Watershed Research Cooperative

Policy Workshop

Presentation Abstracts

Abstracts are in order of presentation

November 13, 2013

Willamette Heritage Center, Salem

WATERSHED RESEARCH COOPERATIVE

POLICY WORKSHOP

DATE:

November 13, 2013

PLACE:

Willamette Heritage Center,
1313 Mill St. SE, Salem, Oregon

AUDIENCE:

Oregon Legislators, County Commissioners, Board of Forestry, Environmental Quality Commissioners, Fish & Wildlife Commissioners, Oregon Watershed Enhancement Board, Oregon Forest Resources Institute Board, State Natural Resource Agencies, Governor's Natural Resources Advisor, WRC Advisory Committee

PURPOSE:

Discuss management and policy implications of the findings of the WRC Paired Watershed Studies

TENTATIVE AGENDA:

10:00 Welcome – Mike Cloughesy, Oregon Forest Resources Institute

10:15 Forest and Watershed Policy Context – Thomas Maness, Dean, OSU College of Forestry

10:45 WRC Paired Watershed Study Overview – Liz Dent, Oregon Department of Forestry

11:15 Water Quality Improvements: How Far Have We Come? – George Ice, National Council for Air & Stream Improvement (retired)

11:45 Aquatic Invertebrate Research: Management Implications – Judy Li, OSU Fisheries and Wildlife Department (retired)

12:15 Lunch & Presentation – Contemporary Forest Practices – Dan Newton, Weyerhaeuser Company

1:00 Fisheries Research: Management Implications – Doug Bateman, OSU College of Forestry

1:30 Watershed Dogma and Counterintuitive Research Results – Arne Skaugset, OSU College of Forestry

2:00 Social, Economic & Legal Considerations on Forest Watershed Policy – Paul Barnum, Oregon Forest Resources Institute

2:15 Policy Maker Panel: Response to WRC Research Implications (10 minutes each)

a. Board of Forestry – Tom Imeson
b. Environmental Quality Commission – Jane O'Keeffe
c. Fish & Wildlife Commission – Holly Akenson
d. Oregon House of Representatives – Rep. Brad Witt
e. Resilience Alliance – Mike Jones

3:15 Wrap Up - Policy/Research Nexus - Next Steps – Thomas Maness, OSU College of Forestry

3:30 Adjourn

WATERSHEDS RESEARCH COOPERATIVE

Watershed Research Cooperative: Examining the Effects of Contemporary Forest Practices on Aquatic Ecosystems at Multiple Scales- An Overview

Liz Dent, State Forests Deputy Division Chief, Oregon Department of Forestry

Abstract:
This is an opportunity to begin the very important dialogue between watershed study scientists and Oregon forest and water quality policy makers. It is this dialogue which ultimately will facilitate science-based policy decisions for Oregon's forested streams and therefore is one of the more important outcomes of the research you are going to hear about today.

Oregon is not alone and watershed studies aren't new. There is a long history of watershed studies informing forest policy. The first watershed study in the United States was in 1910 with the Wagon Wheel Gap (Colorado). The cornerstone findings from the original Alsea Watershed Study in Oregon (1966) significantly advanced forest resource protection policies. Examples include advancements in stream buffers, removal of slash from streams, and BMPs to minimize sediment input to streams. Collectively, through adaptive management- forestry has a rich history of improving management approaches to better protect stream resources.

So what is next? Oregon has three paired watershed studies that are addressing three critical questions facing forest and water quality policy makers today:

- What are the effects of forest harvest small non-fish streams?
- If small non-stream characteristics change as a result of harvest are those changes also observed downstream?
- If there are changes in the physical or chemical characteristics of the stream- what does that mean for the biology?

Following in the footsteps of previous studies, these current watershed studies are designed to inform policy discussions. Three new paired watershed studies were initiated in Oregon, starting with Hinkle Creek in the headwaters of the Umpqua River. This was followed by the Alsea Watershed Revisited and finally by the Trask River Watershed Study. All of three studies are linked with common research questions and organized under an umbrella organization- Oregon Watersheds Research Cooperative (WRC). The WRC organization increases our ability to collaborate, increases efficiency, and creates a critical mass of watershed research that is greater than the sum of its parts at informing policy.
In general the goals of these studies are to quantify effects of contemporary forest practices on the physical, chemical and biological characteristics of streams at multiple spatial scales. The studies are using a watershed scale, cooperative, multi-disciplinary and long-term approach. Data are collected throughout the watersheds for 2-4 years prior to harvest. Then harvest takes place in the "treatment" portion of the watershed while other portions of the watershed are left un-harvested ("reference conditions") for the life of the study. There are "references" at both the small catchment scale as well as larger watershed scale.

These studies link forest management to a range of aquatic responses. They are designed to connect local upstream responses to downstream responses. By evaluating multiple physical, chemical, and biological interactions these studies can link biological responses to observed physical responses. Results of the watershed research will be presented in detail. In general we observe that contemporary forest practices resulted in detectable changes (both increases and decreases). However, changes were

often difficult to detect and were often within observed variability of the watershed. The magnitude of change is far less than observed with earlier forest practices.

We continue to evaluate these patterns and processes. This work is designed to inform policy and further scientific understanding of the interactions between ecosystem processes and working forest. The intent of this workshop is to initiate the science to policy dialogue.

Protecting Forest Water Quality: Progress and Management Implications

George Ice, National Council for Air & Stream Improvement (retired)

Abstract

The effectiveness of Best Management Practices and forest practice rules in protecting water quality has been extensively researched. However, some people have a distorted image of forest management impacts on water quality because of a focus on historic practices and immediate responses. The Watersheds Research Cooperative addresses the impacts of ***contemporary*** forest management and has produced both expected findings and some surprises. Key management implications arising from these finding include:

- ***Oregon's Forest Practice rules and contemporary forest management practices are effective, reducing water quality impact to small changes;***
- ***these small water quality changes recover rapidly downstream and over time;***
- ***water quality criteria used to assess forest stream conditions can be unattainable and in some cases unproductive;***
- ***technology allows measurements of small changes that may be statistically but not ecologically significant; and***
- ***there is a law of diminishing returns for forest practice rules.***

Long-term Studies of Macroinvertebrate Response to Harvest in the Hinkle, Alsea and Trask Watersheds

Judith Li[1], William Gerth[1], Janel Sobota[1], Richard VanDreische[1] and Doug Bateman[2]

