Andrews Forest LTER

Midterm Review Report
July 2011

HJA
HJ ANDREWS EXPERIMENTAL FOREST

OSU
Oregon State University

FOREST SERVICE
U S
DEPARTMENT OF AGRICULTURE

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EXECUTIVE SUMMARY

The H.J. Andrews Experimental Forest was already a productive research station when it was selected as a Long Term Ecological Research (LTER) site in 1980 by the National Science Foundation (NSF). Today, the Andrews Forest is a nationally-recognized center for research, education, research-management partnerships, and science-humanities connections relating to forest and forest-stream ecosystems. It is a very large program, and it is safe to say that no single person is truly aware of all of the moving parts of the overall program. This report is designed to provide a summary of the major components of the program. It is specifically targeted for the team that will be visiting the Andrews site in August, 2011, to conduct a midterm review of the Andrews LTER program for NSF, although the report should also be useful to anyone who is interested in the Andrews program. Most of the information provided in the report is available on the Andrews website (http://andrewsforest.oregonstate.edu/), but the report pulls together information in a way that we hope will assist the midterm review committee. The report is organized according to the five major review criteria established by NSF for mid-term program reviews of LTER sites—scientific merit, information management, site management, network participation, and outreach/education. In addition we have included a separate "Humanities" section because our site has been particularly proactive in establishing connections between environmental scientists and creative artists (writers, philosophers, musicians, and more), and these connections are not "outreach" so much as they are new forms of interdisciplinary collaboration. In each case we have provided information that we hope will help members of the midterm review committee evaluate the quality, productivity and impact of our program.

Throughout this report we refer to our site as both "HJA" (the H.J. Andrews Experimental Forest) and "AND." AND is the designation for the Andrews LTER program and is the primary research entity of the HJA, but the HJA has research, financial support, educational activities and personnel that are outside of AND. We refer to the broader research/education program at the HJA as the "Andrews Forest Program." This Midterm Review Report focuses primarily on the current funding cycle for AND. This is our sixth funding cycle, and we use the term "LTER6" to refer to the current project. Because AND is intimately connected to the HJA and the broader Andrews Forest Program, we also provide information about the broader program. AND is an important component in many other, independently-funded research projects that utilize the HJA site or AND data and involve collaborations with AND personnel. We call these "LTER-related" projects and we identify them because they leverage the human and financial capital invested in the AND program and in some cases they are essential for accomplishing our LTER6 goals.

I. INTRODUCTION

I.A. SITE DESCRIPTION

The H.J. Andrews Experimental Forest is situated in the western Cascade Range of Oregon in the 15,800-acre (6400-ha) drainage basin of Lookout Creek, a tributary of Blue River and the McKenzie River. Elevation ranges from 1350 feet (410 m) to 5340 feet (1630 m) (Fig. I.A.1). Broadly representative of the rugged mountainous landscape of the Pacific Northwest, the Andrews Forest contains excellent examples of the region's conifer forests and associated wildlife and stream ecosystems. The site is situated in the Pacific Northwest-North Pacific Ocean Bioclimatic region, which is dominated by cool, wet conditions derived from the North Pacific Ocean. The wet-dry seasonal climate favors development of massive, long-lived conifers and forest stands with periodic disturbance by wildfire. Rapidly flowing mountain streams are the primary type of aquatic ecosystem in the Andrews Forest. Season trends in streamflow closely follow the precipitation pattern and winter maximum flows are three orders of magnitude larger than summer minima. When it was established in 1948, the Andrews Experimental Forest was covered with virgin forest. Before timber cutting began in 1950, about 65% of the Andrews Forest was in old-growth forest (~500 years old) and the remainder was largely in mature stands developed after wildfires in the mid-1800s to early 1900s. Clearcutting and shelterwood cuttings over about 30% of the Andrews Forest have created young plantation forests varying in composition, stocking level, and age that continue to be studied.

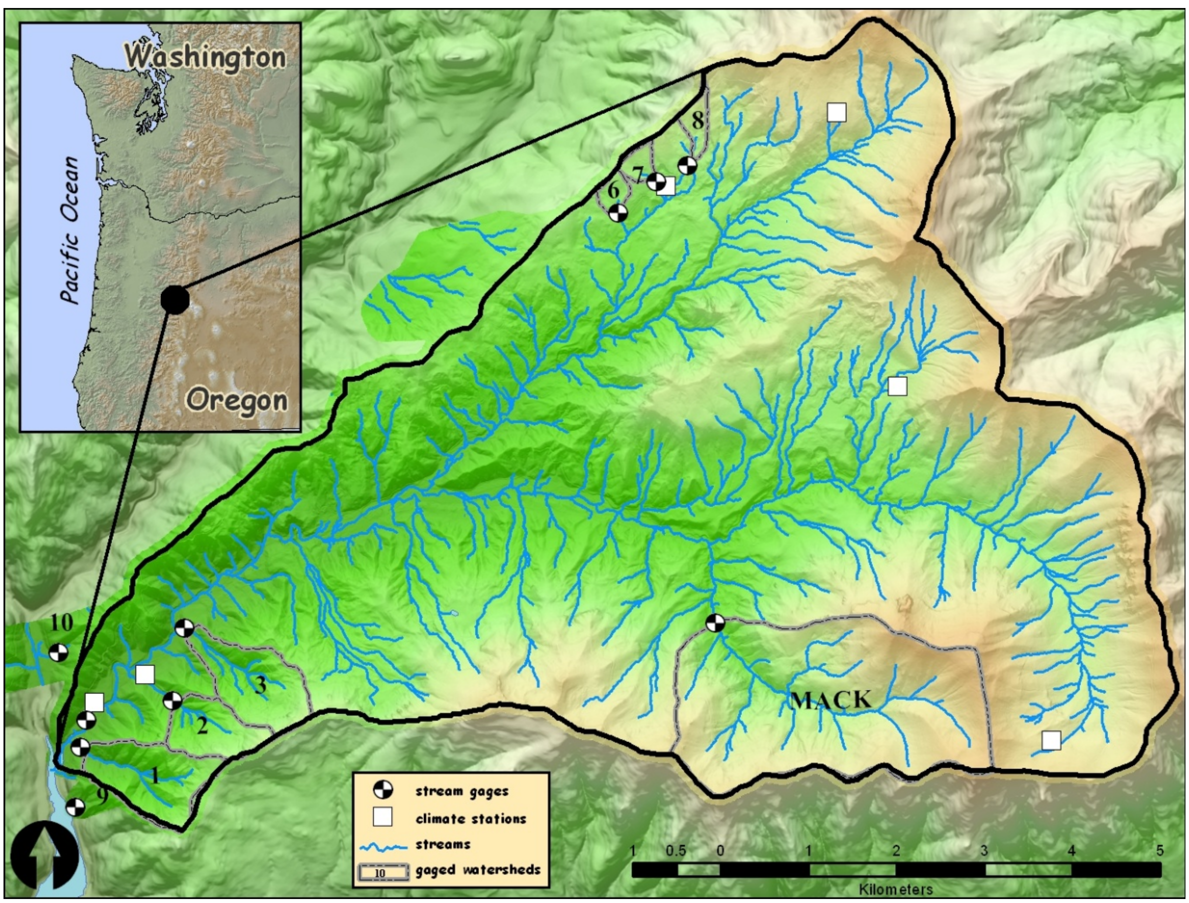


Fig. I.A.1. Map of the H.J. Andrews Experimental Forest LTER Site

I.B. History of the Andrews Program

Over its 31-year history, the Andrews LTER ("AND") program has remained a major center for analysis and knowledge of forest and stream ecosystems in the Pacific Northwest. Today, several dozen university and federal scientists use this Experimental Forest/LTER site as a common meeting ground, working together to gain basic understanding of ecosystems and to apply this knowledge in management and policy.

The Andrews Forest program has its roots in the establishment of the H. J. Andrews Experimental Forest (HJA) by the US Forest Service in 1948 (Fig. I.B.1.). This began two decades of predominantly Forest Service research in the 1950s and 1960s on the management of watersheds, soils, and vegetation. With the inception of the International Biological Programme-Coniferous Forest Biome (IBP) in 1969, university scientists began to play increasingly important roles in the Andrews program. Focus shifted from single disciplines to interdisciplinary research on forest and stream ecosystems, especially old-growth forests. IBP ended in the late 1970s and LTER commenced in 1980, with AND among the initial cohort of six sites.

The first decade of LTER work at AND solidified a foundation of long-term field experiments as well as long-term measurement programs focused on climate, stream flow, water quality, vegetation succession, and biogeochemical cycling (see the Andrews Forest website for a complete list of online databases: http://andrewsforest.oregonstate.edu/). As AND has matured, we aim to preserve the integrity of the long-term measurements and experiments and to focus on long-term research goals even as we adapt them to new questions and emerging technologies. Along the way we have discovered that the long-term commitment to interdisciplinary, site-based inquiry has created a powerful and resilient community of LTER researchers and educators. Ultimately, this community, and the way it freely exchanges values and ideas across the scientific community may be our most valuable and precious asset.

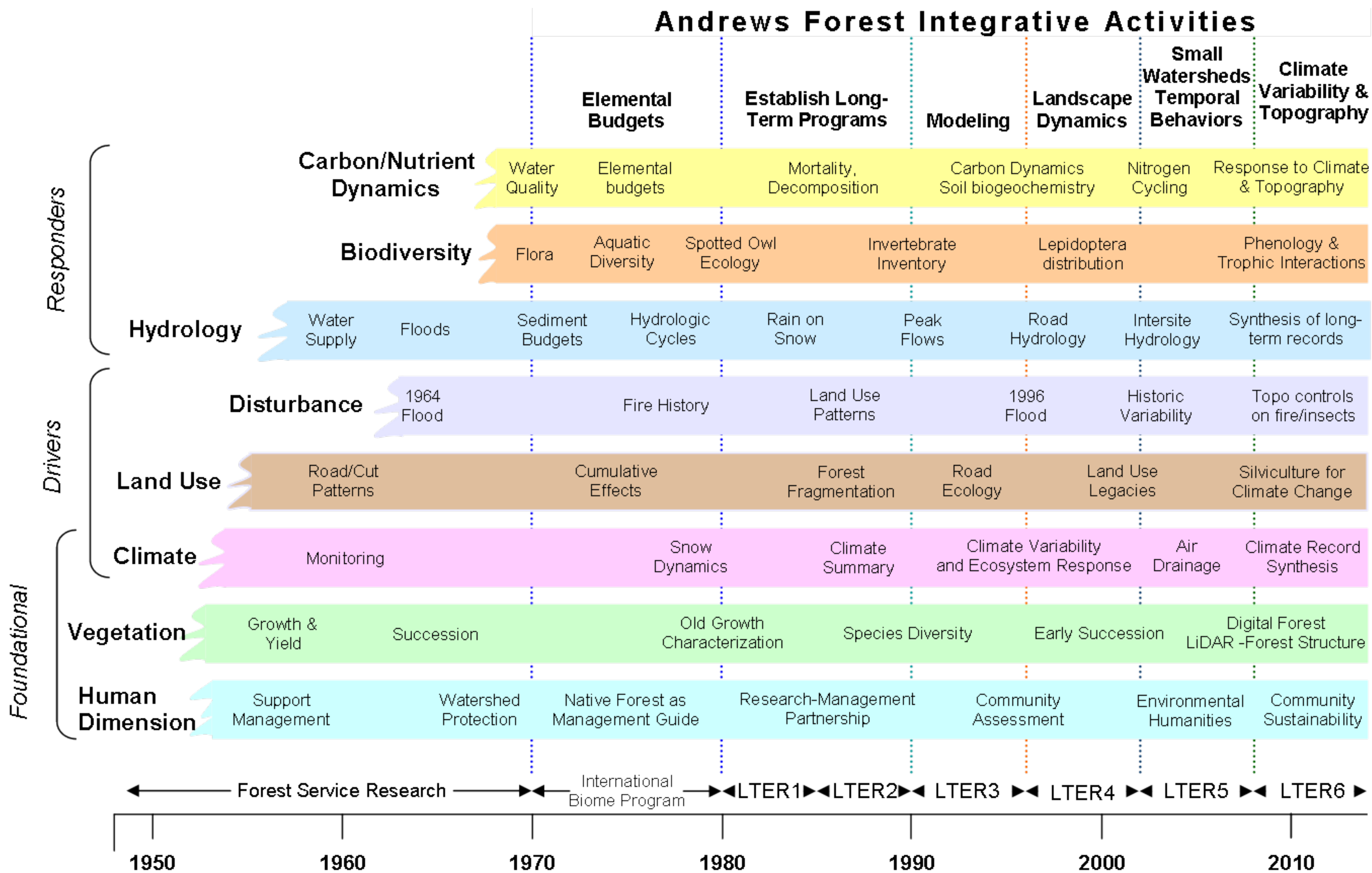


Figure I.B.1. Timeline of major research themes (horizontal bars), prominent topics within each theme (e.g., Water Quality within Carbon/Nutrient Dynamics theme bar), and integrative activities (integration across several themes during a grant period, such as LTER5, as a vertical time slice through the themes). Over time the level of integration has increased, weaving the individual themes into a more holistic, interdisciplinary view of ecosystem structure and function. See http://andrewsforest.oregonstate.edu/lter/about/site/history/HJA Timeline 0708.pdf for more detail.

I.C. Conceptual Framework

I.C.1. Overview of the Central Question and conceptual development of the Andrews program

The AND Central Question, "How do land use, natural disturbances, and climate affect three key ecosystem properties: carbon and nutrient dynamics, biodiversity, and hydrology?" was developed in LTER3 (our third funding cycle). At the time we knew that addressing this question would require decades of supporting measurements, experimentation, and conceptual advances as well as integration and synthesis across disciplinary boundaries. This question serves more as common framework for our long-term studies than as a specific, achievable goal. In each funding cycle we have focused on different themes and specific hypotheses that help us explore critical dimensions of the Central Question.

I.C.2. Evolution of research LTER themes at the Andrews

In pursuit of the Central Question we have focused on a process-based understanding of landscape dynamics (LTER3); effects of early succession on ecosystem dynamics and impact of species attributes on ecosystem dynamics (LTER4); and small watershed behavior and temporal behaviors (LTER5) (Fig. I.C.2). Work under the integrated themes has improved our understanding of the system's behavior. During LTER5 we made significant progress in understanding how our system's climate is influenced by topography and how this introduces asynchrony across our forested landscape. We also gained insights into the complexities of interacting biogeochemical cycling in small watersheds in the Small Watershed Synthesis area. These findings and insights inspired a focus in LTER6 on the roles of topography on interactions among drivers and responders, including feedback responses, and in addition stimulated an interest in how the highly diverse topography of the HJA may influence ecosystem responses to potential climate change. In addition, the AND community resonates very positively with the directions established in the LTER Network's plan, *Integrated Science for Society and Education* (ISSE), and we are expanding our conceptual organization in a way that is consistent with both the AND Central Question and the ISSE.

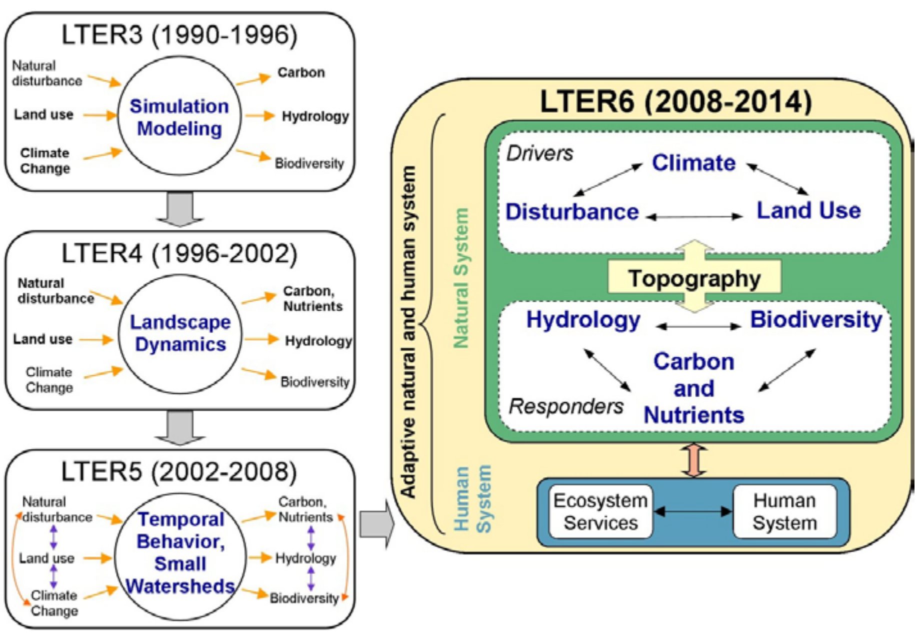
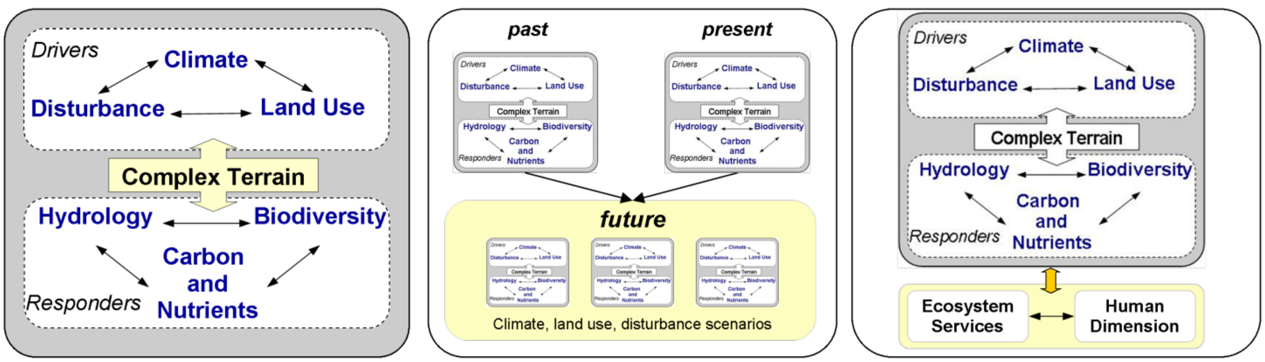


Figure I.C.2. The evolution of the Central Question and conceptual framework for AND research

I.C.3. Goals, Hypotheses and Objectives of LTER6

The conceptual organization of LTER6 highlights three complementary goals (Fig. 1.C.3.). The complex terrain and dense canopy cover of our site profoundly influence biodiversity, ecosystem processes and services, and their likely responses to climate variability and change. Therefore, in Goal I we aim to develop a deeper understanding of the Central Question in the context of complex terrain. For Goal II, we are applying this mechanistic understanding to evaluate potential future responses to change scenarios, and in Goal III we are expanding our inquiry to consider the Andrews Forest as a coupled natural/human system. It is important to acknowledge that we knew in advance that the LTER core budget allocations from NSF would be insufficient to accomplish these goals. In all cases we rely on researchers to leverage LTER funds to both accomplish and expand the core goals. Goal III is particularly novel in that we were not able to allocate any funds from the LTER budget for this goal, and yet we felt it was imperative to include the goal explicitly in the proposal in order to create a priority and hold ourselves accountable for progress in these areas. We expect our research and outreach to provide information to better inform decision-making in society about natural resources locally and regionally. As part of the full LTER network, AND contributes to science that informs understanding and prediction of responses of the nation's and globe's ecological responses to environmental change. In this report we present results and findings from activities that extend far beyond LTER funding, but as it was our intent all along to leverage LTER funds, we feel this is reasonable.



