoring strategies to optimize return on the capital investment in monitoring. *We call for an interagency scientific panel to review the status and effectiveness of trend monitoring efforts, and identify data sets that could be useful in drawing inferences for improved monitoring programs.* New monitoring programs should be capable of assessing the effects of management actions and climate change on aquatic ecosystems and biological resources associated with BLM and USFS lands. They should be robust to both anticipated and unanticipated environmental changes.

Third, agency-driven improvements in monitoring programs should include *increased emphasis on tracking ecological conditions, including explicit biological condition measures, and the ability to establish with some certainty that trends in Key Watersheds result from specific management actions or choices (which may include deferral of active management).* Key Watersheds are especially critical for the medium- and long-term conservation success of the ACS, and may be disproportionately important to the survival and recovery of ESA-listed and other sensitive species. The special need to focus sustained time-trend effectiveness monitoring in Key Watersheds again raises the concern that re-delineation of Key Watersheds with each new piece of legislation or management planning cycle could disrupt long-term monitoring efforts. Pursuant to our third recommendation, we also recommend that agencies retain some degree of flexibility in allocation of monitoring resources to allow for occasional more directed and intensive investigation where assessments indicate that surprising and ecologically important outcomes have occurred.

CONCLUSIONS

In this report we examine selected new and emerging science that is relevant to the future of the ACS, and touch on concepts that should be integral to whatever might replace the ACS in the future. We believe more exhaustive consideration of the topics we raised--and a broadened consideration of others, including the functions of riparian and watershed reserves for conservation of terrestrial wildlife species--will only strengthen our conclusion that the founding rationale, basic architecture, and core conservation elements of the ACS remain sound. We also maintain that some specific improvements in ACS protection and conservation provisions are warranted.

New science raises many concerns about the adequacy of implementation of the ACS by the federal agencies. These issues include including post-fire and other logging after disturbances, logging and fuels treatments in riparian areas, the degree of riparian protection for headwater streams, the adequacy of past efforts for road system downsizing and remediation, the adequacy of conservation priorities for and delineations of Key Watersheds, the effectiveness of grazing management, and whether current monitoring is as useful as it should be.

This report raises concerns about anticipated climate change. While climate change does not fundamentally alter the basic facts of good conservation and responsible management, it both theoretically and materially raises the level of concern about many specific management issues, including the potential effectiveness of restoration actions, the effectiveness of riparian areas as stream buffers, and implications for the burden of proof for management actions that balance known environmental problems against presumed restorative benefits. Most watersheds in the region are of mixed federal and other ownership. Because progress in protection and restoration on private lands has been limited (Stout et al. 2012), federal lands will likely continue to be the focus of watershed protection and aquatic habitat conservation, and related climate change initiatives for the foreseeable future.

Finally, an improved monitoring program will be necessary to ascertain that conservation of aquatic ecosystems and resources is in fact occurring, especially in the face of increasing physical and biotic stresses imposed by changing climate and human population growth. It will be of continued or increasing importance to evaluate the degree to which Riparian Reserves can serve as effective buffers against the cumulative effects of logging, roads, and other disturbances on forest lands catchment-wide. This question has assumed greater importance as research in disturbed ecosystems worldwide has demonstrated that watershed condition can sometimes affect fish assemblages more strongly than does riparian condition (Roth et al. 1996; Wang et al. 2003; 2006; Sály et al. 2011; Marzin et al. 2012).

We conclude that attempts to reduce protections to watershed, riparian, and freshwater ecosystems by weakening major components of the ACS and other related conservation elements of the Northwest Forest Plan are not justified by new and emerging science. Improved ecosystem protections--and better monitoring of outcomes--are warranted across all land ownerships, including federal forest lands, if freshwater ecosystems and their biota, including salmon and other sensitive species are to be effectively conserved in an era of increased ecological stress and changing climate.

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