[1] Department of Fisheries and Wildlife, Oregon State University; [2] Department of Forest Engineering, Oregon State University

Abstract

Using a before, after, control and impact (BACI) study design we are examining the impact of current-practice forestry on salmonid diet, benthic (bottom-dwelling) invertebrates and adult aquatic insects emerging out of the stream. Pre-harvest comparisons between WRC watersheds identified strong differences in the composition of benthic organisms between Hinkle, Alsea and Trask. There were also significant differences between headwaters and mainstems at both Hinkle and Trask sites. Pre-harvest samples at 24 Hinkle sites established temporal differences in benthic densities and fish diet between years and seasons. After headwater harvest at Hinkle, benthic taxa richness decreased, while benthic densities, adult emergence and percent midges increased at harvested sites; these patterns persisted during the four years post-harvest. No changes were detected downstream. Following a dam-break flood and harvesting at mainstem sites, patterns for taxa richness, emergence and percent midges were similar to headwater responses, but benthic densities did not change. Though fish diet did not change significantly, salmonid biomass increased at the mainstem sites. Studies at Alsea revealed few significant responses to harvest; we detected greater adult aquatic emergence at the harvested site, but without pre-harvest data we do not know if this was due to timber activity. Habitat differences and the fewer number of sites at Alsea influence our ability to detect differences. However the contrast in responses, in combination with identified differences pre-harvest, highlight the importance of watershed-specific responses by invertebrates following harvest. Stronger initial physical and biological differences between sub-basins of the Trask will likely underscore the importance of spatial and temporal contexts in assessing responses.

Contemporary Forest Practices

Dan Newton, Weyerhaeuser Company

Abstract

Contemporary forest practices have evolved significantly in the last several decades. Our state is quite young (1859), but our forest practices act was the first in the nation, passed by the legislature in 1971. Oregon has been a leader in the sustainable production of forests products through innovation in silviculture and in the protection of other natural resources. Improvements have been made in reforestation and growth enhancement techniques designed to increase the productivity of highly valued products, while protecting soil, water, air, fish and wildlife.

Very little cause/effect data were available when we first began deliberately growing forests. We learned a lot by observing how natural forests recovered and grew to maturity in successional patterns following periodic disturbance. Perhaps it would be possible to emulate natural disturbance patterns? Timber harvest could provide the periodic disturbance necessary to renew new forests, while providing wood products, jobs and other benefits. At the same time, fire suppression was needed to protect the forest from fire. Without fire protection, there would be little incentive to invest in forestry.

With the advent of the forest practices act and other environmental awareness, questions arose as to whether we were adequately protecting water quality, fish and other wildlife. The original Alsea Watershed Study, initiated in the 60s, provided the impetus to require riparian management areas along fish- bearing streams. The rules have been added to a number of times since their inception.

With the listing of Coho came new questions regarding the needs for stream protection. It had been 3 decades since the original Alsea Watershed study. Rules had been written and added to, but new watershed studies were needed to assess whether current rules were adequately protecting fish. Numerous reach level studies had been done, including some where canopy opening improved fish biomass, but these studies generally did not address temperature effects or effects on a watershed scale. After a great deal of discussion and the input of a lot of energy (and cooperative spirit), the Watershed Research Co-operative was founded, along with the installation of three large, paired watershed studies. Primary co-operators included: Oregon Dept of Forestry, Oregon Watershed Enhancement Board, Oregon Dept of Forestry, Oregon State Geological Survey, Oregon Forest Industries Council, Forest and Rangeland Ecosystem Science Center, National Council on Air and Stream Improvement, Douglas County, Oregon Forest Resources Institute, Associated Oregon Loggers, Douglas Timber Operators and many others.

The success of the this cooperative and the projects could not have been done without the land provided by Roseburg Forest Products, Plum Creek, Weyerhaeuser, Oregon Dept of Forestry, and BLM, or without the support of people genuinely interested in improving our knowledge base to make data assisted decisions. We have learned a lot from these studies and we will continue to learn even more.

Thanks to all who have contributed.

Response of Coastal Cutthroat Trout to Timber Harvest in Previously Harvested Catchments

Doug Bateman, OSU College of Forestry

Abstract

A before-after, control-impact (BACI) design was used to determine the effects of logging on salmonid populations and associated physical conditions at Hinkle Creek and Alsea River paired-watershed studies. Passive integrated transponder tags were used to evaluate growth, movement, and survival of individual fish ≥ 100 mm fork length in both studies. From annual electrofishing surveys during the low-flow period, we estimated abundance and collected length and weight information from all captured individuals. Annual habitat surveys were conducted over the entire fish-bearing portion of both watersheds.

At Hinkle Creek each catchment had three tributaries which supported resident fish populations. Comparisons were made between treated and reference tributaries and between catchments. The study included three phases: 1) a calibration phase (3-5 years depending on the metric), 2) a 3-year treatment phase that followed logging in the headwaters of the South Fork Hinkle Creek adjacent to nonfish-bearing streams, and 3) a final 3-year treatment phase that followed logging adjacent to fish-bearing sections of both the tributaries and mainstem of the South Fork of Hinkle Creek. A relative increase in both biomass and abundance of age 1+ cutthroat trout was observed at the tributary scale following the first harvest in Hinkle Creek; this difference persisted into the second harvest period. We failed to detect any other significant changes in fish responses at either the tributary or the catchment scale during the first harvest. Following the second harvest at Hinkle Creek, age 0 trout were larger (relative increases in biomass, mean fork length) and more abundant at both the tributary and catchment scales. Similarly age 1+ cutthroat trout were longer (increased mean fork length) at both the catchment and tributary scales, and grew more (measured as relative growth rate) at the catchment scale.

Flynn Creek was the reference stream and logging occurred adjacent to fish bearing portions of Needle Branch in the Alsea study. Pretreatment data were collected for four years prior to timber harvest, and currently there are three years of post-treatment data. Age 1+ cutthroat biomass and abundance increased in Needle Branch relative to Flynn Creek post logging. We failed to detect significant treatment effects for any other biotic variables at this site; however, there was a significant shift in distribution of age 1+ cutthroat trout in an upstream direction in Needle Branch. Few changes in habitat variables were detected in either the Hinkle Creek or Alsea studies. Results suggest that current forest practice rules may be effective in ameliorating the acute negative effects of logging on coastal cutthroat trout observed in the original Alsea Watershed Study. However, effects of current rules on coastal cutthroat trout and their habitat over longer periods remain speculative.