(A). **Goal I: Complex terrain and canopy cover moderate interactions between drivers and responders**

Multiple processes at micro-, meso-, and regional scales affect relationships between microclimate and regional climate.

Cold air drainage transiently decouples low elevation microclimates from regional climate; hence low elevation is less sensitive than high elevation to climate variability.

Heterogeneity and multiple flow paths of C, N and water cycle processes at small scales reduce sensitivity of fluxes and flows at larger scales to variability in drivers.

Complex terrain alters the sensitivity of trophic interactions to drivers.

(B). **Goal II - Complex terrain moderates ecosystem responses to future change**

High elevation will be more sensitive than low elevation to climate change due to tighter atmospheric coupling and rain/snow threshold

Climate-induced changes in disturbance (fire, pests) will have greater impact on future ecosystem structure and function than will the direct effects of climate change.

Complex terrain will mitigate potential trophic responses to climate change, such as asynchrony in phenology.

(C). **Goal III - Shared understanding of roles and capacities among environmental scientists, social scientists and local communities and institutions promotes adaptive management for future change.**

Social networks and research-management partnerships are required to develop policies for forest management for future climate change.

Exploration of alternative futures helps communities and institutions make choices, openly and adaptively.

Societal decisions about natural resource use depend on awareness of ecological services

Figure I.C.3. The three overarching goals of AND LTER6 research.

I.C.4. Research structure

Our research is organized within a set of eight discipline-focused themes that maintain continuity of long-term measurements and experiments, and another set of interdisciplinary, Integrated Research Projects that cut across the discipline-focused themes. The discipline-focused themes (also known as "component areas") are sustained over LTER funding-cycles, with slight modifications to adapt to changing research objectives and personnel. Although these do not map 1:1 to the "Core Areas" of the LTER Network, they are closely related (Table 1.C.4.1).

Table I.C.4.1 Relationship between AND long-term measurements and experiments and LTER Network Core Areas

AND Long-Term Measurements	LTER Network Core Area
Biodiversity	Populations/Trophic Structure (2)
Carbon and Nutrients	Primary Production (1), Organic Matter (3), Nutrient Cycling (4)
Climate	Primary Production (1), Populations/Trophic Structure (2), Organic Matter (3), Nutrient Cycling (4), Disturbance (5)
Disturbance	Disturbance (5)
Hydrology	Nutrient Cycling (4)
Soils	Organic Matter (3)
Stream Ecology	Populations/Trophic Structure (2), Nutrient Cycling (4)
Vegetation	Primary Production (1), Populations/Trophic Structure (2)

The long-term measurements and experiments yield research products that are broader than the specific goals and objectives of LTER6, and many are also important foundations for the specific goals of this funding cycle. Complementing the long-term measurements and experiments, we have defined six Integrated Research Projects in LTER6 that are specific to this funding cycle (Table. I.C.4.2). These are structured to address the specific goals, objectives and hypotheses presented in the current proposal. One of them ("Digital Forest") provides a foundation for much of the other LTER6 research, another ("Intensifying connections with society and social sciences") helps chart a new research direction. The remaining projects integrate the information from several long-term measurements and experiments and in some cases employ new measurements. The integrated projects are themselves linked via the three LTER6 goals to promote broader synthesis.

Table I.C.4.2. Contributions of AND long-term measurements and experiments and LTER6 Integrated Research Projects to LTER6 Goals and Objectives

Research Area	LTER6 Goals and Objectives
Long term measurements and experiments	
Biodiversity	Goal I, objective 3; Goal II, objective 3
Carbon and Nutrients	Goal I, objective 2
Climate	Goals I and II; all objectives
Disturbance	Goal II, objective 4
Hydrology	Goal I, objective 2
Soils	Goal I, objective 2
Stream Ecology	Goal I, objective 3; Goal II, objective 3
Vegetation	Goal I, objective 2
Integrated Research Projects	
Digital Forest	Goals I and II, all objectives
Long-term trends at the Andrews Forest: what's changing and what's not?	Goal I, objectives 2 and 3
Phenology and trophic interactions in complex terrain	Goal I, objective 3; Goal II, objective 3
Carbon and water cycle processes within a small watershed: the role of complex terrain	Goal I, objective 2; "CyberForest" objectives (as described in the LTER6 proposal)
Potential effects of future change	Goal II, objective 2; Goal 2 objective 4
Intensifying connections with society and social sciences	Goal III

II. Scientific Merit

II.A. Research Productivity

The AND has a strong history of publications (Fig II.A.1). From the start of LTER6 to present, the Andrews LTER program has produced 160 publications including 109 journal articles, 8 book chapters, and 26 dissertations and theses. Additional manuscripts are in review. For a list of LTER6 publications, see Appendix 1. Publications are available online via a searchable bibliography on the Andrews Forest website, http://andrewsforest.oregonstate.edu.

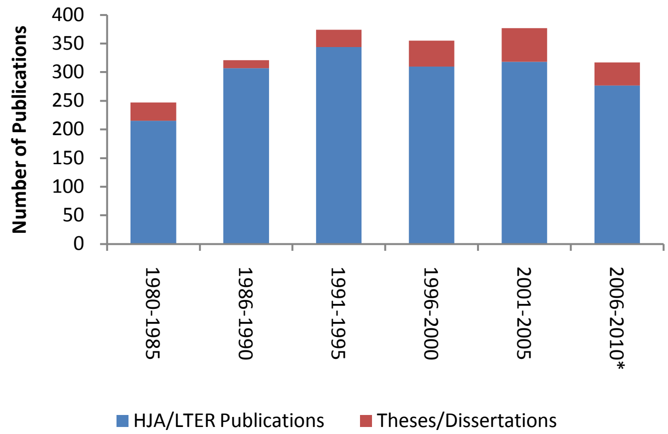


Figure II.A.1. Publications from the Andrews Forest program, 1980-2010. **the number of publications for the 2006-2010 period may not be complete*.

II.B. Research Summaries

II.B.1. Biodiversity

Project objectives and relationship to LTER6 goals: Long-term measurements of biodiversity play an important role in LTER6 for addressing questions relating phenology and trophic interactions, especially questions relating to the influences of complex terrain and potential impacts of climate change (Goal I, objective 3; Goal II, objective 3).

Activities: Continued study of long-term vegetation dynamics in LTER6 has been undertaken to examine controls of landscape position on vegetation. Research has examined climate and biotic controls on tree invasion in high elevation meadows. Studies have examined the diversity of Lepidoptera, their distribution in the landscape, and the sensitivity of emergence to climate and topographic position. Surveys of birds have been undertaken in three summers, combined with bioacoustical monitoring of bird activity. Studies of long-term records of owl pellet data have been used to create maps of small mammal prey in the landscape.

Common moth species in the Andrews Forest

Progress Report: Studies of exotic plants and their roles in forest and meadow succession tested hypotheses about whether exotic plant invasion is regulated by invisibility (properties of the community being invaded) or species invasiveness (properties of the invasive species); results in moth environments indicate that invasiveness is the more important factor. Using 16 yr of species richness and abundance data from 1 m2 plots in a clearcut and burned forest in the Cascade Range of western Oregon, Compagnoni and Halpern (2009) showed that at peak abundance, neither cover nor density of exotics differed between controls and plots from which native, mid-successional dominants were removed (Fig. II.B.1.1). Natives and exotics did not differ consistently for any measure of colonizing ability or population success (i.e. rate of spread, rate or magnitude of increase in local density, or persistence). In this early successional system, local richness and abundance of exotics are not explained by properties of the native community, by the presence of dominant native species, or by superior colonizing ability among exotics species. Instead natives and exotics exhibit individualistic patterns of increase and decline suggesting similar sets of life-history traits leading to similar successional roles.

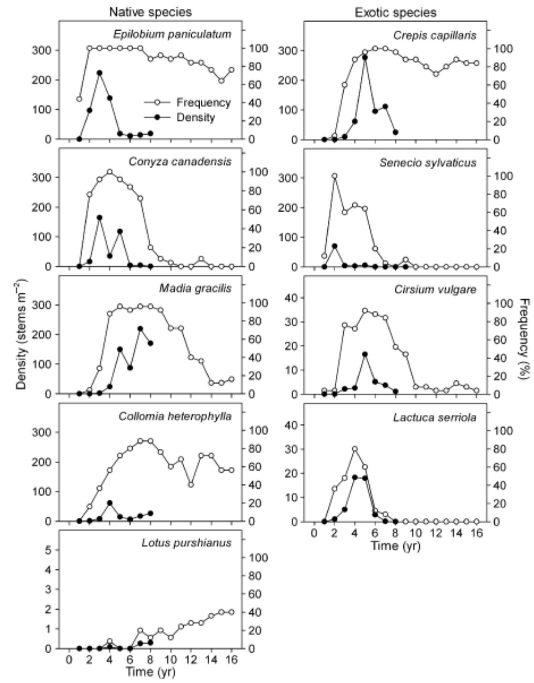


Fig. II.B.1.1. Patterns of native and exotic species did not differ in WS1 (Compangnoni and Halpern 2009)

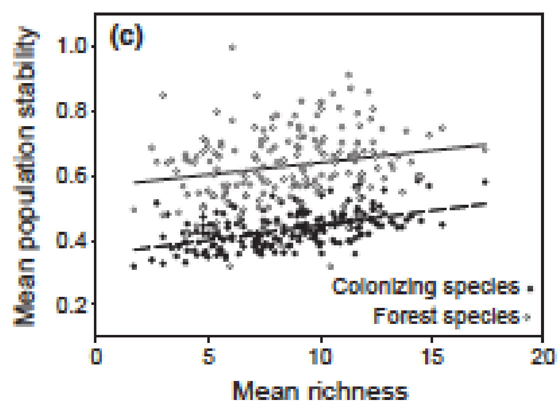


Fig. II.B.1.2. Stability was positively related to diversity in WS1 and WS3 (Dovciak and Halpern 2010)

In a study of exotic plants in meadows, Firn et al. (2011) used data from the Andrews Forest Nutnet site and 38 other Nutnet sites in eight countries, and showed that species abundances were similar at native (home) and introduced (away) sites – grass species were generally abundant home and away, while forbs were low in abundance, but more abundant at home. Sites with six or more of these species had similar community abundance hierarchies, suggesting that suites of introduced species are assembling similarly on different continents. Overall, Firn et al (2011) found that substantial changes to populations are not necessarily a pre-condition for invasion success and that increases in species abundance are unusual. Instead, abundance at home predicts abundance away.

Other research has used long-term data from vegetation plots in clearcut WS1 and WS3 to test the relationship between diversity and stability. Dovciak and Halpern (2010) found that mean stability of all species pooled was positively correlated to diversity over the four decades of study (Fig. II.B.1.2) and that this positive diversity–stability relationship and the overall stability of populations did not vary among communities regardless of composition or position along the soil moisture ⁄ productivity gradient.

Long-term vegetation research also has examined how abiotic (climate, soil) and biotic (competition, facilitation) factors influence tree invasion of montane meadows. Halpern et al (2010) examined tree invasion (by *Pinus contorta* and *Abies grandis*) in a montane meadow at Bunchgrass Ridge (10 km E of the Andrews Forest) beginning in the late 1700s (Fig. II.B.1.3). They found that older (>90 yr) *P. contorta* were randomly distributed, but older *A. grandis* were strongly clustered (0.2-20 m). Younger (<90 yr) stems were clustered at small distances (both within and between species), but were spatially displaced from older *A. grandis,* suggesting a temporal shift from facilitation to competition.

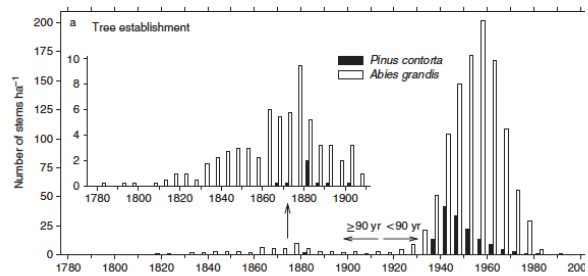


Fig.II.B.1.3. *Pinus contorta* and *Abies grandis* facilitated invasion of tree seedlings initially, but after 90 yrs *A. grandis* competed with itself (Halpern et al 2010)

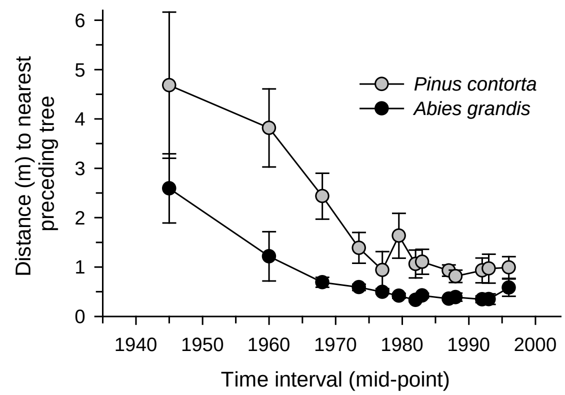


Fig. II.B.1.4. *Pinus contorta* consistently established further than *Abies grandis* from nearest preceding neighbor tree (Rice 2009)

In a study of a more recently invaded montane meadow Rice (2009) found that distances to nearest preceding tree decreased over the period of invasion, but *P. contorta* consistently established further than *A. grandis* from nearest preceding neighbors (Fig. II.B.1.4).

Other work in montane meadows has examined mechanisms that promote the invasion of perennial grasslands by annual grasses. Using the montane meadows of the Andrews Forest as study sites, Moore (2010) used a metapopulation disease model to identify the potential effects of landscape connectivity, patch heterogeneity, and host community composition on the spread, prevalence, and persistence of multi-host pathogens at the local and regional scales. In an observational study of barley and cereal yellow dwarf viruses (B/CYDV) in a set of Cascades meadows, Moore (2010) found that patterns of disease prevalence are primarily driven by the diversity and composition of the local host community; *Festuca idahoensis* individuals were more likely to be infected than *Elymus glaucus* or *Bromus carinatus*. Manore (2011) developed a mathematical model to determine how pathogen-mediated interactions between perennial and annual competitors are altered at the local and regional scale when the host populations are spatially structured. Application of the model by Manore (2011) and Moore et al. (2011) showed that the spatial configuration of the patch system, host composition within patches, and patch connectivity affect not only the ability of the pathogen to invade a fragmented system, but also determine whether the pathogen facilitates the invasion of a non-native host species. Their results suggest that connectivity can interact with arrival time and host infection tolerance to determine the success or failure of establishment for newly arriving species.

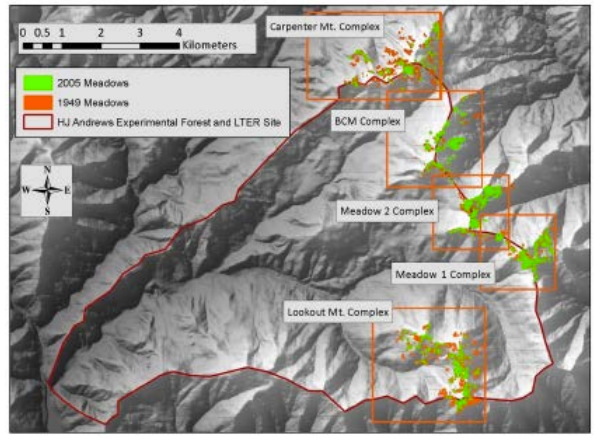


Fig. II.B.1.5. Meadows in the Andrews Forest contracted by 50% from 1949 to 2000 (Highland 2011)

Montane meadows in the western Cascades of Oregon occupy approximately 5% of the landscape, but contribute greatly to the region's biodiversity. However, Rice (2009) and Highland (2011) found that montane meadows in the Andrews Forest have contracted by over 50% in the past two hundred years (Fig. II.B.1.5). Although a range of factors may be responsible for meadow contraction, Highland (2011) showed that Native American archaeological sites were preferentially located on ridgetops, where montane meadows occur, suggesting that meadow contraction may be in part the result of fire suppression initiated when Native Americans were extirpated.

Five hundred fourteen species of macromoths were sampled from 2004-2008 in the Andrews Forest (Highland 2011; Miller, unpub.). Moth species abundance and diversity were significantly higher in low elevation coniferous forests than in riparian forest, high-elevation conifer forest, or montane meadow. However, sixty-six rare moth species, mostly hardwood or herb-feeders, were associated with montane meadows, whereas the 26 most common moth species were associated with low elevation coniferous forests and were conifer-feeders (Highland 2011).

Many researchers have predicted that warming of climate could cause earlier insect emergence and possibly desynchronize prey availability from timing of predator arrival, such as songbirds. To test how insect phenology is related to temperature, Highland (2011) examined moth abundance from 2004 to 2008 and found that common moth species tended to emerge earlier in warmer years than in cooler years. However, Sheldon (unpub.) modeled moth emergence and showed that emergence of the most common moth species occurred later at higher elevation, but only in three of five years; in the other years moth emergence seemed to be insensitive to elevation effects on temperature (Fig. II.B.1.6).

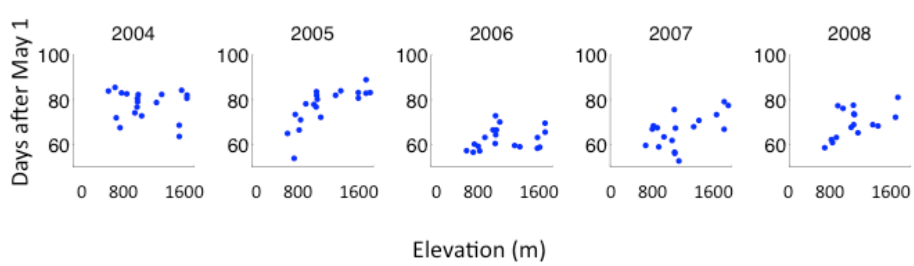


Fig. II.B.1.6. Emergence of a moth species, *Semiothisa signaria*, depends on elevation in only 3 of 5 yrs (Sheldon, unpub.)

There are >600 moth species in the Andrews Forest, and diversity is related to many factors, including date, accumulated heat units, and vegetation type, so it is difficult to visualize patterns of moth diversity in the landscape. To help researchers, Pham and Metoyer (unpublished) developed a moth diversity visualization tool that permits interactive visualization of common and rare moth species in the Andrews Forest. These visualization tools are publicly accessible and computer scientists are exploring the tools to understand how the structure of the visualization can be improved to help ecologists frame and initially text hypotheses in a dynamic, interactive setting. Anyone is welcome to play with these tools, which can be found at the following links: Common Moths: http://purl.oclc.org/diversitymap/commonmoth; Rare Moths: http://purl.oclc.org/diversitymap/raremoth

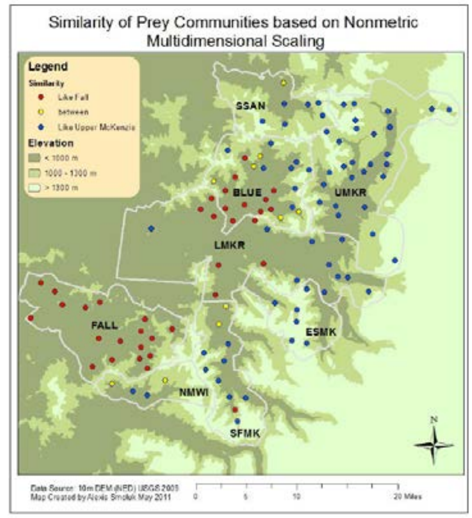


Fig. II.B.1.7. Spotted owl prey in the Andrews is flying squirrels plus red tree voles (blue dots), whereas in the high Cascades it is flying squirrels, gophers, and hares (red dots) (Smoluk 2011)

Another area of active research at the Andrews Forest is the development of techniques for modeling the distributions of species in the landscape. Most species distribution models are based on the notion that species respond to abiotic environmental factors (climate, elevation) or perhaps to biotic factors such as habitat (vegetation), but species distribution also may be determined by the presence of other species of that group. To explore this idea Yu et al (2011) have adapted multi-label classification algorithms from the image identification literature and applied them to predict the distribution of moth and bird species in the Andrews Forest and bird species at Hubbard Brook.