Assessing the Environmental Effectiveness of Contemporary Forest Practices: Counterintuitive Results from Contemporary Paired Watershed Studies

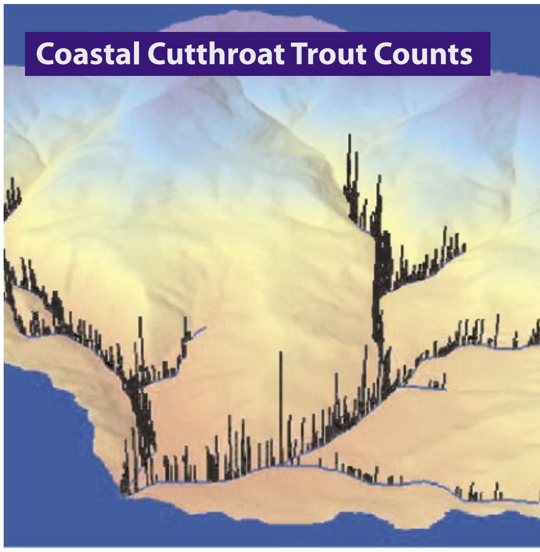
Dr. Arne Skaugset, OSU College of Forestry

Abstract

Over the past 40 to 50 years, the practice of forestry and, more specifically, intensive forest management has changed dramatically. Despite these changes, there is still significant resistance to intensive forest management and, for the most part, this resistance centers around environmental concerns. The seminal watershed studies from the 50', 60's, and 70's left some indelible images in the form of research results and these images persist. A barrier to gaining acceptance for contemporary forest practices is overcoming the inertia of these historic research results. Given these outdated results and the expectations that they bring with them, the results from contemporary paired watershed studies are often perceived as counterintuitive. The impacts of contemporary forest practices on sediment or accelerated erosion, stream temperature, and fish populations are three issues or topics that are highly socially salient and thus elicit concern. These issues elicit concern because during the seminal paired watershed studies the effect of old-growth conversion on sediment, temperature, and fish was often an acute response. On small, headwater watershed the first year after a 100 % clearcut and site preparation by a broadcast burn, the effect on sediment, temperature, and fish was often drastic. Sediment yields increased by one to two orders of magnitude, maximum daily stream temperatures had increases that approached 16°C (29°F), and, in some locations, drastic declines in the populations of fish were observed. In response to these results, forest practice rules were adopted and site-specific practices were prescribed to mitigate the impact of forest practices on sediment, stream temperature, and fish. These forest practices included, the prescription of buffer strips, elimination of stream cleaning, changes in logging systems, changes in site preparation prescriptions, changes in roads (location, quality, and connectivity), and clear cut size limits with adjacency constraints. How well did these changes in forest practices work? Research results from contemporary paired watershed studies have exhibited similar results among the studies. A synopsis of these results includes the following observations;

- *Contemporary forest practices have resulted in the elimination of short-term, acute responses for sediment, temperature, and fish.*
- *Chronic levels of change for sediment, temperature, and fish were detected. However, the results are equivocal and range from decreases, to no change, to increases.*
- *The management related changes that were detected for sediment, temperature, and fish are within the range of natural variability of these parameters in space and time.*

Watersheds Research Cooperative



EXPANSIVE WATERSHED STUDIES TAKE A NEW LOOK AT CONTEMPORARY FOREST PRACTICES

In 1971, Oregon passed the landmark Forest Practices Act (OFPA), based in part on results from the Alsea Watershed Study, the most far-reaching forest watershed study of its time. Since then, dramatically changed harvest practices, broader environmental concerns and a limited amount of new research have raised questions about whether current stream-protection laws are adequate, go too far or don't go far enough.

Three modern paired watershed studies of unprecedented scope—on Hinkle Creek and the Trask and Alsea rivers—have been designed to help guide future stream protection practices in the Pacific Northwest. Each study is a ten-year set of projects across thousands of acres, using sophisticated monitoring and tracking technology that did not exist 30 years ago. The same scientists are using the same techniques in different geographic locations to investigate fish, water quality, stream flow and aquatic habitat across space and through time in ways never before possible.

These studies will provide the research necessary to help craft appropriate protective measures for 21st century forest practices, including the OFPA.

- After 30 years, new watersheds research is underway in Oregon in the form of paired watershed studies.
- Scientists at three major research sites —Hinkle Creek, Trask River and Alsea Watershed—are monitoring the effects of timber harvest on watersheds.
- Research is focusing on fish, amphibians and invertebrates as well as water temperature, quality and chemistry.
- Research data will help guide future forest practices in Oregon and elsewhere in the Pacific Northwest.


Photo: Michael Feinstein

WHAT ARE PAIRED WATERSHED STUDIES ?

Paired watershed studies monitor two similar streams to evaluate the effects of forest harvests on those streams. One area (the control basin) is left unharvested. Another area (the treatment basin) is logged using current harvest practices. Effects are measured on water, soils, habitat and wildlife. Such studies are rare because they are immense, expensive and long-term, involving a wide range of scientists working across disciplines. Research partners commit to ten years of monitoring and data analysis. Costs can average nearly a million dollars a year, and funding is a formidable challenge. However, because they are conducted on such a large scale—5,000 acres or more—these studies can look at fish and wildlife behavior in a whole system, and reveal the cumulative effects of forest management throughout an entire watershed, rather than just the activities in one location.

PROTECTING FOREST STREAMS

Until recently, there has been limited study of forest headwater streams regarding the appropriate amount of streamside protection during harvest operations. Early regulations did not include streamside vegetative buffers for small streams. Yet small, non-fish-bearing streams can comprise 80% or more of all stream miles within a watershed and may be more sensitive to forest harvest than larger down-stream rivers. While there have been many studies of the effects of logging on larger, fish-bearing rivers, head-water streams have not been studied in depth. This new watershed research will play a key role in guiding future forest practices.