Species distribution models for birds face additional issues of data reliability, including the question of false absences (birds that were present at a site but not detected). To address this question, Hutchinson (unpublished) has developed some dynamic occupancy models for detecting bird presence.

An alternative approach to bird detection is to make recordings at sampling sites and use automated methods (machine learning) to identify birds; such an approach would have the advantage of providing spatially and temporally continuous information on multiple species. The Bioacoustics group at OSU (Fern, Raich, Betts, Briggs, Frey) have obtained songmeter recordings for three summers at 13 locations in the HJ Andrews Forest. Briggs et al (2009) show that machine learning techniques can be used to identify multiple birds simultaneously with 8% accuracy using multi=-label multi-attribute modeling.

A long-term iconic research topic is the northern spotted owl. Smoluk (2011) analyzed 20 years of spotted owl pellet data and created a map showing that spotted owl prey on distinct groups of small mammals in the Andrews Forest and other western Cascade watersheds compared to high elevation watersheds in the High Cascades. In the Andrews Forest the owl prey on flying squirrels but also red tree voles, whereas in the High Cascades red tree voles are absent so owls prey on flying squirrels but also pocket gophers and hares (Fig. II.B.1.7).

People:

PIs: Matt Betts, Sherri Johnson, Mark Schulze, Vrushali Bokil, Elizabeth Borer, Tom Dietterich, Xiaoli Fern, Steven Highland, Rebecca Hutchinson, Ron Metoyer, Sean Moore, Raviv Raich, Lydia O'Halloran, Dan Sheldon, Alexis Smoluk, Tom Spies, Weng-Keen Wong

Students: Forrest Briggs, Kevin Briggs, Sarah Frey, Adam Hadley, Balaji Laksminarayanan, Tuan Pham, Vera Pfeiffer, Jun Yu

Associated Projects:

LTER6 Projects:

- LTER6 goals
- The LTER6 Phenology project
- The LTER6 Climate project

Other Projects:

Databases used in this study

- Spatial and temporal distribution and abundance of moths in the Andrews Experimental Forest -- SA015
- Plant succession and biomass dynamics following logging and burning in the Andrews Experimental Forest Watersheds 1 and 3, 1962-Present -- TP073

Selected Publications

Briggs, Forrest; Raviv Raich, and Xiaoli Z. Fern. 2009. Audio Classification of Bird Species: a Statistical Manifold Approach. Proc. of the International Conference on Data Mining.

Compagnoni, Aldo (2008) Controls on plant species invasions during early secondary succession: the roles of plant origin and community properties. (Pub No: 4412)

Compagnoni, Aldo; Halpern, Charles B. (2009) Properties of native plant communities do not determine exotic success during early forest succession. (Pub No: 4437)

Dovciak, M.; Halpern, C. B. (2010) Positive diversity-stability relationships in forest herb populations during four decades of community assembly. (Pub No: 4578)

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Halpern, C. B.; Antos, J. A.; Rice, J. M.; Haugo, R. D.; Lang, N. L. (2010) Tree invasion of a montane meadow complex: temporal trends, spatial patterns, and biotic interactions. (Pub No: 4579)

Haugo, Ryan D.; Halpern, Charles B. (2010) Tree age and tree species shape positive and negative interactions in a montane meadow. (Pub No: 4574)

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Manore, Carrie. 2011. "Non-Spatial and Spatial Models for Multi-Host Pathogen Spread in Competing Species: Applications to Barley Yellow Dwarf Virus and Rinderpest" PhD thesis, Oregon State University

Moore, Sean M;, Carrie A. Manore; Vrushali A. Bokil; Elizabeth T. Borer; Prasad R. Hosseini. 2011.

Spatiotemporal Model of Barley and Cereal Yellow Dwarf Virus Transmission Dynamics with Seasonality and Plant Competition. Bull Math Biol. DOI 10.1007/s11538-011-9654-4
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Neal, Lawrence; Forrest Briggs, Raviv Raich, and Xiaoli Z. Fern. 2011. Time-Frequency Segmentation of Bird Song in Noisy Acoustic Environments. To Appear in Proc. International Conference on Acoustics, Speech and Signal Processing.
Rice, Janine. 2009.. Forest-Meadow Dynamics in the Central Western Oregon Cascades: Topographic, Biotic, and Environmental Change Effects. [Ph.D Thesis] Oregon State University.
Smoluk, Alexis. 2011. Geographic Distributions of Prey of the Northern Spotted Owl in the Central Western Cascades, Oregon, 1988-2009. MS thesis, Oregon State University.
Yu, Jun; Weng-Keen Wong, Tom Dietterich Julia Jones Matthew Betts, Sarah Frey, Susan Shirley Jeffrey Miller, Matt White. 2011. Multi-label Classi_cation for Multi-Species Distribution Modeling. Proceedings of the 28 th International Conference on Machine Learning, Bellevue, WA, USA,

II.B.2. Carbon & Nutrients

The Andrews Forest Program includes many long-term studies of carbon and nutrient dynamics. Many of these studies also fall into other long-term research categories, such as "Vegetation" and "Stream Ecology". In the current LTER funding cycle, we are continuing these long-term studies and measurements, but much of the focused research effort is occurring within the Integrated Research Project "Carbon and Water Cycle Processes within a Small Watershed: Role of Complex Terrain", described in a later section. For a more long term view of this area of long-term measurements at the Andrews, see the Andrews website, http://andrewsforest.oregonstate.edu/research/component/carbon.cfm?topnav=59

II.B.3. Climate

Climate studies are important as a long-term measurement area in the AND research portfolio, and they are also an essential foundation for the LTER6 goals.


The PRIMET Meteorological station at the Andrews Forest.

Project objectives and relationship to LTER6 goals: We are using the AND long-term climate measurements in LTER6 to understand and model the influence of complex terrain and canopy cover on microclimate at fine spatial and temporal scales (Goal 1, objective 1) and to develop projections for future climate conditions at the local level given potential scenarios for our region. We are exploring topography interactions across three spatial scales: the regional scale (Pacific Northwest), mesoscale (watershed) and microscale (sub-canopy). To better understand topography-climate-canopy interactions at the microscale, we are combining climate data with modeling to understand surface energy balance and vegetation-snow dynamics. We are examining how vegetation influences microclimate and snow dynamics during storm and melt events. We are using a physically based snow model to simulate snow accumulation and ablation and project the impact of future climate scenarios on snow cover. At the meso-scale, we combine long-term climate records at low, intermediate and high elevations with spatial mapping of climate to test the hypothesis that high elevation ecosystems are more coupled to regional climate than low elevation ecosystems, which are more affected by air drainage processes. We are using our climate records at low, intermediate and high elevations to reconstruct periods of temperature inversions versus normal lapse rates, and anabatic (up-slope) versus katabatic (down-slope) winds, and identify the regional climate conditions and mechanisms that generate these conditions. We will improve the resolution of existing climate maps of the Andrews Forest to a 50-m grid. We will use gridded climate datasets (e.g., PRISM, the National Center for Environmental Prediction/National Center for Atmospheric Research (NCEP/NCAR) Reanalysis Project data) to characterize Pacific Northwest climate. We will expand analyses of regional upper-atmosphere airflow patterns on climate in the Andrews Forest to investigate how regional climate is expressed at the meso- and micro-scale, and in particular how regional cyclonic (troughing) and anticyclonic (ridging) circulation patterns are correlated with the occurrence and strength of local cold air drainage events at the Andrews Forest. We will examine coupled atmosphere-ocean general circulation model (AOGCM) simulations from the World Climate Research Programme's Coupled Model Intercomparison Project phase 3 multi-model dataset to determine which AOGCMs best reproduce observed Pacific Northwest circulation patterns. We will use these simulations to develop downscaled future climate datasets for the Andrews Forest that incorporate the effects of cold air drainage on temperature at approximately the same scale as the PRISM extrapolations (50m or less).

Progress Report:

<u>Trends in climate.</u> Air temperatures have warmed significantly at the HJ Andrews since 1958 (Figure II.B.3.1.), but precipitation has not changed. See the retrospective analyses section for more discussion of these results.

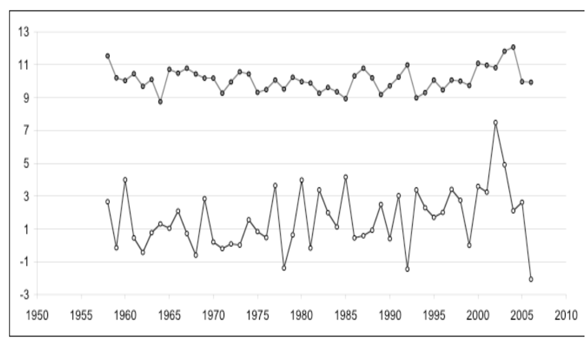

Fig. II.B.3.1. Mean annual temperature at cs2met (485 m), 1958-2006 (closed symbols), and mean monthly temperature in January, the month of greatest increase (open symbols).

<u>Snowpack modeling.</u> Eric Sproles (PhD student) and Anne Nolin modeled the changing snowpacks in the HJ Andrews Experimental Forest and the larger McKenzie River Basin. Using a modified version of SnowModel, Sproles (PhD, in prep.) has simulated daily accumulation/ablation of snow 2002-2010 and is continuing the model runs for 1985-2010. Sproles used meteorologic data from the HJA as driving inputs and measured snow water equivalent (SWE) as validation data. Projected snowpacks for 2040 (Fig. II.B.3.2) show significant declines in SWE throughout the winter season and a much lower fraction of snowfall relative to total annual precipitation, especially at lower elevation sites. As a result, the extent of snowpack in the HJ Andrews Forest in 2020 is expected to be much smaller than in 2000 (Fig. II.B.3.3). Interannual variability can be very high, and models of future snowpack indicate variability will continue and possibly increase (Fig. II.B.3.4).

Climate mapping in the Andrews Forest. In the Andrews Forest, temperatures on the ridges often are warmer than those in valleys by as much as 15°C. Pooling of cool, dense air in valleys "decouples" them from the upper atmosphere and makes valleys less sensitive to variations in regional weather patterns compared with exposed ridges. Using a model that links air circulation patterns in the upper atmosphere to temperature patterns on the ground, Daly et al. (2010) estimated that an overall rise in the regional climate of 2.5°C, combined with an increase in the frequency of anticyclonic circulation events, would cause temperatures on exposed ridges to increase by up to 8°C compared with only about 3°C in nearby valleys (Fig. II.B.3.5).

In an expansion of this study to the western US, Pepin et al. (2011) showed that many topographically sheltered locations are decoupled from regional circulation patterns. Little winter warming has occurred at decoupled sites over the past 60 years, especially in snow covered locations, but in fall warming has been enhanced. These patterns correspond with increased anticyclonicity in winter and increased cyclonicity in fall over the majority of the western US, but the influence of snow appears independent of circulation changes. Daly et al. (in press) mapped mean extreme annual minimum temperatures across the entire US and showed that local temperatures were often coldest in areas susceptible to cold air pooling.

Work is underway to develop improved spatial climate data sets (grids) to be used as input for modeling and analysis activities. These include new 1971-2000 mean monthly and annual precipitation grids at 50-m resolution prepared by C. Daly using PRISM (Fig. II.B.3.6). The mapping activity served as impetus for the digitizing, cleaning, and organizing of historical datasets collected over the past 60 years at HJ

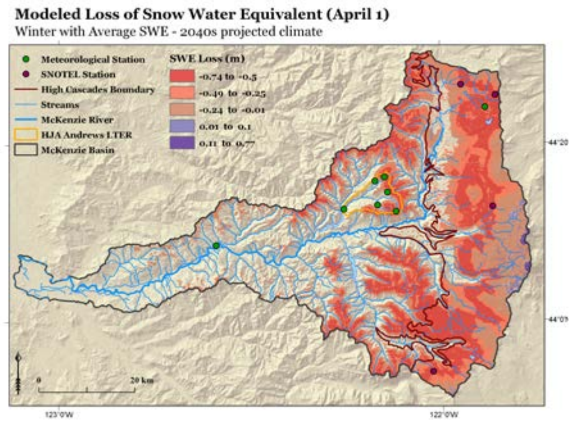

Fig. II.B.3.2. Modeled loss of snow water equivalent in the McKenzie River basin including the HJ Andrews Forest, for 2040, using Snowmodel.

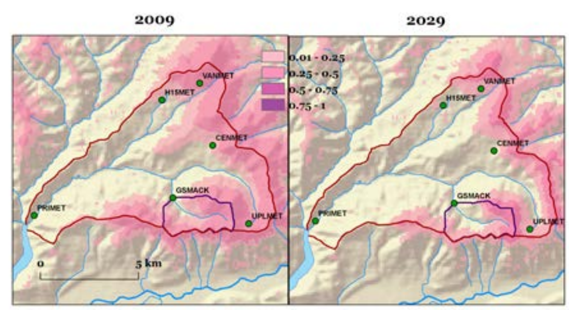

Fig. II.B.3.3. Modeled ratio of SWE to total annual precipitation for present-day (left) and future (right; 2020s) climate conditions.

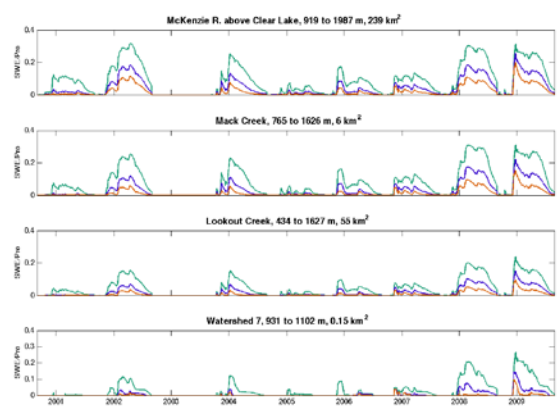

Fig. II.B.3.4. Modeled SWE for 2000, 2020, and 2040 in selected subwatersheds of the McKenzie River including Lookout Creek (HJ Andrews) and WS7.

Andrews. Temperature measurements at 50 to 200 new sites within the HJA are being used to develop improved maps of temperature and explore relationships of temperature with topography and cold air drainage.

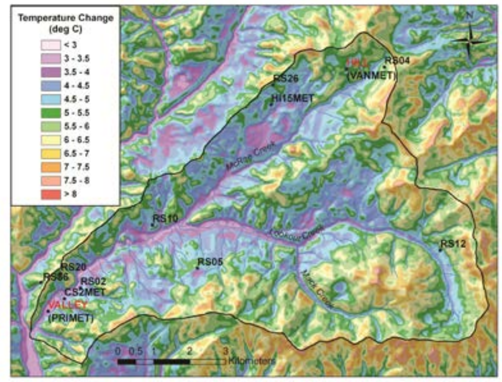

Fig. II.B.3.5. Modeled future air temperature increases in ridges and valleys of the HJ Andrews Forest.

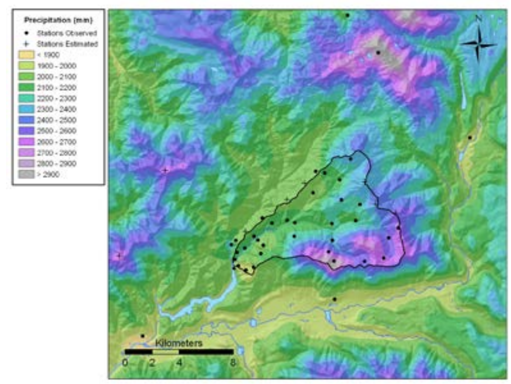

Fig.. II.B.3.6. Modeled average annual precipitation at the HJ Andrews Forest.

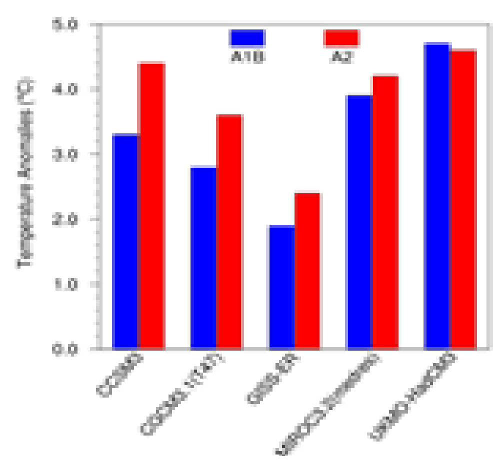

Fig. II.B.3.7. Mean annual temperature anomalies (°C) for 2070-2099 (30-year mean) as compared to a 1961-1990 (30-year mean) base period for the Andrews Forest. Anomalies were calculated from climate simulations as described in the text.

<u>Future climate simulations and datasets</u>. Sarah Shafer has downscaled data from coupled atmosphere-ocean general circulation model (AOGCM) simulations to a 30 arc-second (~1-km) grid for a large region of western North America encompassing the Andrews Forest. Shafer used climate simulations from five AOGCMs, CCSM3 (Collins et al. 2006), CGCM3.1 (Scinocca et al. 2008), GISS-ER (Schmidt et al. 2006), MIROC3.2(medres) (K-1 Developers 2004), and UKMO-HadCM3 (Pope et al. 2000) run under two future greenhouse gas emissions scenarios (A1B, A2; Nakicenovic et al. 2000). These simulations were produced for the World Climate Research Programme's Coupled Model Intercomparison Project Phase 3 (CMIP3) and used in the Intergovernmental Panel on Climate Change Fourth Assessment Report (IPCC AR4) (Meehl et al. 2007). The data were downscaled using climate interpolation programs developed by P. J. Bartlein (Univ. of Oregon). All of the AOGCM and emission scenario combinations project increases in mean annual temperatures for the Andrews Forest ranging from 1.9 °C to 4.7 °C by the end of the century (2070-2099 30-year mean; Fig. II.B.3.7). Projected future precipitation changes for the Andrews Forest display less agreement, with some simulations projecting increases in mean annual total precipitation and other simulations projecting decreases for 2070-2099 (30-year mean; Fig. II.B.3.8).