WATERSHEDS RESEARCH COOPERATIVE STUDY SITES

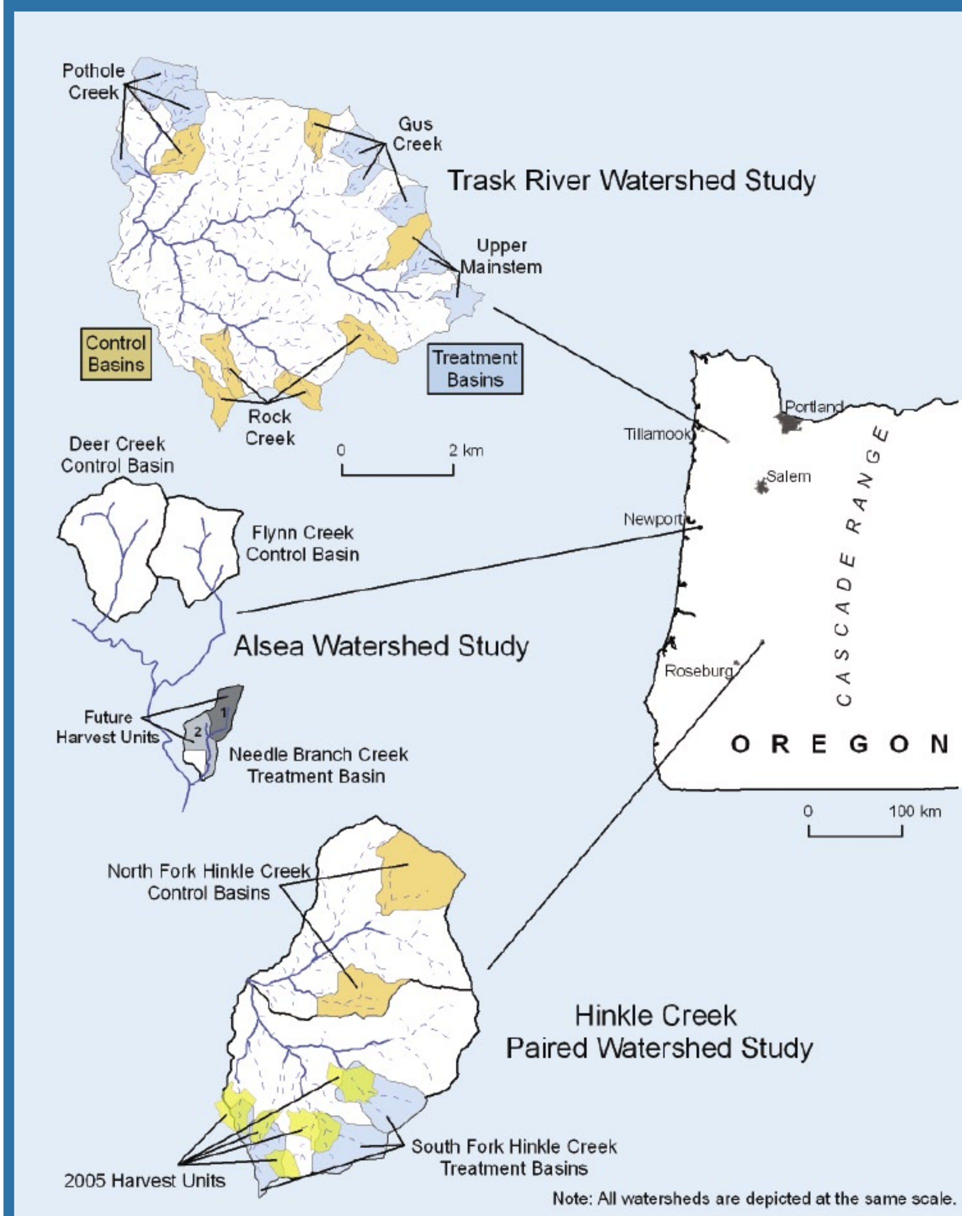



Photo: OFRI

Photo: Public Domain

WATERSHED STUDIES: THEN AND NOW

The original Alsea Watershed Study was conducted between 1959 and 1973 in Oregon's Coast Range, and the results helped to set the initial stream protection rules of the OFPA. Both headwater and smaller fish-bearing streams were examined on watersheds up to 750 acres. The study evaluated the effects of logging practices, which at that time included clearcuts up to the edge of the stream and large, old trees being dragged across the ground. In the new studies, trees are smaller and harvested using aerial cables that elevate the logs being moved. All new harvesting efforts follow the current requirements of the OFPA.

Photo: Ed Hoffman

TRASK RIVER (2006–2016)

The Trask study examines the effects of harvesting on small headwater streams including any impacts that are detected downstream. The study area extends across 6,000 acres in the headwaters of the Trask River. Watersheds are managed with a range of strategies including clearcuts or thinning with and without stream buffers on small non-fish bearing streams. Using advanced computer modeling, extensive field observations and additional experiments, scientists will examine the effects of logging on headwater streams. The findings should help improve our understanding of the important influence of headwater streams with and without tree-retention buffers. Treatment areas will be harvested following the OFPA, state and federal management plans. All three management approaches are being evaluated in the Trask study area.

Photo: Jason Dunham

ALSEA WATERSHED (2006–2016)

In the original Alsea Watershed Study, one basin was completely clearcut and slash-burned, leaving bare soil and no streamside vegetative buffers. The study recorded some of the most dramatic effects on water quality, stream temperature and dissolved oxygen ever observed in response to logging. The basin was successfully reforested, and the area is again ready for commercial harvest. Conducting a paired watershed study within this new harvest area offers a unique scientific opportunity to compare the effects of old and new forest practices on watershed resources. A new site for monitoring water flow has been installed, and state-of-the-art equipment is being added to monitor water quality, including turbidity, stream temperature and dissolved oxygen.

Photo: Cody Hale

HINKLE CREEK (2001–2010)

Set on 5,000 acres of second-growth forest, Hinkle Creek is the first paired forest watershed study conducted entirely on private land. Scientists are gathering data on water quality, water quantity, fish, amphibians and aquatic invertebrates. High-tech equipment is tracking stream temperature, water flow, turbidity and fish movement. Scientists are tracking the movement of hundreds of individual fish throughout the watershed using stationary antennae and over 4400 PITs (Passive Integrated Transponders) implanted in resident cutthroat trout. One surprising result to date is that stream temperatures did not rise significantly after clearcutting.

Photo: Michael Feinstein

STREAM TEMPERATURE STUDIES

Concurrent with these paired watershed studies, the Watersheds Research Cooperative (WRC) is leading a series of four stream temperature studies in Oregon that explore the influence of modified, and in some cases narrower vegetative buffers on stream temperature and productivity. Although cool water temperatures are desirable for many reasons, openings along streams can contribute to aquatic productivity. This study seeks to quantify those tradeoffs. Study areas include Big Rock Creek (west of Monmouth), Brome Creek (north of Roseburg), West Fork Mary's River (near Philomath) and Mill Creek (near Toledo).