These downscaled future climate data will be used to incorporate the potential effects of climate change on cold air drainage and temperatures at finer spatial scales. The data are also being used as input for numerical models simulating future ecosystem responses to climate change for the Andrews Forest. As part of current work, we are examining geopotential height data from new AOGCM simulations developed for Phase 5 of the Coupled Model Intercomparison Project (CMIP5) to identify AOGCM simulations that are best able to reproduce observed Pacific Northwest circulation patterns. Given that regional circulation patterns have been found to be a key driver of the spatial patterns of temperature responses at the Andrews Forest, the ability of AOGCMs to simulate historical circulation patterns is an important consideration when evaluating confidence in projected future temperature changes across the site.

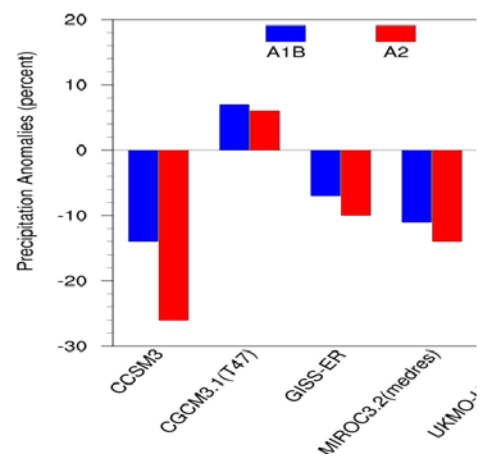

Fig. II.B.3.8. Mean total annual precipitation anomalies (percent) for 2070-2099 (30-year mean) as compared to a 1961-1990 (30-year mean) base period for the Andrews Forest. Anomalies were calculated from climate simulations as described in the text.

Personnel:

PIs: Chris Daly, Anne Nolin, Sarah Shafer, Julia Jones, Mike Unsworth, Matt Betts

Students: Sarah Frey, Brian Wilson

Others: Bird crew, Jay Sexton

Associated Projects:

- LTER6 Projects:
  - LTER6 goals
  - The LTER6 Hydrology project
  - The LTER6 Modeling project
- Other Projects:
  - PRISM
  - Mountain Hydroclimatology Group

Databases used in this study

TW003 - Sap flow measurements to estimate overstory water use in small watersheds at the Andrews Experimental Forest

TW006 - Ecohydrology and Ecophysiology in Watershed 1 at the Andrews Experimental Forest

TW007 - Sapflow in Watershed 1 in the Andrews Experimental Forest

MV001 - Airshed tower data in Watershed 1 in the Andrews Experimental Forest

Selected Publications

Daly, C., D.R. Conklin, and M.H. Unsworth. 2010. Local atmospheric decoupling in complex topography alters climate change impacts. International Journal of Climatology, 30, 1857–1864.

Daly, C., M.P. Widrlechner, M.D. Halbleib, J.I. Smith, and W.P. Gibson. In press. Development of a new USDA Plant Hardiness Zone Map for the United States. Journal of Applied Meteorology and Climatology.

Pepin, N., C. Daly, and J. Lundquist. 2011. The influence of surface/free-air decoupling on temperature trend patterns in the western U.S. Journal of Geophysical Research – Atmospheres, 116, D10109, doi:10.1029/2010JD014769.

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Collins, W. D., C. M. Bitz, M. L. Blackmon, G. B. Bonan, C. S. Bretherton, J. A. Carton, P. Chang, S. C. Doney, J. J. Hack, T. B. Henderson, J. T. Kiehl, W. G. Large, D. S. McKenna, B. D. Santer, and R. D. Smith. 2006. The Community Climate System Model Version 3 (CCSM3). Journal of Climate, 19:2122-2143.

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Schmidt, G. A., R. Ruedy, J. E. Hansen, I. Aleinov, N. Bell, M. Bauer, S. Bauer, B. Cairns, V. Canuto, Y. Cheng, A. Del Genio, G. Faluvegi, A. D. Friend, T. M. Hall, Y. Hu, M. Kelley, N. Y. Kiang, D. Koch, A. A. Lacis, J. Lerner, K. K. Lo, R. L. Miller, L. Nazarenko, V. Oinas, J. Perlwitz, J. Perlwitz, D. Rind, A. Romanou, G. L. Russell, M. Sato, D. T. Shindell, P. H. Stone, S. Sun, N. Tausnev, D. Thresher, and M.-S. Yao. 2006. Present day atmospheric simulations using GISS ModelE: Comparison to in-situ, satellite and reanalysis data. Journal of Climate, 19:153-192.

Scinocca, J. F., N. A. McFarlane, M. Lazare, J. Li, and D. Plummer. 2008. The CCCma third generation AGCM and its extension into the middle atmosphere. Atmospheric Chemistry and Physics, 8:7055-7074.

II.B.4. Disturbance

Project objectives and relationship to LTER6 goals: Disturbances are an ever-present part of ecosystems and ecosystem research – revealed in the legacies of past events, the experiences of a contemporary event, and the prospects for the next big one. Over the 60+ years of research at Andrews Forest we have sustained records of ecosystem change (e.g., vegetation plots, channel maps and cross sections), assessed impacts of individual disturbance events (e.g., flood, landslide, wildfire, clearcutting), and interpreted the disturbance regimes they compose. This work addresses Goal II, Objective 2: "to characterize the interactive roles of disturbance, land use, and climate on ecosystem responders." Important components of this work occur in other parts of the LTER6 program, including modeling landscape dynamics (Harmon, Seidl, Spies), growth of forests in the absence of disturbance (including landscape-scale effects of suppression of wildfire and near-cessation of logging), and flood hydrology studies. We also consider broader concepts of disturbance ecology, such as in contexts of volcano ecology and inter-site synthesis efforts.

Progress Report: Disturbance studies in the first half of LTER6 operated mainly in two areas: 1) Dendrochronologic studies by recently completed PhD student Alan Tepley examine developmental pathways of forest stands in response to low- and moderate-severity fire over the past 800 years across the Blue River basin and a second study area further west in the Cascades. He examined how fire regime and forest types vary with microclimate imposed by topography and over time in relation to Pacific Decadal Oscillation. Tepley also serendipitously found evidence of spruce budworm defoliation of Douglas-fir over the past ca 300 yrs, so he examined temporal and spatial patterns of this disturbance agent. 2) A moderate magnitude flood in January 2011 moved big wood in the larger streams of the Andrews Forest, but it did not trigger debris flows, which create a series of major modifications to downstream channel and riparian systems, as we witnessed in the February 1996 flood (Fig. II.B.4). We are studying this important class of intermediate-magnitude flood to refine our theories of flood disturbance in a forested, mountain river network. Other continuing studies include the Bunchgrass Meadow restoration manipulative experiment, tracking ecological and geomorphic change in experimental watersheds and selected stream reaches, and continuing volcano ecology research at Mount St Helens and Chaiten volcano, southern Chile, and using these observations in comparative disturbance ecology in LTER inter-site projects (Peters et al 2011).

Figure II.B.4. Multiple debris flows from Watershed 3 (upper right) entered Lookout Creek (lower left) during the Feb 1996 flood, causing severe damage to stream and riparian habitat.

Tepley's (2010) work on mixed-severity fire regimes characteristic of the southern end of that region's extensive and productive Douglas-fir forest has been an important feature of disturbance research in LTER6. This work revealed six types of stand developmental pathways. Only 25% of sampled stands (n=124) contained only one post-fire cohort, indicating that stand-replacement wildfire disturbance was not the dominant case, as commonly believed. Only 15% of stands lack evidence of fire within the last 400 years, whereas 10% probably have not gone longer than 100 years without fire during their development. The majority of native stands (as distinguished from plantations) contain two or more post-fire cohorts. The substantial component of trees surviving fire suggests that the historic wildfire regime could sustain abundant live and dead structural elements of forest habitat across the landscape through millennia of fire history. This may help explain how low mobility organisms, such as some canopy lichen species, can be widely distributed. Fire extent appears to have varied across the region in response to centennial-scale climate variability via poorly understood mechanisms. Findings have been used in several modeling efforts within the Andrews Forest program.

We have designed our work in the Bunchgrass Meadow Restoration Study as an integrated set of observational and experimental studies to explore:

- two centuries of conifer encroachment (primarily lodgepole pine and grand fir) and the factors contributing to the timing and spatial patterning of establishment
- the consequences of encroachment for biological diversity (loss of meadow species and their replacement by forest herbs)

- The centerpiece of our research is a restoration experiment designed with three replicates of three treatments randomly assigned to 1-ha experimental units with treatments (1) control; (2) "unburned": tree removal (Jan/Feb 2006); and (3) "burned": tree removal with slash broadcast burned. Initial findings include:
- Tree removal, with or without burning, appears to benefit meadow species at the expense of forest herbs.
- Meadow species show strong potential for recovery across a broad range of initial forest structures.
- Recruitment of conifer seedlings has been low, particularly in unburned treatments.
- Studies of multiple types of disturbance processes affecting the Andrews Forest in recent centuries, the recent eruptions of Mount St Helens (Dale et al 2005) and Chaiten Volcano (Chile) (Pallister et al 2010), and in inter-LTER-site syntheses (Peters et al in press) highlight the value of distinguishing disturbance mechanisms and disturbance types when seeking generalizations in disturbance ecology.

People:

PIs: Frederick J. Swanson **,** Charlie Halpern

Others: Bryan Black, Warren B. Cohen, Cheryl Ann Friesen, Gordon E. Grant, Stanley V. Gregory, Mark E. Harmon, Steven Highland, Sherri L. Johnson, Julia A. Jones, Thomas A. Spies, Alan Tepley, Randall C. Wildman, Steven M. Wondzell:

Associated Projects

LTER6 Projects:

The LTER6 Digital Forest project
The LTER6 Climate project
The LTER6 Modeling project
The LTER6 Hydrology project

Other Projects:

- Bunchgrass Ridge: Restoration of montane meadows in western Oregon - A center for research and adaptive management.
- USGS Mass Movement Dynamics - Experimental Debris-Flow Flume
- RHESSys (http://fiesta.bren.ucsb.edu/~rhessys/)

Databases used in this study

DF007 – Dendrochronology study of fire history, Andrews Experimental Forest and vicinity, Oregon (Teensma thesis)

DF014 – Dendrochronology study of fire history, Blue River watershed, Oregon (Weisberg thesis)

DF020 – Fire history dendrochronology study, super old growth data, central western Cascades, Oregon (Giglia thesis)

GS002 – Stream cross-section profiles in the Andrews Experimental Forest and Hagan Block RNA

DF028 (in progress) – Stand- and age-structure data from Blue River and Fall Ck areas. Alan Tepley (2010, PhD diss).

Selected Publications:

Goodrich, C.; Moore, K.D.; Swanson, F.J., eds. 2008. In the blast zone: catastrophe and renewal on Mount St. Helens. Corvallis, OR: Oregon State University Press. 124 p. pub no 4181

Haugo, R.D. 2010. Causes and consequences of conifer invasion into Pacific Northwest grasslands. Seattle, WA: University of Washington. 187 p. Ph.D. dissertation.Pub no. 4640

McFadden, A.K. 2010. The effects of stand thinning on soil erosion rates at Jim's Creek in the Willamette National Forest, Oregon. Corvallis, OR: Oregon State University. 96 p. M.S. research paper. Pub no. 4655

Nash, S. 2010. Making sense of Mount St. Helens. BioScience. 60(8): 571-575. Pub no. 4631

Pallister, J.S.; Major, J.J.; Pierson, T.C.; [and others, including F. Swanson, J. Jones, and C. Crisafulli] 2010. Interdisciplinary studies of eruption at Chaiten Volcano, Chile. EOS, Transactions of American Geophysical Union. 91(42): 381-392.Pub no. 4584

Perry, DA; Hessburg, PF; Skinner, CN; [and others]. (in press) The ecology of mixed severity fire regimes in Washington, Oregon, and Northern California. Forest Ecology and Management. Pub no. 4664

Peters, D.P.C.; Lugo, A.E.; Chapin, F.S.; Pickett, S.T.A.; Duniway, M.; Rocha, A.V; Swanson, F.J.; Laney, C; Jones, J. 2011 (in press). Synthesis and Integration: Cross-system comparisons elucidate disturbance complexities and generalities. Ecosphere.

Swanson, M. E.; Franklin, J. F.; Beschta, R. L.; Crisafulli, C. M.; DellaSala, D. A.; Hutto, R. L.; Lindenmayer, D. B.; Swanson, F. J. 2010. The forgotten stage of forest succession: early-successional ecosystems on forest sites. Frontiers in Ecology and the Environment. doi:10.1890/090157. Pub No 4558

Tepley, A.J. 2010. Age structure, developmental pathways, and fire regime characterization of Douglas-fir/western hemlock forests in the central western Cascades of Oregon. Corvallis, OR: Oregon State University. 278 p. Ph.D. dissertation. Pub no. 4628

Tepley, A.J.; Thomann, E.A. in review. Analytical approximation of a stochastic, spatial simulation model of fire and forest landscape dynamics. Ecological Modeling.

Tepley, A.J.; Swanson, F.J.; Spies, T.A. submitted. Forest Age Structure and Fire-Mediated Pathways of Stand Development in Douglas-fir/Western Hemlock Forests of the Central Western Cascades, Oregon. Ecological Applications.

II.B.5. Hydrology

Project objectives and relationship to LTER6 goals: Hydrology research in LTER6 aims to understand and model the influence of regional, meso- and micro-scale processes on microclimate in complex terrain, and understand influences of complex terrain on the sensitivity of water cycle processes to environmental drivers at different scales (Goal I, objectives 1 and 2). Hydrology research also will examine the sensitivity of hydrology as a function of elevation (Goal II. Objective 1) and test the hypothesis that climate-induced changes in disturbance (fire, pests) will have greater impact on future ecosystem structure and function than will the direct effects of climate change (e.g., responses to changes in temperature, moisture, snowpack) (Goal II, objective 2). We will project how the water cycle might change under alternative scenarios of future climate, disturbance and land use, and consider influences of complex terrain.

Progress Report: Hydrology research has focused on four sets of controls on hydrology: (1) evapotranspiration and temperature, (2) hillslope processes, (3) snow and climate, and (4) channel structure and the hyporheic zone. We examined the relationships between streamflow and regional climate indices (Goal I, objective 1). We evaluated the sensitivity of streamflow to environmental drivers at the plot, small watershed, and large watershed spatial scale, and at time scales from diel to half-century (Goal I, objective 2). We estimated streamflow variability and streamflow change as a function of elevation (Goal II, objective 1). Based on continued analyses of paired-watershed experiments at high, intermediate, and low elevation we compared streamflow response to forest harvest in treated watersheds versus climate change and succession in old-growth and mature forest in reference watersheds, as a function of elevation and climate regime (Goal II, objective 2). As part of an integrated study of water and carbon cycles at the small watershed scale, we expanded the network of soil moisture measurements (see integrated studies of WS1).

Students working in WS3 stream channel.

Evapotranspiration and temperature controls on hydrology.

Streamflow is strongly related to some regional climate indices (e.g., Pacific Decadal Oscillation), but not to others (e.g., ENSO) (Goal I, objective 1). In particular, winter (Nov – Apr) streamflow is lower than average and early summer streamflow (Jun – Jul) is higher than average during warm PDO conditions. Winter streamflow is low during warm PDO because winter temperature is higher than average and snowpack is lower than average during warm PDO. Summer streamflow high during warm PDO because summer precipitation is higher than average and summer temperature is lower than average (Jones, in prep.).

In a study of hydrology and climate at all LTER sites with long-term records, Jones et al (in review) showed that actual evapotranspiration (AET = P – Q) is related to potential evapotranspiration (a function of T) as expected for a group of 31 reference watersheds in the US and Canada (Budyko curve, Fig. II.B.5.1). However, at the Andrews Forest, observed mean streamflow at the decadal time scale is lower (and observed actual evapotranspiration, is higher, whereas in dry sites, streamflow is higher, and AET is lower, than would be expected from energy balances alone. This finding illustrates how ecosystem adaptations for water use efficiency alter water balances, and underscore the importance of understanding ecosystem controls on water yield.

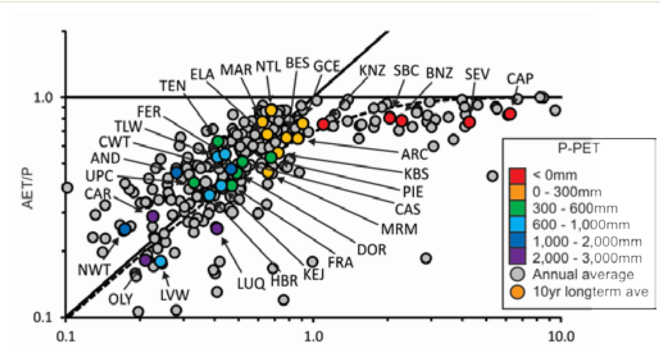

Fig. II.B.5.1. Distribution of AET (P-Q) as a function of PET for annual average and individual years relative to the Budyko curve for a 10-year common time period 1993 to 2002. (Jones et al, in review). AND = Andrews Forest.

Transpiration effects on streamflow are difficult to detect, but diel cycles in streamflow represent a direct relationship between transpiration and streamflow. Diel cycles in streamflow have been a major issue in hydrology, but researchers have debated about how much area of the watershed is effectively connected to the stream during periods of low flow. Moore (2003) showed that during dry summer periods at the Andrews Forest, air temperature, vapor pressure, sapflow, soil moisture, and streamflow were all linked to one another: sapflow was perfectly synchronized with vapor pressure deficit, soil moisture deficits lagged about 3 h behind maximum sapflow, and minimum streamflow lagged about 7 h behind minimum soil moisture in WS1 (Fig. II.B.5.2). Bond et al (2002) argued that transpiration in the riparian zone alone could explain the diel cycles. Wondzell et al (2007) focused on the propagation of diel signals along the stream channel in WS1, showing how naturally produced fluctuations in discharge constitute discrete impulse functions within the stream network that can be used to analyze eco-hydrologic behavior during baseflow periods.

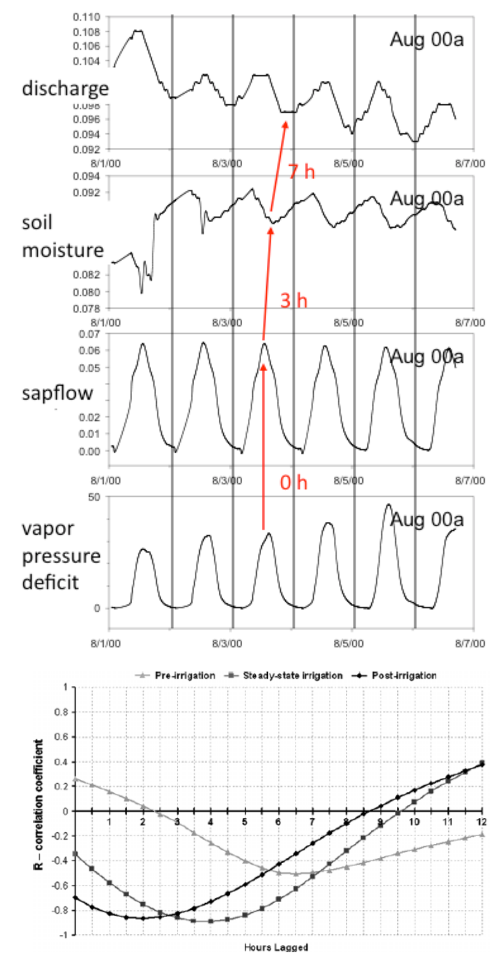

Fig. II.B.5.2. The lag between maximum transpiration (sapflow) and minimum streamflow was 6.5 h before irrigation, 4 h during irrigation, and 2 h after irrigation (Moore 2003).