OUTREACH AND EDUCATION

These paired watershed studies offer the opportunity to create a dynamic and expanding educational outreach program. Local K-12 schools witness scientific research on site and through classroom materials and lesson plans based on findings from the study. Pilot projects are being developed to share data with schools across the state. Tours are offered at demonstration areas, making the research accessible to neighboring landowners, students and the general public. State and regional policy leaders have visited and toured sites to learn about the research efforts underway. University classes in forest engineering and hydrology have examined the studies' research protocols. Numerous graduate students have used the research opportunities to advance their own degrees.

Photo: Javier Goirigolzarri

WATERSHEDS RESEARCH COOPERATIVE

The Watersheds Research Cooperative designs and conducts field-based research to study the effects of modern forest practices on fish and other aquatic organisms, along with water quality and quantity. The Cooperative is a collaboration of a diverse group of individuals, companies, organizations and agencies, with primary leadership provided by the Oregon State University College of Forestry. Committees include the Executive Steering, Advisory, Science Steering, Finance and Outreach. Cooperators and contributors include:

Bureau of Land Management • Colorado State University • Department of Fisheries and Wildlife, OSU College of Agricultural Sciences • Douglas County • Douglas Timber Operators • Friends of Paul Bunyan Foundation • Associated Oregon Loggers • Forest Capital Partners • Forest Engineering Department, OSU College of Forestry • Forest Science Department, OSU College of Forestry • National Council for Air and Stream Improvement • Oregon Department of Fish and Wildlife • Oregon Department of Forestry • Oregon Forest Industries Council • Oregon Forest Resources Institute • Oregon Watershed Enhancement Board • Plum Creek Timber Company • Resource Management Services • Roseburg Forest Products • Roseburg Public Schools • Starker Forests • U.S.D.A. Forest Service • U.S. Geological Survey Forest and Rangeland Ecosystem Science Center • Umpqua Fisheries Enhancement Derby • Weyerhaeuser Company

To learn more about the Watersheds Research Cooperative, or to view reports from the individual watershed studies, visit www.watershedsresearch.org.

WATERSHEDS RESEARCH COOPERATIVE

PROTECTING FOREST WATER QUALITY:
PROGRESS AND MANAGEMENT IMPLICATIONS[1]

Dr. George Ice[2]

Abstract: The effectiveness of Best Management Practices and forest practice rules in protecting water quality has been extensively researched. However, some people have a distorted image of forest management impacts on water quality because of a focus on historic practices and immediate responses. The Watersheds Research Cooperative addresses the impacts of ***contemporary*** forest management and has produced both expected findings and some surprises. Key management implications arising from these finding include:

- ***Oregon's Forest Practice rules and contemporary forest management practices are effective, reducing water quality impact to small changes;***
- ***these small water quality changes recover rapidly downstream and over time;***
- ***water quality criteria used to assess forest stream conditions can be unattainable and in some cases unproductive;***
- ***technology allows measurements of small changes that may be statistically but not ecologically significant; and***
- ***there is a law of diminishing returns for forest practice rules.***

INTRODUCTION

Forty years ago I came to study at Oregon State University, intrigued by research at the original Alsea Watershed Study testing practical solutions to reduce water quality impacts from timber management (Krygier and Hall 1971). Over my career I conducted, supported, and monitored research advancing forest management practices designed to protect water quality. I also studied how water quality varies in forest settings as a result of natural disturbances, weather, geology, vegetation, and other factors. The Watersheds Research Cooperative (WRC) (http://watershedsresearch.org/), with research at Hinkle Creek, the Alsea Watershed Study Revisited, and Trask Watershed, is contributing to our understanding of forest watersheds and the effectiveness of Oregon's Forest Practices Act (FPA) rules.

Partly from design and partly from serendipity, the three WRC studies address hydrology, water quality, and aquatic responses with different but complementary replication approaches. The first, Hinkle Creek, was designed to assess the effectiveness of Oregon's current FPA rules. It provides replication of managed and control watersheds for two reach types of concern: fish-bearing and non-fish-bearing streams. The study design also allows assessment of impacts at different watershed scales, from onsite impacts to downstream effects. The Alsea Watershed Study Revisited does not have the same replication of watersheds but instead replicates in time, directly comparing impacts of contemporary management with impacts that resulted from practices of the 1960s in the same watershed. The Trask Watershed looks at alternative riparian practices with replication of individual treatments along non-fish-bearing reaches, and also assesses how these impacts translate downstream. The conditions represented by these three watersheds reflect an important cross section of managed forests in Oregon.

---

[1] Watersheds Research Cooperative Policy Workshop. Salem, OR. November 13, 2013.

[2] Fellow (retired) with the National Council for Air and Stream Improvement, Inc. 24554 Alpine Road, Monroe OR 97456; (541) 424-3034.

WATER QUALITY FINDINGS

Forest Watershed Research

There are literally hundreds of forest research studies across the United States that have contributed to our understanding of forest water quality responses to forest management (Ice and Stednick 2004; NCASI 2012). The Alsea Watershed Study near Toledo OR was the first paired watershed study in the US to look at hydrology, water quality, fish, and fish habitat responses to alternative forest management practices simultaneously (Stednick 2008). The H.J. Andrews Experimental Forest has hosted key forest watershed research (Fredricksen et al. 1975), and both Oregon State University and the Oregon Department of Forestry have conducted important, sometimes groundbreaking, forest water quality research (e.g., Robison et al. 1999). However, no paired watershed study of contemporary forest practices had been conducted in Oregon since the Alsea Watershed Study was completed in 1973.

Distorted Perspective

Despite (or perhaps because of) this rich history of research, some people have a distorted view of how contemporary forest management affects water quality. Because no paired watershed research had been conducted in Oregon since the original Alsea Watershed Study, many believe the impacts observed then are inevitable consequences of forest management. This ignores the fact that the Oregon FPA was passed in large part to correct poor practices, and further changes have been made since the first rule package as new science has emerged. Forest practices in Oregon today are fundamentally different than they were in the 1960s. Key changes include recognition and protection of stream channels and riparian corridors, reduced soil disturbance during yarding and site preparation, and improved road construction and maintenance. Disconnecting of roads from streams is symbolic of this evolution in management practices.