Although diel cycles appear to be linked to transpiration of a vegetated riparian zone in WS1, Wondzell et al (2009a) showed that diel cycles of streamflow did not appear to be explained by transpiration of trees in the riparian zone. Diel cycles also occur in other watersheds, such as WS10, which lack a vegetated riparian zone. In WS10, Barnard et al (2010) conducted a 24-day, steady-state irrigation experiment to quantify the relationships among soil moisture, transpiration and hillslope subsurface flow. An 8 by 20 m hillslope was irrigated at a rate of 3 to 6 mm/h (the maximum rates of precipitation recorded is about 10 mm/h, see Jones and Perkins 2010). Diel fluctuations in hillslope discharge persisted throughout the experiment. Lags between maximum transpiration and minimum hillslope discharge were 6.5 h before irrigation, 4 h at steady state and 2 h after irrigation (Fig. II.B.5.3). During the post-irrigation period, the diel reduction in hillslope discharge was 90% of total measured daily transpiration. Daily transpiration of trees within the irrigated area changed little during the experiment. This study demonstrates that when soil moisture is high, hillslope trees can be an important factor in diel fluctuations in stream discharge.

The variation in lag time between maximum air temperature (or saplfow) and minimum temperature has been interpreted as an indicator of the size of the effective contributing area (Bond et al 2002), changes in streamflow velocity (Wondzell et al 2007), or changes in hillslope soil moisture (Barnard et al 2010). Although most work on diel cycles has focused on WS1 and WS10, diel cycles were present from Jun – Sep of 2000-2009 in all small watersheds in the Andrews Forest. At WS1, correlations between temperature and streamflow decreased, and lags increased, as the summer progressed, but lags were constant at WS2 and WS10 (WS2: old forest, bedrock and alluvial channel; WS10: young forest, bedrock channel). At WS2 and WS10, although minimum discharge was strongly correlated with, and lagged, to maximum air temperature, the lag between maximum temperature and minimum discharge did not vary over the season (Fig. II.B.5.4) (Albright et al., in prep (EISI REU students)). Mapping of old-growth trees in the channel, combined with estimates of sapflow, suggest that trees in or immediately adjacent to the channel are capable of transpiring the amount of water that is "missing" in the diel cycles in WS1 and WS2. However, diel cycles varied within the channel of WS2, with higher cycles in alluvial reaches compared to bedrock reaches. Thus, diel cycles in streamflow appear to respond to the arrangement of vegetation and the volume of sediment in the channel. REU students developed a mathematical model was developed to show how water tables in lower hillslopes adjacent to channels might respond to localized water table lowering due to diel cycles of transpiration by trees growing in the stream channel. These results show that transpiration in a relatively small area near the stream can account for diel cycles.

Much uncertainty remains about the magnitude of evapotranspiration in these watersheds. Direct measurements of sapflow in a 172 m^2 plot in WS10 (Barnard et al 2010, Graham et al 2010b) indicate that transpiration was <2% of water added during a summer irrigation experiment, and Penman-Monteith evaporation was estimated at only 5-10% over the period of irrigation and up to 10 days after irrigation ceased, making ET about 12% of inputs. In contrast, on an annual basis, ET (measured as P – Q) amounts to about 45% in these small watersheds. Sapflow estimates in WS1 (young forest) and WS2 (old forest) (Moore et al 2004) indicate that transpiration during the summer (June-Sep) alone could account for 2 to 6% of annual P, but transpiration occurs over much of the year, and the initial change in Q after clearcutting is equivalent to about 20% of P, with most changes in spring and fall (Jones and Post 2004).

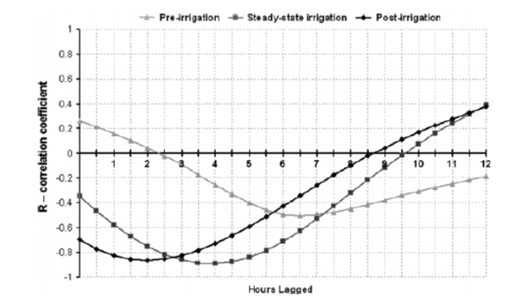

Fig.II.B.5. 3. The lag between maximum transpiration (sapflow) and minimum streamflow was 6.5 h before irrigation, 4 h during irrigation, and 2 h after irrigation (Barnard et al. 2010).

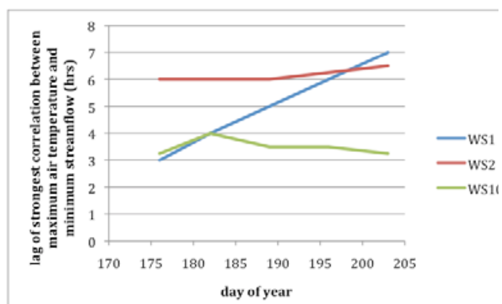

Fig. II.B.5.4. The lag between maximum transpiration (sapflow) and minimum streamflow increases over the summer at WS1, but not at WS2 or WS10 (Albright et al, in prep.) (summer REU students)

Debates about effects of forest harvest on peak flows also have continued in the literature, building on a series of frequently cited analyses of data from small experimental watersheds and controversial findings from the large Lookout Creek watershed in the Andrews Forest (Jones and Grant 1996, Thomas and Megahan 1998, Beschta et al. 2000, Jones and Grant 2001a,b, Thomas and Megahan 2001). Seibert and McDonnell (2010) used a model-based change-detection approach and corroborated many results of Jones and Grant (1996): peak flows increased in the clear-cut WS1, relative to the control (WS2), and peak flows increased in Lookout Creek as a result of partial harvesting. Changes in parameter values in the model after clear-cutting indicated a speeded hydrologic response, consistent with higher soil moisture associated with reduced evapotranspiration from vegetation removal.

Hillslope process controls on hydrology

Hydrologic research at the Andrews Forest has continued to examine how hillslope processes govern storm hydrographs. Hydrographs respond rapidly, but precipitation may be stored for years before emerging. In a flood of record in February 1996, streamflow remained very low after the onset of precipitation, then flow rose suddenly, and synchronously, at all watersheds (Jones and Perkins 2010) (Fig. II.B.5.5). Tracer tests for a series of storms during the wet-up phase of the 2002–2003 winter rainy season on an experimental hillslope in WS10 showed that hillslope discharge was distinctly threshold-like (McGuire and McDonnell 2010). Peak flows responded linearly to precipitation inputs and the quick flow ratio (Q/P) averaged 0.58 when antecedent rainfall was grea ter than 20 mm. Mean transit times ranged from 8-34 h (for water during storm events) to 10 to 25 days (for soil water and runoff between storm events) to 1 to 2 years (for hillslope seeps and baseflow) (McGuire and McDonnell 2010) (Fig. II.B.5.6).

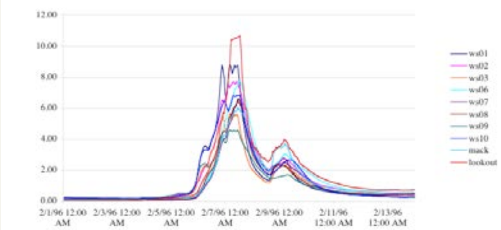

Fig. II.B.5.5. Synchronous peak flows at 10 watersheds in the Andrews Forest, February 5-9, 1996 (Jones and Perkins 2010).

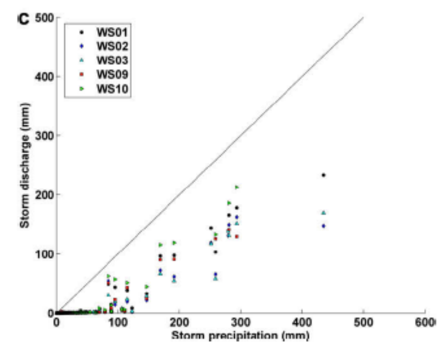

Fig. II.B.5.6. Threshold response of peak streamflows to precipitation inputs in small watersheds, Andrews Forest (Graham and McDonnell 2010).

One hypothesis to explain rapid stormflow response behavior is a "fill and spill" mechanism consisting of a series of depressions in the bedrock surface, which when filled and spilled, create rapid subsurface flow along the soil-bedrock interface and generate a sudden, threshold response of streamflow to precipitation. To illustrate this phenomenon, Graham et al (2010a) measured significantly higher than expected (from Darcy's Law) rates of lateral subsurface flow along the soil-bedrock interface. Graham and McDonnell (2010) developed a numerical model to represent the "fill and spill" concept, and tested it using precipitation and streamflow data from WS1, WS2, WS3, WS9, and WS10, (sizes range from 9 to 101 ha) at the Andrews Forest. Although a plot of total storm precipitation vs. discharge showed little

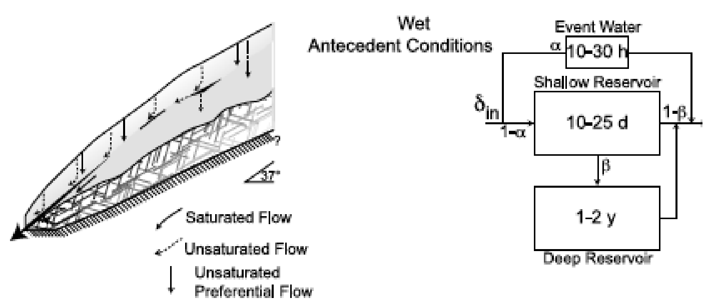

Fig. II.B.5.7. Conceptual model of variable flow pathways and transit times contributing to runoff (McGuire and McDonnell 2010).

evidence of a threshold response, thresholds became evident when storms were binned according to the antecedent drainage time (e.g., Fig. II.B.5.7). This study provides evidence that stormflow response may be explained by "fill and spill" subsurface flow processes, in which geologic factors (bedrock permeability and bedrock topography) create bedrock depressions, and storm spacing and potential evapotranspiration regulate moisture stored in the bedrock depressions, producing predictable, though varying, threshold behavior.

Water added as precipitation may not emerge as streamflow, but instead may be stored and evapotranspired. Although many studies and models assume that water added to hillslopes is completely mixed with water previously stored in soils, soil water is held at many different tensions, and more tightly held water is much less mobile in soil profiles. To test the effect of soil tension on water mixing, Brooks et al (2010) determined water isotopes from various pools throughout WS10. These data reveal a pool of tightly bound water that is retained in the soil and is used by trees, but does not participate in translatory flow, mix with mobile water, or enter the stream. Instead, water from early fall events after dry summers is locked into small pores with low matric potential until transpiration empties these pores during following dry summers. Winter rainfall does not displace this tightly bound water. Brooks et al (2010) infer that complete mixing of water cannot be assumed; two separate sets of water bodies with different isotopic characteristics exist in trees and streams in the Andrews Forest (Fig. II.B.5.8).

Groundwater recharge is an important aspect of hillslope processes. Based on a 24-day irrigation experiment of a 172 m2 area in WS10, Graham et al. (2010b) estimated that deep seepage at the catchment scale (defined as water that enters the groundwater system and does not re-emerge in the stream channel) averaged approximately 21% of precipitation at steady state, but the overall water balance for this 24-day period had an uncertainty of 20%. If deep seepage occurs, it may percolate through fractured bedrock underlying soil in WS10. Gabrielli (MS thesis, unpublished) developed and used an inexpensive, safe, and portable bedrock drilling system to explore bedrock groundwater dynamics in WS10. Gabrielli (unpublished) found a highly fractured and transmissive region within the upper 1 m of bedrock that acts as a corridor for rapid subsurface stormflow and lateral discharge.

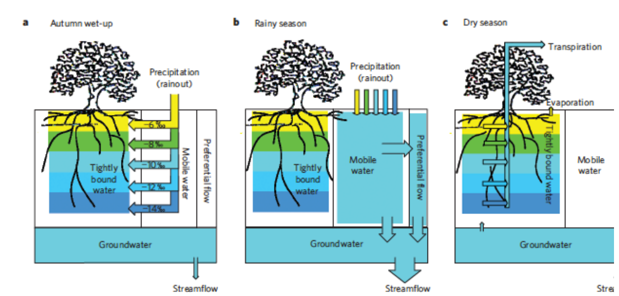

Fig. II.B.5.8. Schematic diagram of wetting and drying, creating two separate pools of water in soils (Brooks et al. 2010).

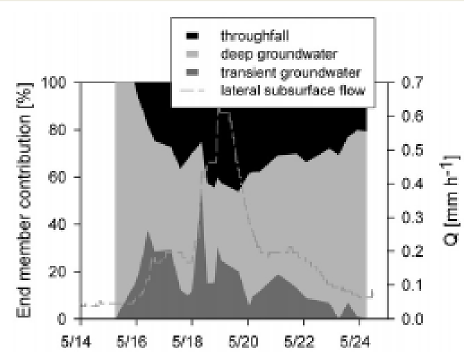

Fig. II.B.5.9. Changing importance of water sources in storm hydrograph (van Verseveld et al. 2008).

Hillslope processes at the watershed scale may be summarized using the distributions of transit time (or residence time) of water. Transit time is the elapsed time from the input of water through a system input boundary at time t_{in} to the output of that water through a system output boundary at time t_{out} (McDonnell et al 2010). The mean transit time for water through catchments can be orders of magnitude longer than the timescale of hydrologic response (thus producing prompt discharge of old water). The shapes of transit time distributions in catchments are unknown, but conceptually they represent a powerful and concise representation of how water and solutes are stored and transported in watersheds.

Hillslope flowpaths in groundwater and shallow subsurface and lateral flow combine to influence solute concentrations such as dissolved organic carbon (DOC) and nitrogen (DON) in streamflow. In small watersheds at the Andrews Forest, concentrations DOC, DON and SUVA (a measure of the aromaticity of DOC) tend to rise rapidly during storm events and decline more rapidly than stormflow. Using a combination of hydrometric data, natural tracer data, and DOC quality indices such as SUVA and fluorescence, Van Verseveld et al (2008) inferred that stormflow involves rapid vertical transport of solutes from a finite source of DOC and DON in the organic horizon to a bedrock interface and rapid lateral subsurface flow to streams. Increased flow from deep soil water and groundwater during the falling limb compared to the rising limb of the hydrograph contributed to the dilution of DOC, DON and SUVA over the course of the storm (Fig. II.B.5.9).

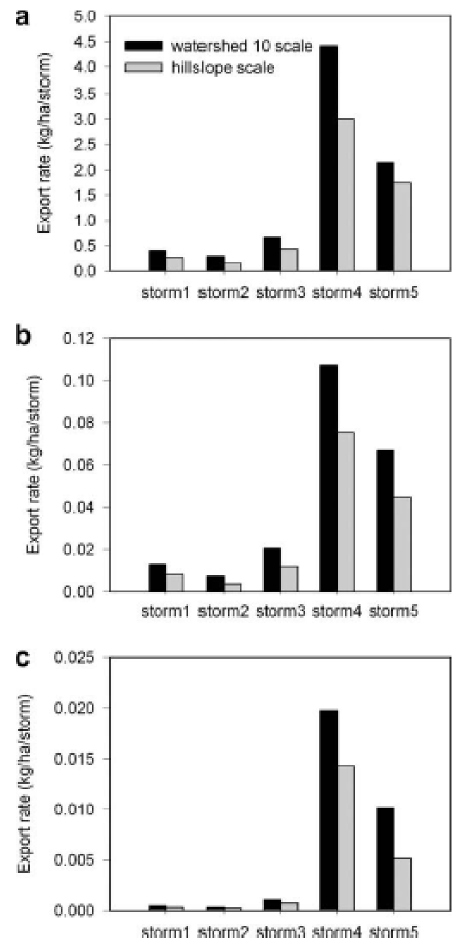

Fig. II.B.5.10. Export of DOC, DON, and DIN increases with storm size over the wet season (van Verseveld et al. 2009).

During baseflow and stormflow conditions over fall to spring of one water year, DON was the dominant form of total dissolved nitrogen (TDN) in all sampled solutions in soil and streams, except in transient groundwater, where DIN was the dominant form (van Verseveld et al. 2009) (Fig. II.B.5.10). Organic horizon leachate and transient groundwater were characterized by high SUVA, DOC and total N concentrations, and SUVA and DOC and DON concentrations in lysimeters decreased with depth in the soil profile. These findings indicate that DOC and DON

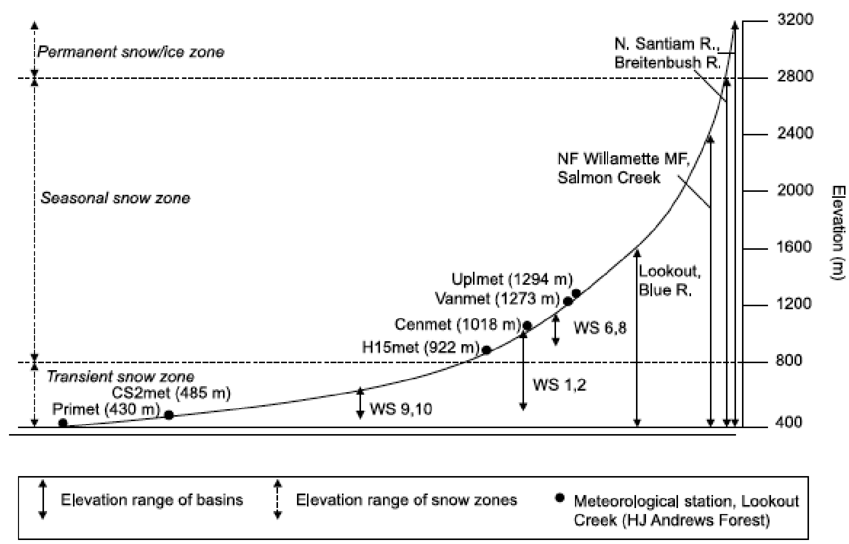

Fig. II.B.5.11. Snow zones vary with elevation in the Andrews Forest and its instrumented watersheds (Jones and Perkins 2010).

sources were limited, producing the highest concentrations after the longest periods between storms, and that vertical preferential flow occurs without much soil matrix interaction, contributing to effective separation in the chemistry of water held at high vs. low matric tensions.

<u>Snow and climate controls on hydrology</u>

Snowpacks have many effects on hydrology of the Andrews Forest. The Andrews Forest, which ranges from 430 to >1600m elevation, spans the rain, transient snow, and seasonal snow zones (there are no glaciers in the Andrews Forest) (Fig. II.B.5.11). Therefore, hydrology is influenced by ephemeral snow accumulation and melt at low elevations and by seasonal snow accumulation and melt at high elevations (Fig. II.B.5.12). Seasonal snowpack melt augments spring discharge in high-elevation small basins (WS 8) and in Lookout Creek, compared to low-elevation basins (Fig. II.B.5.13).

In high-elevation basins underlain by young, porous volcanics, the annual hydrograph is much flatter, with higher flows during the summer dry season, than in the low to intermediate-elevation basins that characterize about 2/3 of the area of the Andrews Forest. Hydrographs of High Cascades basins are characterized by high summer baseflows, memory of past years' precipitation, and mean water residence times of 3 to 14 years (Figure II.B.5.14, Jefferson et al 2006, 2008). In contrast, western Cascades basins such as Lookout Creek (= Andrews Forest) are characterized by very low summer baseflows, no memory of past years' precipitation, and mean water residence times of 1 to 3 years (McGuire et al 2005). Larger more persistent snowpacks at high elevations explain some of these differences, but effects of snowpack on hydrology are confounded with geology.