Research showed that road segments draining directly to streams (direct delivery) can be an important source of suspended sediment (Bilby et al. 1989; Ketcheson and Megahan 1996; Furniss et al. 2000; Mills et al. 2007). Some early surveys found as much as 75% of the road network draining directly to streams. The forest community has been actively relocating and disconnecting legacy roads and constructing new roads to avoid these conditions. Martin (2009) reported on a survey of private forest roads covering more than 1000 miles of roads in eastern and western Washington. He found that 73% of the road network had low delivery potential (located on ridgelines, in shallow terrain, or without crossing defined channels). About half of the road system with high delivery potential was disconnected. Based on that survey, only about 12% of the road network was hydrologically connected with the stream. Mills et al. (2007) in Oregon and Dubé et al (2010) in Washington documented similar reductions in the length of the road network delivering directly to streams. It will be impossible to remove all direct delivery culverts and ditches, but the forest community is making progress and has other practices, such as special hardening of sensitive road segments, that reduce sediment impacts from roads.

Another distorting factor is a typically limited period of assessment. Almost invariably, forest watershed research is limited to a short period around management activities and does not account for the full management cycle of a forest (Hewlett 1979). This can leave the impression that impacts are perpetual. In addition, watershed scientists commonly use a control watershed that has not experienced recent disturbance to help assess the magnitude of any management impacts and account for weather patterns.[3] The choice of control watersheds without any recent disturbance tends to skew our perspective, because we know fire, insect outbreaks, windstorms, and other natural disturbances constantly shape forested watersheds (Ice and Schoenholtz 2002). Ironically, the United States Geological Survey's National Water Quality Assessment Program often chooses forested watersheds to serve as "least impaired" controls, yet these are sometime the same watersheds forest scientists are studying as "impacted."

Current Forest Practices Act rules effective

Compared to water quality impacts measured in benchmark studies at the Alsea Watersheds in coastal Oregon and H.J. Andrews Experimental Forest in the Oregon Cascades, impacts following the WRC harvests are small (Beschta and Jackson 2008; http://watershedsresearch.org/assets/reports/WRC_Skaugset_Hinkle%20Sediment_2013_S3.pdf). In the first benchmark studies suspended sediment loads increased 100 to 400% over expected values based on the paired watershed response. In the original Alsea Watershed Study the two treatment watersheds appear to have experienced increases in suspended sediment losses for different reasons: one as a result of severe channel disturbance and the other due to uncompacted sidecast road failures (landslides). Both issues were addressed in the Oregon FPA rules. Compared to these large impacts, sediment responses in WRC study basins harvested using contemporary practices are generally small. There appears to be no shift in suspended sediment concentrations for the treated watershed in the Alsea Watershed Study Revisited. Hinkle Creek increases in suspended sediment were in the range of 20 to 40%. Most of the increase is believed to have resulted from increased stream power due to elevated discharge, as no overt sediment delivery was observed. This is consistent with findings from other forest watershed studies across the US (NCASI 2012). In the Alto Watershed Project in Texas, sediment losses for contemporary forest practices with BMPs were 80 to 90% less than historic levels and were within the range of natural disturbance events (McBroom et al. 2008).

This story is repeated for stream temperature changes. Increases in temperature for harvests near fish-bearing streams were small compared to impacts we would have expected without FPA rules. In the Alsea Watershed Study Revisited we can look at water quality responses in the same watershed to compare effects with and without the Oregon FPA rules (Ice et al. 2011; http://watershedsresearch.org/assets/reports/WRC_Light_Alsea%20stream%20temps_2013_S2.pdf). The maximum temperature increase was about 1°F (7 day moving average of maximum daily water temperature) compared to as much as 18 to 25°F increases observed in the original study. There was also little temperature response in the harvests near fish-bearing reaches of Hinkle Creek.

There were also some surprises. The consensus among forest hydrologists was that harvests along non-fish-bearing reaches in Hinkle Creek would produce large stream temperature increases, perhaps approaching those observed in the original Alsea Watershed Study. FPA rules do not require shade retention along these types of streams. Instead, water temperature responses were small and variable (Kibler 2007). In some cases streamwater temperatures actually *decreased* following logging. The small responses were a result of shade produced by low-hanging shrubs and slash in the riparian area. The decrease in water temperature was probably a result of increased streamflow from reduced

[3] This requires stationarity; the development of a predictable relationship between the control and treated watersheds. Some have criticized the control watersheds used, arguing that human impacts are commonly found on these "least impaired" watersheds. However, for water quality and hydrology some forest hydrologists and statisticians have pointed out that if there are residual "impacts" to a control watershed and it continues to recover, then the "impacts" measured on the treated watershed will be overestimated (Hewlett et al. 1969; Thomas 1990).

evapotranspiration following harvesting. The headwater reach in the treatment watershed in the Alsea Watershed Study Revisited also showed little change in temperature, as waters remained very cold.

Recovery

Another finding was the rapid recovery of observed water quality changes. Changes in water quality resulting from forest management can diminish rapidly downstream and over time. Forest streams often have features, such as deep gravel deposits, that allow for mixing and muting of temperature increases. All water parameters are non-conservative, meaning that they do not transport downstream without reductions. Suspended sediment particles can be trapped in long-term storage or dissolve. Watershed scientists use the term "delivery ratio" to reflect the change in sediment amount delivered downslope or downstream from an erosion site. Delivery ratios are always less than one, often reflecting a large reduction in sediment delivered. Water temperature is constantly interacting with its environment to gain or lose heat. The Hinkle Creek study showed that temperature increases were not propagating far downstream. Nutrients may be taken up by aquatic or riparian plants. Forests also recover over time and provide the cover and forest floor conditions that provide high quality water resources. Even for severe disturbances such as the original Alsea Watershed Study, temperatures recovered to within the range of values observed in the 1959-1965 pre-treatment period (Hale 2007).