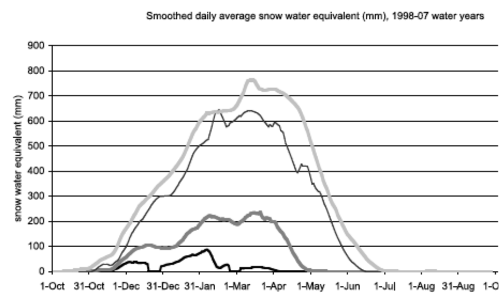

Fig. II.B.5.12. Snow is ephemeral at low elevation and seasonal at high elevation (Jones and Perkins 2010).

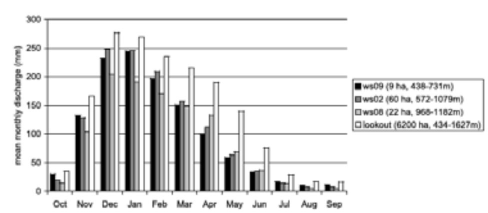

Fig. II.B.5.13. Watersheds with seasonal snowpacks have higher spring streamflow (Jones and Perkins 2010).

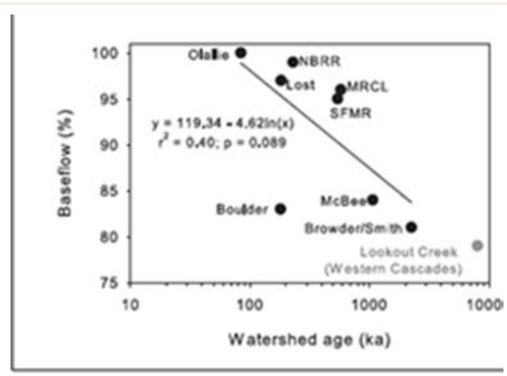

Figure II.B.5.14. Baseflow as a portion of annual flow increases with eleveation in the Oregon Cascades, because of increasing snowpack and younger nad more porous rock types (Jefferson et al 2010).

It has long been understood that rain-on-snow floods account for the extreme flood events in the Pacific Northwest, but the conditions that produce a rain-on-snow flood are debated, and the effects of forest harvest on rain-on-snow floods also are quite controversial. During floods a pre-existing snowpack may melt simultaneously with rain, creating a rain-on-snow flood. The presence of a snowpack on near-saturated soil sped up and steepened storm hydrographs in a basin with short steep slopes, but delayed storm hydrographs in basins with longer or more gentle slopes (Fig. II.B.5.15, Perkins and Jones 2008).

Although the presence of a melting snowpack did not increase peak discharges compared to rain events in small reference watersheds (<1 km2) with old forest, peak discharges of >10 year rain-on-snow events were almost twice as high as rain peaks in large basins (Fig. II.B.5.16, Jones and Perkins 2010). In extreme floods, despite very high infiltration capacity, high soil porosity, and steep hillslope gradients, prolonged precipitation and synchronous snowmelt produce rapid, synchronized hydrograph responses to small variations in maximum precipitation intensity. At the large basin scale, forest harvest may increase the area of snowpack and simultaneous snowmelt, especially in elevation zones normally dominated by rain and transient snow, thereby increasing large basin peaks without producing very large percent increases in small basin peaks. Further work is needed to describe water flow paths in melting snowpack, snow cover and the area experiencing snowmelt, synoptic peak discharges, and routing of flood peaks through the stream network during extreme rain-on-snow floods. The evolving structure of the forest on the landscape is a potentially very important factor influencing extreme rain-on-snow floods (Jones and Perkins 2010).

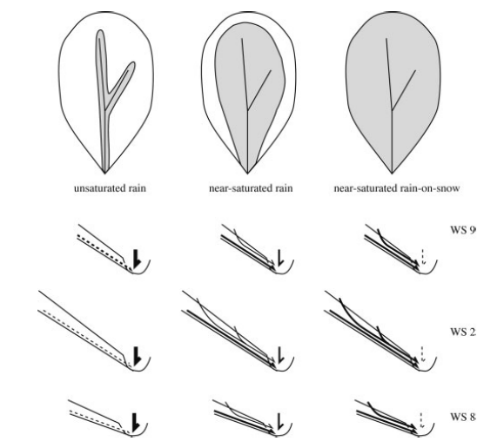

Fig. II.B.5.15. During rain-on-snow floods on near-saturated soils, the presence of a melting snowpack appears to increase the effective contributing area (Perkins and Jones 2008).

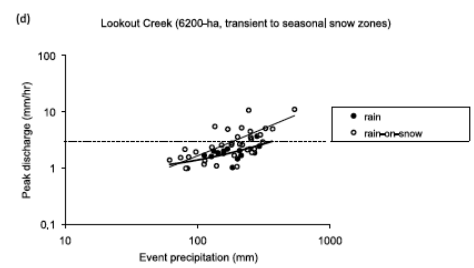

Fig. II.B.5.16. During >10-yr events, the presence of a snowpack doubles flood peaks

The snowmelt that is contributed during a rain-on-snow flood is generated from a combination of heat from net radiation, sensible heat flux (from turbulent fluxes dependent on wind), latent heat flux (from condensation of water vapor on the snowpack), ground flux (because soil temperatures are >0), and advected heat (in precipitation). Mazurkiewicz et al (2008) used the SNOBAL model and data from the Andrews Forest and showed that during the flood of record in February 1996, the energy contributed from the combination of sensible, latent, and especially advected heat, increased relative to that from net radiation during the 3-h period of the first peak on the evening of February 6 (which generated debris flows in WS3 and WS10), and over the course of the early part of February 7 up to the peak at 11 AM to 1 PM, and declined thereafter (Fig. II.B.5.17).

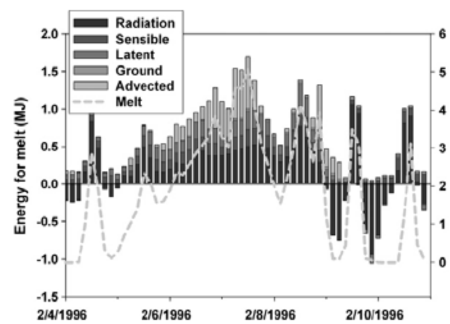

Fig. II.B.5.17. The "recipe" for an extreme rain-on-snow flood includes widespread snow cover, near-saturated soils, and synchronized snowmelt (Jones and Perkins (2010).

Climate warming is expected to reduce snowpack, and some authors have speculated that rain-on-snow floods will be less frequent. However, extreme rain-on-snow floods are the result of a combination of factors that historically have been quite rare (Fig. II.B.5.18); given this "recipe," the ingredients for extreme rain-on-snow floods are likely to still be present in the landscape for decades to come. Multiple factors, including groundwater inputs (Tague et al 2008, Tague and Grant 2009), the effects of increased temperature on evapotranspiration (Moore 2010), the effects of young forest regeneration on evapotranspiration, and water management in dams (Hatcher 2011) also will mediate climate change effects on snow and hydrology. Ongoing work is addressing the many factors that influence snow and seasonal streamflow, including climate change, geology, and changes in forest evapotranspiration.

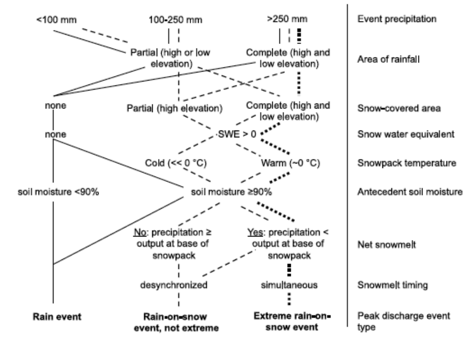

Fig. II.B.5.18. The "recipe" for an extreme rain-on-snow flood includes widespread snow cover, near-saturated soils, and synchronized snowmelt (Jones and Perkins (2010).

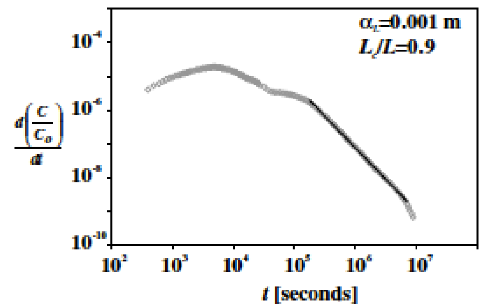

Fig. II.B.5.19. Power-law residence time distribution from a simulation model of a hyporheic zone (Cardenas et al 2008).

Channel structure and hyporheic zone effects on hydrology

The hyporheic zone (the zone of subsurface flow in the channel bed and banks) has been increasingly recognized as important for understanding the behavior of water flow, and especially the transport of heat and solutes in streams. A key issue has been to characterize the residence time distribution (RTD) of solute fluxes in stream hyporheic zones. Building on earlier work of R. Haggerty at the Andrews Forest, Cardenas et al (2008) used simulation modeling to show that RTDs associated with interfacial (hyporheic) exchange follow a power-law from timescales of several minutes to tens of days, in the absence of strong heterogeneity in the stream sediments and significant in-channel storage zones, but in the presence of topography along the sediment–water interface (e.g. Fig. II.B.5.19). This power-law tailing is expected to be ubiquitous since bedforms tend to be self-similar across several scales. Additional field studies using a novel tracer (Argerich et al in press) have explored the effects of biological activity on tracer measurements of residence time in the hyporheic zone.

Power-law residence time distributions in the hyporheic zone imply that it may be difficult to predict the residence time of solutes moving in streams. Alternative approaches involve numerical modeling. However, Wondzell et al (2009b) showed that multiple models with alternative conceptualizations of hyporheic flow provided equally good fits to observed well and travel time data in WS1, and concluded that although groundwater flow models can be used to provide rough answers to questions about physical factors controlling the development of the hyporheic zone, nevertheless the models they developed and calibrated using detailed well information were no sufficiently accurate to predict the movement of solutes through the hyporheic zone.

Steep mountain streams tend to have low sediment storage, so the presence of large wood is important for creating sediment wedges. However, it is difficult to determine the depth of alluvial material in stream channels, and hence the magnitude of the hyporheic zone, non-invasively. Crook et al (2008) show how electrical resistivity imaging reveals the sediment/bedrock boundary in the channel of Mack Creek where a long-term wood inventory experiment has been underway since the 1980s. Three images were obtained in the vicinity of a channel-spanning wood jam in Mack Creek. The images indicate a sediment thickness of approximately 5 m in the region of the debris dam, which increases to as much as 6 m deep just upstream from the debris dam. The sediment wedge tapers off as it approaches the outcropping bedrock exposure at the upstream end of the transects. Using these data Crook et al (2008) estimate that 5400 m^3 of sediment is held behind the debris dam. This approximation of the sediment volume and detailed sediment geometry can now be used to inform hydrogeologic models of the stream dynamics, such as the hyporheic exchange through this sediment wedge.

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Others: Holly Barnard, Craig Creel, Greg Downing, Chris Graham, Anne Jefferson, Kevin McGuire, Georgianne Moore, John Moreau, Reed Perkins, Jan Seibert, Christina Tague, Willem van Verseveld

Associated Projects:

LTER6 Projects:

- LTER6 goals
- The LTER6 Climate project
- The LTER6 Modeling project

Other Projects:

Hillslope and Watershed Hydrology lab at OSU (http://www.cof.orst.edu/cof/fe/watershd/index.php)
Watershed Processes group - USFS (http://www.fsl.orst.edu/wpg/index.htm)
Mountain Hydroclimatology Research Group at OSU
<http://www.geo.oregonstate.edu/~nolina/RESEARCH_GROUP/>
Forest Ecophysiology and Ecohydrology Transect; http://oregonstate.edu/feel/

Databases used in this study

HF004
MS001
TW006

Selected Publications

Albright Jason, Nathaniel Gustafson, Michaeline Nelson, Jorge Ramirez, Bianca Rodriguez-Cardona, Chris Shughrue, Julia Jones. 2010. Diel fluctuations in small headwater streams: roles of riparian vegetation and alluvium. AGU abstract, Fall meeting, San Francisco.

Argerich, A., R. Haggerty, E. Marti, F. Sabater and J. Zarnetske, in press. Quantification of metabolically active transient storage (MATS) in two reaches with contrasting transient storage and ecosystem respiration, J. Geophys. Res.

Barnard, H. R., C. B. Graham, W. J. Van Verseveld, J. R. Brooks, B. J. Bond, and J. J. McDonnell. 2010. Mechanistic assessment of hillslope transpiration controls of diel subsurface flow: a steady-state irrigation approach. Ecohydrol. 3, 133–142.

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Brooks, J.Renee, Holly R. Barnard, Rob Coulombe and Jeffrey J. McDonnell. 2010. Ecohydrologic separation of water between trees and streams in a Mediterranean climate. Nature-Geoscience, 3, 100 - 104 DOI: 10.1038/NGEO722.

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Graham, Christopher Brian. 2008. A macroscale measurement and modeling approach to improve understanding of the hydrology of steep, forested hillslopes. Corvallis, OR: Oregon State University. 158 p. Ph.D. dissertation. (Pub No: 4580)

Graham, C., McDonnell, J.J. 2010. Hillslope threshold response to rainfall: (2) Development and use of a macroscale model. Journal of Hydrology, doi:10.1016/j.jhydrol.2010.03.008

Graham, C.B, Woods, R.A., McDonnell, J.J. 2010a. Hillslope threshold response to rainfall: (1) A field based forensic approach. Journal of Hydrology, doi:10.1016/j.jhydrol.2009.12.015

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Hatcher, Kendra L. 2011. Interacting Effects of Climate, Forest Dynamics, Landforms, and River Regulation on Streamflow Trends since 1950: Examples from the Willamette Basin and Forested Headwater Sites in the US. MS thesis, Oregon State University.

Jefferson, A.; Grant, G. E.; Lewis, S. L.; Lancaster, S. T. 2010. Coevolution of hydrology and topography on a basalt landscape in the Oregon Cascade Range, USA. Earth Surface Processes and Landforms. doi:10.1002/esp.1976. (Pub No: 4426)

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Mazurkiewicz, Adam B. 2006. Measurement and modeling the physical controls of snowmelt in the Pacific Northwest. Corvallis, OR: Oregon State University. 107 p. M.S. thesis. (Pub No: 4295)

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McGuire, K. J., and J. J. McDonnell. 2010. Hydrological connectivity of hillslopes and streams: Characteristic time scales and nonlinearities, Water Resour. Res., 46, W10543, doi:10.1029/2010WR009341.

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II.B.6. Soils

Figure. II.B.6. DIRT plot at the Andrews Forest.

Work on soils in the HJ Andrews Experimental Forest began with a soil survey conducted in 1962 by Forest Service scientists. Efforts are now underway to update the classification of these soils and map them in a way that will be most useful to researchers. Early work on soil characterization focused largely on hydrologic properties. More recent studies have concentrated on C storage in soils supporting tree stands of different ages, root decomposition, and N fixation. Both early and recent studies have examined effects of forest harvest practices on soil erosion.

In 1997 the DIRT (Detrital Input, Removal, and Trenching) experiment was installed as a part of a national network of similar experiments. The DIRT experiment tests how organic C and respiration respond to treatments of removing litter input, doubling litter input, trenching to remove fine root input, addition of woody detritus, and removal of the A horizon. Other studies have examined the movement of DOC and DON in soils and how soil properties control the release of N following timber harvest.

In 1999 the Microbial Observatory at the H.J. Andrews Experimental Forest was established with a grant from the National Science Foundation. This Microbial Observatory is dedicated to the study of bacteria and fungi central to biogeochemical processes in coniferous forest ecosystems in the Central Cascade Mountains of Oregon. Because nitrogen (N) is the most limiting nutrient to tree growth in this ecosystem, research focuses on the functional diversity of microorganisms that perform N cycling processes. Studies primarily examine the microorganisms that produce and consume NO3- because of their pivotal role in supplying N for plant growth and controlling N losses to ground and surface waters as NO3- or to the atmosphere as N2O.

Links

DIRT: Detrital Input and Removal Treatments
Microbial Observatory at the H. J. Andrews LTER

Key Databases

Soil descriptions and data for soil profiles in the Andrews Experimental Forest, selected reference stands, Research Natural Areas, and National Parks -- SP001
Seasonal relationships between soil respiration and water-extractable carbon as influenced by soil temperature and moisture in forest soils of the Andrews Experimental Forest -- SP004
Synoptic soil respiration of permanent forest sites in the Andrews Experimental Forest (1993 REU Study) -- SP005
Chemical and microbiological properties of soils in the Andrews Experimental Forest (1994 REU Study) -- SP006
The relationship between early succession rates and soil properties in the Andrews Experimental Forest -- SP012

Personnel

Leader(s): Kate Lajtha,
Key Personnel: Bruce A. Caldwell, Markus Kleber, David D. Myrold, Jay Stratton Noller, Julie Pett-Ridge, Phillip Sollins

II.B.7. Stream Ecology

Project objectives and relationship to LTER6 goals: Stream ecology research at the Andrews Forest has been designed to explore long-term processes that shape aquatic ecosystems, identify critical links between forests and streams, and examine the influences of natural and anthropogenic disturbances on stream communities and processes. In LTER6, as part of Goal 2, we are exploring how land use legacies and hydrology influence biodiversity and populations in streams. We are examining the long term responses to land use and trends as a function of changing climates for stream temperature and biogeochemistry.

Figure II.B.7.1. Stream survey at the Andrews Forest.

In LTER6, we are examining long term trends of stream chemistry and stream temperature and comparing Andrews Forest data with other sites regionally and nationally. We are continuing sampling of fish and salamander densities in Mack Creek, research that has been occurring annually since 1984 to examine long-term instream responses to land use. Additional research includes phenological responses macroinvertebrates to temperature variability, interactions of geomorphic and hydrologic processes with instream metabolism, nutrient retention and fluxes, and riparian dynamics.

Questions being asked include: Do dynamics across reaches, whether fish population density, stream nutrient concentration or stream temperature, respond synchronously from year to year? If variations appear coupled, this would suggest environmental influences are determining population dynamics and ecosystem responses, and more study of among-site variability in microhabitat or environmental factors would follow. If variations are not coupled over time, this would suggest site or community specific factors are dictating responses. Continued long-term measurements play an important role during LTER6 for addressing these questions.

Progress Report:

Stream nutrient dynamics- USFS and LTER researchers have studied stream hydrology and solute chemistry in disturbed and undisturbed watersheds at 11 Experimental Forests across the country for decades. These headwater streams provide high quality water as one of their important ecosystem services. Changes in land use land cover, as well as natural processes and disturbances, affect water quality in these streams. We are synthesizing trends in water quality across reference basins and examining stream nutrient responses to disturbance regimes. We are using long term stream chemistry data to inform EPA Nutrient Criteria across regions and asking the following questions:

Are there long-term trends in stream nitrogen concentrations at forested reference basins, given changes in discharge and atmospheric deposition over time?

Is there more variation in trends among EFR sites than among basins within an EFR?

How do the short and long-term responses of stream nutrients to forest harvest and disturbances vary across North America?

Are responses to various types of disturbances similar?

What biotic and abiotic factors explain the variation in responses (magnitude and timing) of stream solutes to forest disturbances?

Figure II.B.7.2. Gauging house and channel below flume at Watershed 10 gauging station.

These Experimental Forest sites across the USA are situated across gradients of precipitation, atmospheric nitrogen deposition, nutrient limitation, vegetation, and soil types. Preliminary results show trends in stream chemistry in reference basins that vary with length of record analyzed. We are also showing that adjacent basins within a site do not necessarily show similar responses over time, which suggests that subtle, site specific processes are driving these trends. Comparison of responses to natural disturbances among sites, including hurricane, fire, insect outbreak, and forest management, indicate that following disturbances, all sites show increased stream nitrate concentrations. The magnitude and longevity of nutrient responses to disturbances varies within and among ecoregions.

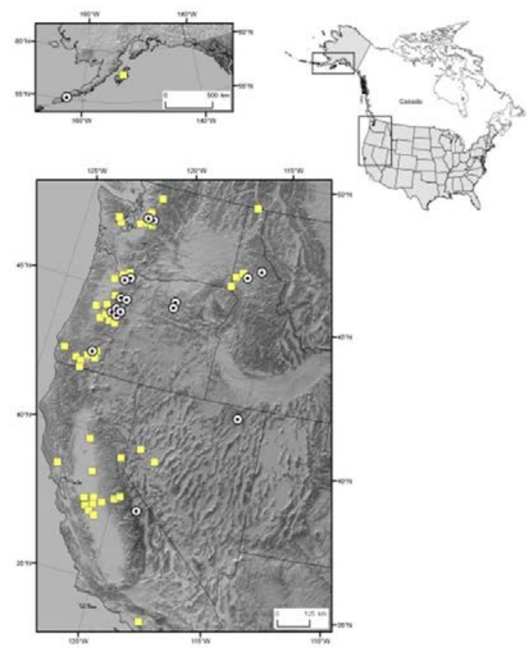

Figure II.B.7.3. Distribution of sites used for trends in air temperature and streamflow.

Stream temperature trends and metrics - We are comparing long term stream temperature trends and metrics at the Andrews Forest with those across forested stream across the Pacific Northwest. Based on observed trends in air temperature and stream flow, we expected to find warming of streams as well as increasing variability of stream temperatures over time. Contrary to this expectation, we found both cooling and warming trends in 18 minimally human-influenced and 45 more human-influenced streams across western North America (Figure II.B.7.3) based on data available from 1951-2009. The most recent two decades (1987-2009) produced mostly cooling trends in minimally human-influenced sites whereas more human-influenced systems showed mixed responses. Lack of coherence between air and stream temperature in recent decades is notable and likely related to complex and lagged interactions among non-climatic and climatic variables. Our results suggest that climate impacts on air and stream water cannot be simply correlated to infer future responses of stream temperature. We also evaluated long-term trends (1979-2009) of stream temperature metrics of magnitude, variability, frequency, duration, and timing in five of these 18 watersheds minimally impacted by other human influences in Oregon (2 of which were from H.J. Andrews Experimental Forest.) Preliminary results from the sites located in the HJ Andrews experimental forest show increases in magnitude of winter stream temperatures and longer duration of warm events over time (Fig II.B.7.4). We also found decreases in temperature variability, frequency and duration of cold events. We suggest that, during the last 31 years, thermal regimes of streams are becoming more homogeneous because decreases in cold water events over time.

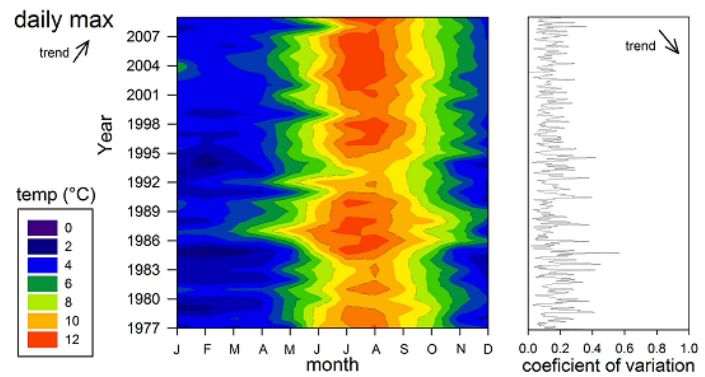

Figure II.B.7.4. Distribution of sites used for trends in air temperature and streamflow.

Fish -Mack Creek fish and salamander data base has allowed us to document fish population responses to forest harvest and forest regrowth as well as to look at more basic population fluctuations in an undisturbed stream reach. Disturbances such as major floods often are assumed to have negative effects on fish populations; major rearrangement of substrates and powerful water velocities have been hypothesized to injure fish or wash them downstream. However, after the flood, fish populations in reaches through old growth and young forest dramatically increased (Fig II.B.7.5). Compared to previous years, trout population densities in both reaches after the flood are the highest measured, and young fish showed especially high densities post flood. Fish densities and discharge continued to be high for several years. The especially high densities of young fish successfully translated into increased numbers of adult fish the following years. Increases in young fish post flood were thought to be the result of increased habitat availability. Removal of fine silt from stream sediment, deposition of spawning gravels along the stream margin, and increased refuges for young in new wood accumulations are all possible contributors

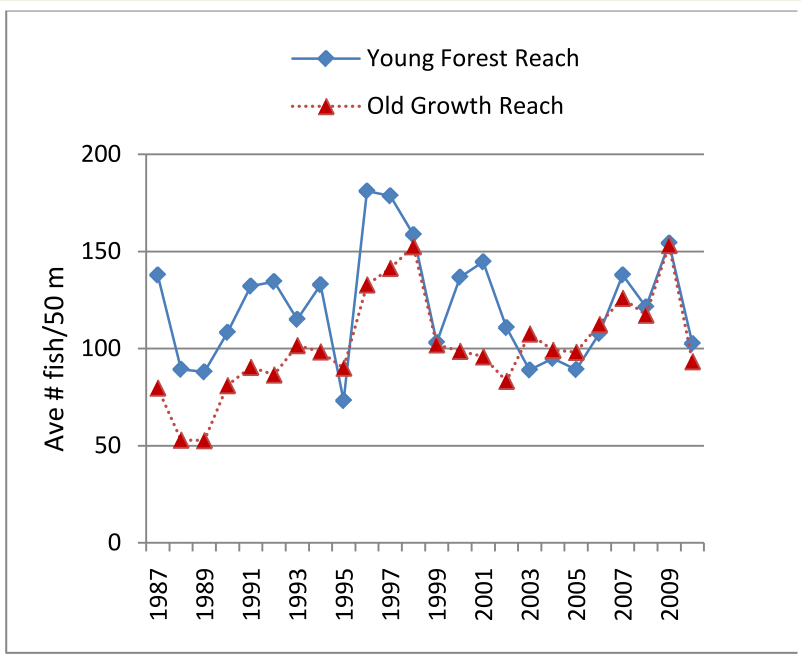

Figure II.B.7.5. Cutthroat trout population, 1987-2010, at Mack Creek at the Andrews Forest

People:

PIs: Stanley V. Gregory; Sherri L. Johnson, Linda R. Ashkenas, Roy Haggerty, Judith L. Li, Randall C. Wildman

Associates: Craig Creel, Cameron R. Jones, Alba Argerich, Ivan Arismendi, Greg Downing, Dana Warren, Mark A. Meleason, Daniel J. Sobota, Frederick J. Swanson, Steven M. Wondzell

Other Links

- Cooperative Chemical Analytical Laboratory (CCAL)
- Stream Ecosystem Model
- Stream Wood Dynamics Model (STREAMWOOD)
- Willamette Basin Consortium
- Willamette River Biocomplexity
- Willamette Basin Explorer
- Lotic Intersite Nitrogen Experiments (LINX1 & 2)

Databases used in this study

- Aquatic Vertebrate Population Study, Mack Creek, Andrews Experimental Forest -- AS006
- Long-term stream chemistry concentrations and fluxes: Small watershed proportional samples in the Andrews Experimental Forest -- CF002
- Stream and air temperature network at the Andrews Experimental Forest -- HT004

Selected Publications

Sobota, Daniel J.; Johnson, Sherri L.; Gregory, Stan V.; Ashkenas, Linda R. In revision. A stable isotope tracer study of the influences of adjacent land use and riparian condition on fates of nitrate in streams. Submitted to Ecosystems

Arismendi, Iván; Johnson, Sherri L.; Dunham, Jason; Haggerty, Roy. In review. Long-term trends in temperature of western North American streams: Linkages to climate and hydrologic alteration. Submitted to Nature GeoSciences

Bernot, Melody J.; Sobota, Daniel J.; Hall, Robert O. Jr.; Mulholland, Patrick J.; Dodds, Walter K.; Webster, Jackson R.; Tank, Jennifer L.; Ashkenas, Linda R.; Cooper, Lee W.; Dahm, Clifford N.; Gregory, Stanley V.; Grimm, Nancy B.; Hamilton, Stephen K.; Johnson, Sherri L.; McDowell, William H.; Meyer, Judith L.; Peterson, Bruce; Poole, Geoffrey C.; Valett, H. Maurice; Arango, Clay; Beaulieu, Jake J.; Burgin, Amy J.; Crenshaw, Chelsea; Helton, Ashley M.; Johnson, Laura; Merriam, Jeff; Niederlehner, B. R.; O'Brien, Jonathan M.; Potter, Jody D.; Sheibley, Richard W.; Thomas, Suzanne M.; Wilson, Kym. 2010. Inter-regional comparison of land-use effects on stream metabolism. Freshwater Biology. 55: 1874-1890. (Pub No: 4587)

Hill, Brian H.; McCormick, Frank H.; Harvey, Bret C.; Johnson, Sherri L.; Warren, Melvin L.; Elonen, Colleen M. 2010. Microbial enzyme activity, nutrient uptake and nutrient limitation in forested streams. Freshwater Biology. 55: 1005-1019. (Pub No: 4435)

Mazza, Rhonda with Sherri Johnson. 2009. Undercover isotopes: tracking the fate of nitrogen in streams. Science Findings 115. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 5 p. (Pub No: 4554)

Mulholland, Patrick J.; Helton, Ashley M.; Poole, Geoffrey C.; Hall, Robert O. Jr.; Hamilton, Stephen K.; Peterson, Bruce J.; Tank, Jennifer L.; Ashkenas, Linda R.; Cooper, Lee W.; Dahm, Clifford N.; Dodds, Walter K.; Findlay, Stuart E. G.; Gregory, Stanley V.; Grimm, Nancy B.; Johnson, Sherri L.; McDowell, William H.; Meyer, Judy L.; Valett, H. Maurice; Webster, Jackson R.; Arango, Clay P.; Beaulieu, Jake J.; Bernot, Melody J.; Burgin, Amy J.; Crenshaw, Chelsea L.; Johnson, Laura T.; Niederlehner, B. R.; O'Brien, Jonathan M.; Potter, Jody D.; Sheibley, Richard W.; Sobota, Daniel J.; Thomas, Suzanne M. 2008. Stream denitrification across biomes and its response to anthropogenic nitrate loading. Nature. 452: 202-205. (Pub No: 4382)

II.B.8. Vegetation

Project objectives and relationship to LTER6 goals. Understanding the role of vegetation succession in forest ecosystems of the Pacific Northwest is a fundamental part of long-term ecological research at H.J. Andrews Experimental Forest. Studies in this component seek to understand how plant communities change in composition and structure over the course of succession and what processes control these changes. We are particularly interested in how changes in vegetation over the course of succession affect other ecosystem processes such as vegetation water-use, carbon storage, nitrogen cycling, and disturbance regimes (Goal II Objectives 1-4). The research for this component primarily makes use of data from a large network of permanent study plots across a wide range of stand ages, habitats, management histories, and disturbance types in Oregon and Washington as well as data from long-term monitoring of experimental watersheds at the H.J. Andrews Experimental Forest. There are more than 130 installations of permanent plots in Oregon and Washington, representing a cross-section of forest types from the Pacific coast eastward to the Cascade Mountains. The Andrews is one of the focal areas in the permanent plot program with plots in 28 forest stands and eight experimental watersheds (Figure 1). The long-term data from the permanent plot program provides the only means of directly observing the relatively slow dynamics of Pacific Northwest forests (Goal II). Another application of these data is for building and validating spatial models of forest structure and dynamics (Goal II objective 4). For example, the plots can be used with remote sensing (e.g. LiDAR and TM imagery) to create spatial models vegetation structure and composition across landscapes (Goal I objective 2). The plots are also used to validate models that simulate successional change in relation to topography and climate.

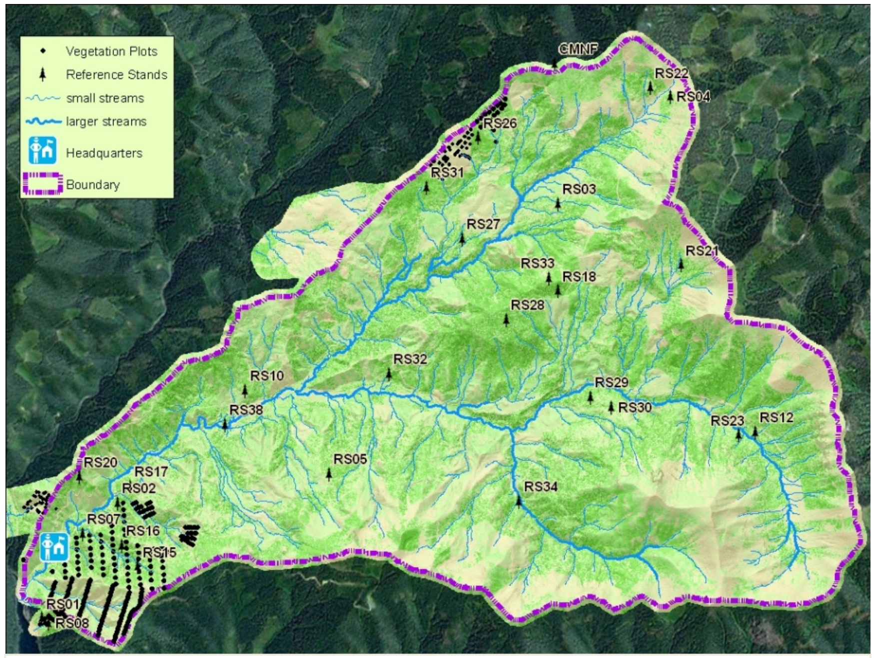

Figure 1.B.8.1. Map of long-term vegetation plots on Andrews

Progress Report: Under LTER6, and with additional funding from the PNW Research Station, our field crews of students and recent graduates have measured trees and assessed tree mortality in more than 50 of the permanent plots. Another 25 installations are scheduled to be measured in 2011. In addition, we resampled the trees and understory vegetation in a long-term study of plant succession in Watershed 10, at the Andrews which was clearcut logged in the mid-1970's. Data collection in the permanent plots has been streamlined with implementation of electronic data collection, reducing the time and expense associated with post-field data entry, data cleaning, and archiving in the Forest Science Data Bank. Furthermore, data collection protocols have been updated to clarify decision rules around the various situations that field crews encounter, and helping to ensure consistency of data over time. Along with that, we have developed a written protocol for creating and updating stem maps of the permanent plots. The updated maps help field crews do their jobs more efficiently, and are used in GIS to assess spatial patterns of tree growth, regeneration and mortality.

Data analyses are moving forward for several plots and locations. For example, current stand structure and biomass were summarized for all of the permanent plots at the HJ Andrews, as part of the Digital Forest project. We evaluated forest productivity, stand structure and tree mortality in three plots with a data record spanning 100 years, the longest in the permanent plot system. We have also summarized 25 years of mortality and ingrowth data from the permanent plot at the Metolius Research Natural Area.

It is suggested that diversity destabilizes individual populations within communities; however, generalizations are problematic because effects of diversity can be confounded by variation attributable to community type, life history or successional stage. A 40-year record of reassembly in forest herb communities was examined in two clearcut watersheds. Population stability was higher among forest than colonizing species and increased with successional stage. Thus, life history and successional stage may explain some of the variability in diversity–stability relationships found previously. However, population stability was positively related to diversity and this relationship held for different forest communities, for species with contrasting life histories, and for different successional stages.

Aspects of the tree mortality regime were characterized for old-growth conifer forests in Mount Rainier National Park, Washington, USA, using individual tree records from a network of permanent forest research plots. Physical agents of mortality (uprooting, stem breakage, and crushing by falling debris) accounted for approximately 40% and 45% of mortality events in trees <15and ≥15cm dbh, respectively. These physical processes were chronic sources of mortality: they were not associated with a single or few disturbance events.

Persistent changes in tree mortality rates can alter forest structure, composition, and ecosystem services such as carbon sequestration. An analysis of longitudinal data from unmanaged old forests in the western United States including many from the Andrews permanent plot network showed that background (non-catastrophic) mortality rates have increased rapidly in recent decades, with doubling periods ranging from 17 to 29 years among regions. Increases were also pervasive across elevations, tree sizes, dominant genera, and past fire histories. Forest density and basal area declined slightly, which suggests that increasing mortality was not caused by endogenous increases in competition. Because mortality increased in small trees, the overall increase in mortality rates cannot be attributed solely to aging of large trees. Regional warming and consequent increases in water deficits may be the contributors to the increases in tree mortality rates.

Key Databases

- Post-logging community structure and biomass accumulation in Andrews Experimental Forest Watershed 10 (TP041)
- Pacific Northwest Plant Biomass Component Equation Library (TP072)
- Plant succession and biomass dynamics following logging and burning in the Andrews Experimental Forest Watersheds 1 and 3 (TP073)
- Ecosystem dynamics in a mature and an old-growth forest stand (Watershed 2, Hagan Block) (TP091)
- DEMO: Vegetation Data - Post-Harvest (TP108)

- Plant biomass dynamics following logging, burning, and thinning in Watersheds 6 and 7 at the Andrews Experimental Forest (TP114)
- Plant biomass dynamics in old-growth Watersheds 8 and 9 at the Andrews Experimental Forest (TP115)
- Dendrometer studies for stand volume and height measurements of trees of the western US (TV009)
- Tree growth and mortality measurements in long-term permanent vegetation plots in the Pacific Northwest (LTER Reference Stands) (TV010)
- Forest structure and biomass in early successional harvest units of the Andrews Experimental Forest (ESSA) (TV052)
- DEMO Wildlife Study: Arboreal Rodents, Small Mammals, Amphibians, and Birds (WE015)

Personnel

PIs: Mark E. Harmon, Robert J. Pabst, Thomas A. Spies

Collaborators: Ken Bible, Jerry F. Franklin, Charles B. Halpern, Donald Henshaw, Janneke Hille, Ris Lambers, Andrew Larson, James Lutz, Suzanne Remillard, Mark Swanson, Todd Wilson,

Associates: Steve Acker, Nelli Chizhikova, Warren B. Cohen, Craig Creel, Greg Downing, Andrew N. Gray, Paul A. Harcombe, Julia Jones, Jane Kertis, John Moreau, Keith Olsen, Jay Sexton, Ashley Steele, Fred Swanson

Other links

Conceptual Model of Constraints on Conifer Regeneration

http://andrewsforest.oregonstate.edu/pubs/webdocs/reports/regen.cfm?topnav=66

Fitting Curves of Bole Production to Long-term Forest Measurements

http://andrewsforest.oregonstate.edu/lter/pubs/webdocs/reports/curv_fit.cfm?topnav=55

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Larson, A.J. and J.F. Franklin. 2010. The tree mortality regime in temperate old-growth coniferous forests: the role of physical damage. Canadian Journal of Forest Research 40: 2091-2103.

van Mantgem, P.J., N.L. Stephenson, J.C. Byrne, L.D. Daniels, J.F. Franklin, P.Z. Fulé, M.E. Harmon, A.J. Larson, J.M. Smith, A.H. Taylor, and T.T. Veblen. 2009. Widespread increase of tree mortality rates in the western United States. Science 323:521-524.