Unattainable Water Quality Criteria and Standards

One surprising finding was the consistent drop in dissolved oxygen (DO) concentrations observed in Needle Branch (Alsea Watershed Study) during the pre-treatment period (http://watershedsresearch.org/assets/reports/WRC_Ice_Dissolved%20Oxygen_2013_S2.pdf). This natural phenomenon appears to be a result of low summer and fall streamflows experienced in Needle Branch, which create reaches that go subsurface. Other researchers have found that low DO concentrations in streams can be used to identify "gaining" reaches with groundwater inputs (Werner et al. 2007). Low DO concentrations are normally associated with high stream temperatures and organic loads. Here we have a watershed without human disturbance for four decades, yielding cold water temperatures, that consistently experiences low DO concentrations and violates Oregon's water quality criteria. Perhaps we should not have been too surprised with this, as we found that small headwater forest watersheds sometimes cannot meet state water quality criteria or standards. The control watershed in the Alsea Watershed Study, Flynn Creek, has one of the highest nitrate-N concentrations found in the Oregon Coast Range, even though it has not been managed since wildfires in the 1800s and it is a USDA Forest Service Research Natural Area. It also experiences high stream temperatures, approaching the state water quality standard (Hale 2007), and has failed macroinvertebrate indicators for sediment impairment (http://www.deq.state.or.us/wq/assessment/2010Report.htm). Similarly, pre-treatment monitoring at Hinkle Creek found stream temperatures to be highly variable between adjacent sub-basins, with some streams exceeding state water quality standards *before harvesting*.

Previous research showed that water quality criteria may not be attainable, even for least-impaired forest watersheds. A survey of nutrient data from small unmanaged forest watersheds in the USDA Forest Service Experimental Forest and Range network found that nutrient criteria proposed by EPA could not be attained for a significant number of sites (NCASI 2001; Ice and Binkley 2003). Additional surveys and investigations found that water quality criteria for unmanaged or least-impaired waterbodies could exceed water quality criteria for important water quality parameters such as sediment and turbidity (Markman 1990), temperature (Ice et al. 2004), and DO (Ice and Sugden 2003).

An ongoing court case, *Barnum Timber Company versus EPA*, is addressing this issue as part of state listings of impaired waterbodies.

Technology

Advances in technology and statistical methods make it possible to detect very small changes that would have been undetected in the past. Water temperature used to be measured using bulky, wound thermographs that mechanically charted temperature. These required frequent servicing and downloading of the paper-charted temperature record. Today, a temperature probe costing $100 can record data for an entire summer and be quickly downloaded directly to a computer database. DO concentrations were historically measured using the Winkler titration method and later with polarographic probes. The probes needed constant stirring and frequent changes of the membranes and reactive solution to avoid "drift" in measurement calibration. Today, a luminescent DO probe can be deployed to collect data every 30 minutes for several days without servicing, and data can be quickly downloaded to a database. These advances have increased our ability to collect data in remote locations at numerous sites and over long periods. The scale of changes in water quality that can be detected needs to be compared to natural variations between basins and years, to assess whether changes that are statistically significant are also ecologically significant. For example, we looked at how suspended sediment loads varied for the three Alsea Watersheds during the 1959-1965 pre-treatment period. During this time all three watersheds were described as having old-growth forest stands. For this seven year period (before management activities) suspended sediment loads varied between 1000 and 2500% for the three watersheds. The average suspended sediment loads (adjusted for watershed size) between the three watersheds during this period varied by ±45%. By using the paired watershed approach scientists were able to detect the 100 to 400% increases in the original study and we should be able to detect the smaller changes in our contemporary studies, but is it affecting aquatic communities that have developed in this type of variability? Maximum temperatures experienced annually during this same period varied by 1.7 to 2.8°C for the three watersheds and the difference in maximum annual water temperature observed between watersheds was 0.6°C.

Diminishing Returns

There is some debate about whether improvements in water quality protection under the current FPA rules are adequate. Scientists and the public generally agree about the value of FPA rules such as streamside management zones to provide shade, litter, large wood, and streambank stabilization. There is less recognition of the "law of diminishing returns," where additional investments in conservation offer diminishing benefits. This is clearly shown in graphs developed to display riparian functions, where benefits for shading, sediment removal, chemical removal, and fine and coarse organic inputs decrease rapidly away from the stream (NCASI 2000), but it is true for all conservation rules. One of the most exciting areas of investigation is optimization schemes. Agricultural research has recently explored methods to optimize investments to achieve water quality objectives, using models such as the Comprehensive Economic and Environmental Optimization Tool (CEEOT) (Osei et al. 2000). These approaches could result in returning the most water quality benefits to the public for a given investment by forest landowners. For example, a study recently tested whether there might be a net environmental benefit to expanding buffer protection on headwater streams with commensurate reductions in the area buffered along larger streams (Dr. Jami Nettles, Weyerhaeuser Company, pers. comm.).

Forest aquatic communities have developed in dynamic systems that vary between watersheds, annually, daily, and in response to disturbance events. Small temperature changes following contemporary timber harvests are often statistically but probably not ecologically significant, and increases diminish rapidly both downstream and over time. Shouldn't regulatory agencies and others consider whether the costs of further reductions in temperature increases might be better invested in other watershed restoration or protection activities such as road restoration or large wood additions?

MANAGEMENT IMPLICATIONS

Based on these findings, management implications include:

Oregon's Forest Practice rules are effective: Suspended sediment responses are reduced by 80 to 90% compared to historic impacts. Similarly, stream temperature increases are reduced to about 1°F or less with current riparian protection compared to increases of 18 to 24°F observed in the original Alsea Watershed Study. We were surprised that small non-fish-bearing streams with adjacent harvesting did not experience major stream temperature increases, but this appears to be a result of protection of the stream channel and especially avoiding hot prescribed fires in these areas.

Water quality impacts from forest management diminish downstream and over time: At Hinkle Creek stream temperatures in headwater streams recovered within a few hundred meters. At the Alsea Watershed Study Revisited temperatures had returned to within the pre-harvest range in about 7 to 10 years.

***Water quality criteria used to assess "effectiveness" are often unattainable*:** Most state water quality criteria were developed for large streams or rivers without considering the natural variability inherent to headwaters. During pre-treatment periods for these watershed studies we have found instances where water would not meet state water quality criteria.

Technology allows measurement of small changes in water quality: New instruments allow watershed scientists to detect small water quality changes but these changes may be within the range of natural conditions or may benefit some aquatic community components.

There is a law of diminishing returns for the effectiveness of rules: Small temperature changes following contemporary timber harvests are often statistically but probably not ecologically significant, and increases diminish rapidly both downstream and over time.

REFERENCES

Beschta, R.L., and Jackson, W.L. 2008. Forest practices and sediment production in the Alsea Watershed Study. 55-66 in Stednick, J. [Ed.]. *Hydrological and Biological Responses to Forest Practices: The Alsea Watershed Study*. New York: Springer Science+Business Media.

Bilby, R.E., Sullivan, K., and Duncan, S. 1989. The generation and fate of road-surface sediment in forested watersheds in southwestern Washington. *Forest Science* 35:453-468.

Dubé, K., Shelly, A., Black, J., and Kuzis, K. 2010. *Washington road sub-basin scale effectiveness monitoring first sampling event (2006-2008) report*. Cooperative Monitoring, Evaluation and Research Report CMER 08-801. Olympia, WA: Washington State Department of Natural Resources.

Fredricksen, R.L., Moore, D., and Norris, L. 1975. The impact of timber harvest, fertilization, and herbicide treatment on streamwater quality in western Oregon and Washington. 293-313 in

Bernier, B., and Winger, C. [Eds.]. *Forest Soils and Land Management*. Quebec: Laval University Press.

Furniss, M.J., Flanagan, S.A., and McFadin, V. 2000. Hydrologically-connected roads: An indicator of the influence of roads on chronic sedimentation, surface water hydrology, and exposure to toxic chemicals. *Stream Notes* (July).

Hale, V.C. 2007. *A Physical and Chemical Characterization of Stream Water Draining Three Oregon Coast Range Catchments*. MS thesis. Corvallis, OR: Oregon State University.

Hewlett, J.D. 1979. *Forest Water Quality: An Experiment in Harvesting and Regenerating Piedmont Forest*. Athens, GA: University of Georgia School of Forest Resources.

Hewlett, J.D., Lull, H.W., and Reinhart, K.G. 1969. In defense of experimental watersheds. *Water Resources Research* 5(1):306-316.

Ice, G., and Binkley, D. 2003. Forest streamwater concentrations of nitrogen and phosphorus. A comparison with EPA's proposed water quality standards. JOURNAL OF FORESTRY 101(1):21-28.

Ice, G.G., Light, J., and Reiter, M. 2004. Use of natural temperature patterns to identify achievable stream temperature criteria for forest streams. *Western Journal of Applied Forestry* 19(4):252-259.

Ice, G., Louch, J., Cook, D., Bousquet, T., Light, J., Hale, C., McDonnell, J., Bateman, D., Li, J., Gerth, B., Stednick, J., and Schoenholtz, S. 2011. The Alsea Watershed Study Revisited: A half century of new lessons. Paper presented at Society of American Foresters National Convention, Honolulu, HI.

Ice, G., and Schoenholtz, S. 2002. Understanding how extremes influence water quality: Experience from forest watersheds. *Hydrological Science and Technology* 19(1-4):99-108.

Ice, G.G., and Stednick, J.D. 2004. *A Century of Forest and Wildland Watershed Lessons*. Bethesda, MD: Society of American Foresters.

Ice, G., and Sugden, B. 2003. Summer dissolved oxygen concentrations in forested streams of northern Louisiana. *Southern Journal of Applied Forestry* 27(2):92-99.

Ketcheson, G.L., and Megahan, W.F. 1996. *Sediment production and downslope sediment transport from forest roads in granitic watersheds*. Research Paper INT-RP-486. Ogden, UT: United States Department of Agriculture Forest Service, Intermountain Research Station.

Kibler, K.M. 2007. *The Influence of Contemporary Forest Harvesting on Summer Stream Temperatures in Headwater Streams of Hinkle Creek, Oregon*. MS thesis. Corvallis, OR: Oregon State University.

Krygier, J.T., and Hall, J.D. [Eds.]. 1971. *Proceedings of a Symposium – Forest Land Uses and Stream Environment*. Corvallis, OR: Oregon State University.

Markman, S.G. 1990. *Longitudinal Variation in Suspended Sediment and Turbidity of Two Undisturbed Streams in Northwestern California in Relation to the Monitoring of Water Quality Above and Below a Land Disturbance*. MS thesis. Arcata, CA: Humboldt State University.

Martin, D. 2009. *Forest road runoff disconnection survey for private timberlands in Washington*. Olympia, WA: Washington Forest Protection Association.

McBroom, M.W., Beasley, R.S., Chang, M., and Ice, G.G. 2008. Storm runoff and sediment losses from forest clearcutting and stand re-establishment. *Hydrological Processes* 22(10):1509-1522.

Mills, K., Dent, L., and Cornell, J.L. 2007. Rapid survey of road conditions to determine environmental effects and maintenance needs. Presented at 9th International Conference on Low-Volume Roads, Austin, TX.

National Council for Air and Stream Improvement, Inc. (NCASI). 2000. *Riparian vegetation effectiveness*. Technical Bulletin No. 799. Research Triangle Park, NC: National Council for Air and Stream Improvement, Inc.

National Council for Air and Stream Improvement, Inc. (NCASI). 2001. *Patterns and processes of variation in nitrogen and phosphorus concentrations in forested streams*. Technical Bulletin No. 836. Research Triangle Park, NC: National Council for Air and Stream Improvement, Inc.

National Council for Air and Stream Improvement, Inc. (NCASI). 2012. *Assessing the Effectiveness of Contemporary Forestry Best Management Practices (BMPs): Focus on Roads*. Special Report No. 12-01. Research Triangle Park, NC: National Council for Air and Stream Improvement, Inc.

Osei, E., Gassman, P.W., Jones, R.D., Pratt, J., Hauck, L.M., Beran, L.J., Rosenthal, W.D., and Williams, J.R. 2000. Economic and environmental impacts of alternative practices on dairy farms in an agricultural watershed. *Journal of Soil and Water Conservation* 55(4):466-472.

Robison, E.G., Mills, K.H., Paul, J., Dent, L., and Skaugset, A. 1999. *Oregon Department of Forestry Storm Impacts and Landslides of 1996: Final Report*. Forest Practices Technical Report 4. Salem, OR: Oregon Department of Forestry Forest Practices Monitoring Program.

Stednick, J. 2008. *Hydrological and Biological Responses to Forest Practices: The Alsea Watershed Study*. New York: Springer Science+Business Media.

Thomas, R.B. 1990. Problems in determining the return of a watershed to pretreatment conditions: Techniques applied to a study at Caspar Creek, California. *Water Resources Research* 26(9):2079-2087.

Werner, S.F., Browne, B.A., Wallschlaeger, C.W., Wyss, J.R., and Bowling, J.M. 2007. Dissolved gases as indicators for stream-ground water interactions. Abstract H51-0460. Abstracts to Fall meeting of American Geophysical Union. http://adsabs.harvard.edu/abs/2007AGUFM.H51B0460W