II.B.9. Integrated Research: Digital Forest: Spatial Models of Vegetation Structure and Composition.

Project objectives and relationship to LTER6 goals: The objective of this project is to spatially model current forest structure and composition of the Andrews. These models and data will then be used by other projects in LTER6 (e.g. water and carbon, modeling) to address questions related to the goals of the LTER. In addition, the spatial models of forest structure and composition will be used to understand how forest structure varies in relation to topography (Goal 1).

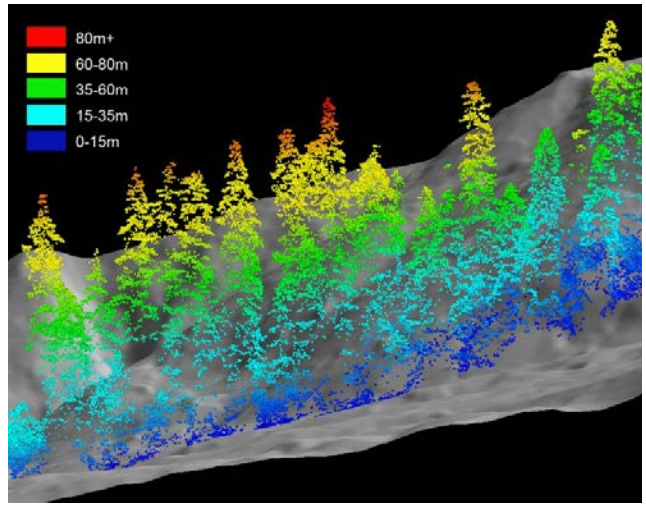

Figure II.B.9.2. Profile of canopy heights in an old-growth Douglas-fir forest based on LiDAR returns. Colors indicate height classes.

Figure II.B.9.2. Some old-growth trees were climbed to measure their heights using a tape measure. In this photo Matt Betts, a wildlife scientist, works his way up a 70 meter tall Douglas-fir. Photo courtesy of OSU media services.

Abstract: The initial stage of this project was to create and evaluate spatially models of canopy height and cover, which can be estimated directly from LiDAR (Fig II.B.9.2). The second phase was to model other forest structural features, such as biomass and basal area, which require that data from ground plots be used in conjunction with LiDAR. Additional ground plots were established to sample underrepresented vegetation types and tree heights were measured with other means to validate the LiDAR in tall coniferous forests (Fig. II.B.9.2). The third phase of the project will be to evaluate how components of structure vary in across the Andrews in relation to topography and elevation. These analyses will be based on statistical models of structural features developed by linking LiDAR to forest plots. If funding permits we will conduct a fourth phase of work that integrates TM imagery and other information to spatially model forest canopy composition (hardwood vs. conifer).

Progress Report: We used permutation statistical models to identify the best predictor variables of live aboveground biomass (AGB) out of 18 lidar metrics and environmental variables. The best model contained only two variables: 95th percentile of 1st lidar returns and elevation. This model has a fit of about 0.60 (range of 0.55 to 0.65 for the middle half of the randomly selected data sets) with R^2s reaching as high as 0.80 to 0.90.

We then applied this model to map AGB across the entire Andrews at a spatial resolution of 5 meters (Figure II.B.9.3). This map reveals strong variation in AGB associated with the pattern of past clearcuts and old growth areas. It is also possible to see areas of lower biomass associated with wildfire in the early 20th century around Lookout Mountain (lower right of map).

We validated the lidar estimates of tree heights using ground-based lasers and trigonometry on more than 40 trees. We also climbed four very tall Doulgas-fir trees and measured their heights directly with a tape. Analyses of the data revealed a very close relationship between laser heights and lidar heights (r = 0.988)) and lidar heights and climbed heights (r = 0.997). There was more scattered between laser heights and lidar heights for trees that were classified as leaning. The height analysis allowed us to validate the existence of a few 90+ m tall trees on the Andrews.

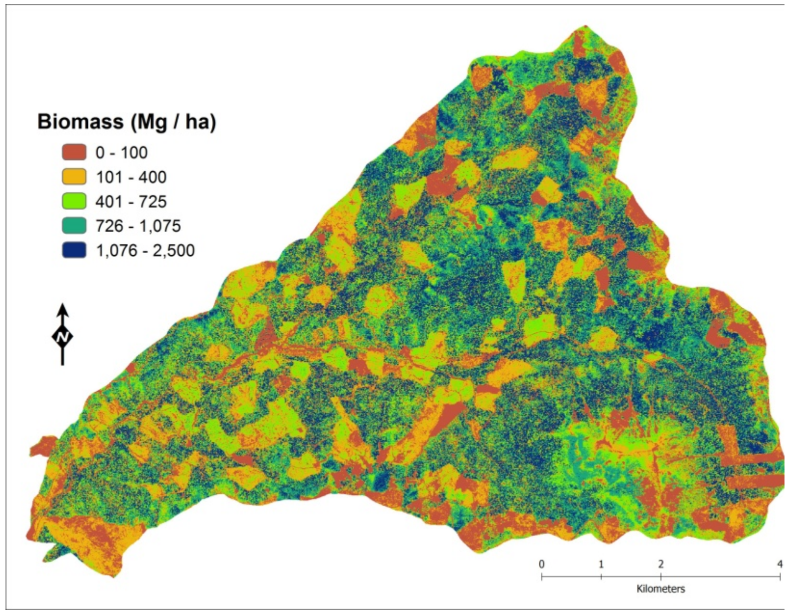

Figure II.B.9.3. Pattern of live aboveground biomass at the Andrews Forest.

Personnel:

PIs: Thomas Spies, Mark Harmon, Mark Schulze, Rupert Seidl, Matt Betts
Other Research Personnel: Rob Pabst, Keith Olsen, Theresa Valentine
Cooperators: Ashley Steel (PNW Research Station), Van Kane (University of Washington)

Associated Projects:

LTER6 Projects:
- LTER6 Goals
- LTER6 Modeling Project
- LTER6 Carbon and Water Cycle

Other projects:
- iLAND (http://land.boku.ac.at/tiki-index.php)

Databases used in this study:

TV010-Long-term vegetation plots

II.B.10. Integrated Research: Long-term trends at the Andrews Forest: what's changing and what's not?

Project objectives and relationship to LTER6 goals: The overall objective of this multidisciplinary project is to quantify long-term trends and variability in selected records of climate, hydrology, ecosystem fluxes, and organisms at the Andrews Forest, especially with respect to climate change (LTER6 Goals I and II). The specific objectives are to 1) quantify long-term variability and trends in climate, streamflow, precipitation and stream chemistry, and selected organisms, and 2) explain how variability and trends vary spatially in the complex terrain of the Andrews Forest.

Figure II.B.10.1 Instrumental records at the Andrews Forest extend back to the early 1950s

Activities: This work draws on long-term records of climate, streamflow, precipitation and stream chemistry, the spotted owl demography study, and Lepidoptera (moths) supported by the US Forest Service, BLM, and LTER. These records extend back to the 1950s (climate, streamflow), 1970s (precipitation and streamflow chemistry), 1980s (spotted owl study) and 1990s (moths) (Fig II.B.10.1). Datasets are available from multiple sites for each property: climate (6 meteorological stations and 20 reference stands), streamflow (9 small watersheds, 6 large watersheds), chemistry (2 precipitation records, 8 stream records), owls (153 nest sites), and moths (20 sites).

Figure II.B.10.2. The Andrews landscape has been changing for thousands of years, even before people arrived in North America, and since then.

Progress Report: Air temperatures at the Andrews Forest increased by 0.05°C per year from 1972-2003 (1.5°C in 30 yrs) (Figure II.B.10.3). Temperature increases are greater for maximum than minimum temperatures, for summer compared to winter, and for upper slopes compared to valleys (Figure II.B.10.4) (Jones, in prep.). Snowpack has declined by ~50% compared to the 1950s, but early 2000s snowpack values are similar to the lowest recorded (1940s), while late 2000s snowpack values are similar to the highest recorded (1950s) (Fig. II.B.10.5). When Pacific sea surface temperatures are warm (positive Pacific decadal oscillation), the Andrews Forest experiences higher than average winter temperatures, less snow, less winter streamflow, cooler and wetter than average summers, and more summer streamflow. August streamflow has declined since 1915 in high-elevation watersheds in the High Cascades (Fig. II.B.10.6) (Jefferson et al 2008). In response to warming air temperatures, spring streamflow has declined in old-growth control watersheds (Fig. II.B.10.7) (Moore 2010).

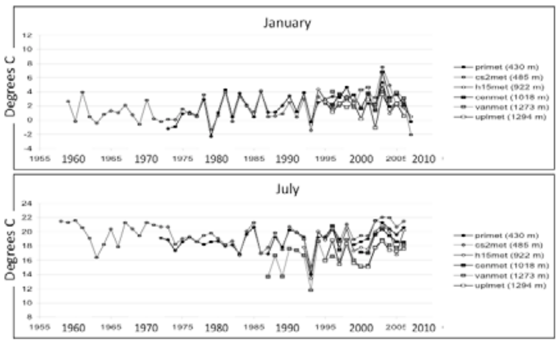

Figure II.B.10.3. Trends since 1958 in mean daily temperature at the Andrews Forest (Jones, unpublished)

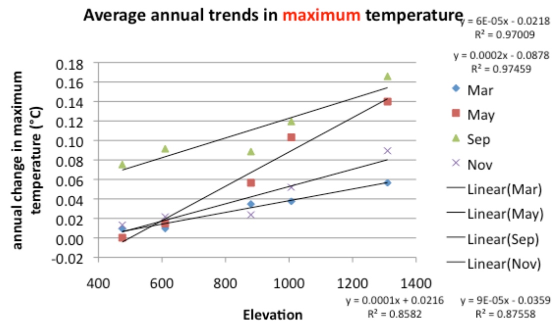

Figure II.B.10.4. Trends since 1971 in mean daily temperature at the Andrews Forest , by elevation (Jones, unpublished)

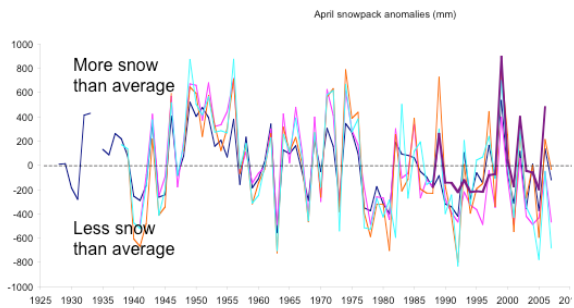

Figure II.B.10.5. Trends since 1940 in April snowpack anomalies of at five sites in and near the Andrews Forest (Jones, unpublished)

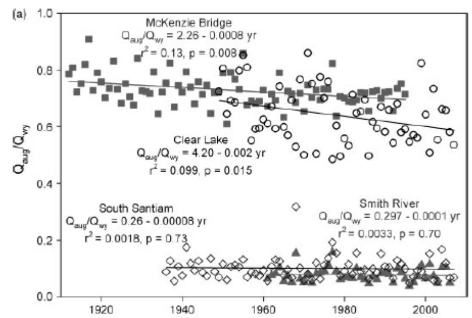

Figure II.B.10.6. Trends since 1915 in August:annual discharge in High (McKenzie, Clear Lake) and western Cascades (S. Santiam, Smith) rivers (Jefferson et al 2008)

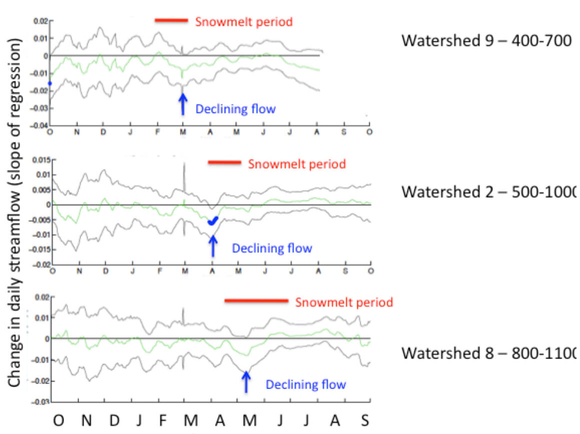

Figure II.B.10.7. Trends since 1952 in daily streamflow at the Andrews Forest, by elevation (Jones, unpublished)

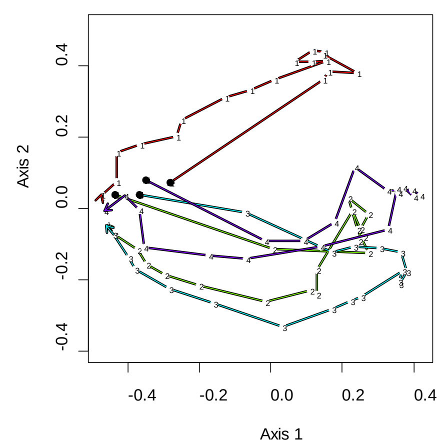

Fig II.B.10.8. Trends since 1962 (after harvest) in herb species composition (ordination of multi-dimensional scaling) at the Andrews Forest. (Chizhikova, unpublished, Halpern 1988, 1989)

Precipitation chemistry is quite pure, pH 5.5, with total N inputs <1.5 kg/ha/yr. Since 1971, precipitation chemistry has undergone a decline in cations, especially Ca, and Si, but few other elements experienced significant trends, perhaps as a result of a steep decline in logging, road construction, and truck traffic beginning in 1990, when spotted owls were listed as a threatened species. Stream chemistry also is very pure, pH 7.4, with total N outputs 0.6 kg/ha/yr. Streamflow chemistry has experienced no significant trend, although stream chemical concentrations increased briefly after harvest in treated experimental watersheds.

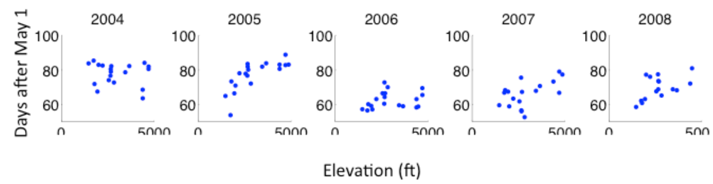

Figure II.B.10.9. Trends in moth emergence with elevation, 2004-2008 (Sheldon, Miller, et al unpublished)

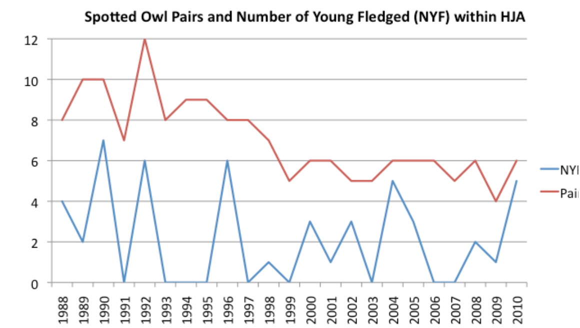

Figure II.B.10.10. Trends since 1988 in spotted owl pairs and young at the Andrews Forest. (HJ Andrews Northern Spotted Owl Demography Study , Smoluk 2010)

Forest succession is underway in clearcuts, createdin the 1950s and 1960s, that occupy about 20% of the Andrews Forest. Biomass accumulation is proceeding rapidly, and species composition of young forest has returned to close to that before harvest of old-growth forest (Fig. II.B.10.8).

In contrast to the plant species recovery to past conditions in clearcuts, montane meadows in the Andrews Forest have lost about half their area from 1950 to the present (Rice 2009, Highland 2011). Trees have invaded these meadows and other montane meadows in the High Cascades. Although the causes of initial tree invasion are debated (fire suppression, grazing, other), once tree invasion begins biotic interactions govern patterns of tree invasion in montane meadows (Rice et al. in review).

Insects (Lepidoptera), which are expected to respond to climate variability, appear to emerge later at higher elevations, but this pattern occurs only in some years (Fig. II.B.10.9).

Northern spotted owl populations have declined since 1988 (Fig. II.B.10.10).

Associated Projects:

- LTER6 Projects:
  - LTER6 goals
  - The LTER6 Climate project
  - The LTER6 Hydrology project
  - The LTER6 Modeling project
  - The LTER6 Phenology project
- Other Projects:
  - Bunchgrass Ridge project <http://depts.washington.edu/bgridge/>

Databases used in this study

CF002 Long-term stream chemistry concentrations and fluxes: Small watershed proportional samples in the Andrews Experimental Forest

CP002 Long-term precipitation and dry deposition chemistry concentrations and fluxes: Andrews Experimental Forest rain collector samples

GS002 Stream cross-section profiles in the Andrews Experimental Forest and Hagan Block RNA

HF004 Stream discharge in gaged watersheds at the Andrews Experimental Forest

MS001 Meteorological data from benchmark stations at the Andrews Experimental Forest

MS005 Reference Stand air and soil temperature network at the Andrews Experimental Forest

SA015 Spatial and temporal distribution and abundance of moths in the Andrews Forest

TP041 Post-logging community structure and biomass accumulation in Watershed 10

TP073 Plant succession and biomass dynamics following logging and burning in the Andrews Experimental Forest Watersheds 1 and 3, 1962-Present

TP114 Plant biomass dynamics following logging, burning, and thinning in watersheds 6 and 7 at the Andrews Experimental Forest

TP115 Plant biomass dynamics in old-growth watersheds 8 and 9 at the Andrews Forest

II.B.11. Integrated Research: Phenology and Trophic Interactions in Complex Terrain

Project objectives and relationship to LTER6 goals: This study is designed to evaluate the influences of microclimatic heterogeneity, associated with complex terrain, on phenology (Goal I, objective 3) and to evaluate potential trophic responses to scenarios of change in climate, disturbance and land use (Goal II, objective 3). We focus on a simplified model trophic system involving vascular plants, terrestrial and aquatic insects, and migratory neotropical and resident birds (Fig II.B.11.1). This work uses and extends our long-term studies of plant phenology, climate, Lepidoptera, and aquatic insects in LTER5 and earlier, and allows us to expand our biotic studies to include birds. The model trophic system is ideal because the phonological behaviors across trophic levels are both independent (responding to different abiotic drivers) and dependent (due to trophic interactions), potentially leading to complex system behaviors.

Figure II.B.11.1.. Phenology research at the Andrews Forest includes phenophase for 17 species of plants, activity pulses of flying insects, timing of emergence of aquatic insects and bird arrival and changes in occupancy throughout spring.

Abstract: Plant phenology is highly dependent on temperature. Hence, the spatially variable microclimate that occurs in complex terrain results in asynchrony (low spatial coherence) of plant phonologic stages across the landscape (Fig. II.B.11.2). Phenologies of terrestrial arthropods also have wide spatial and temporal variation, likely in response to temperature variation across terrestrial microclimates such as cold air drainage patterns and temperature inversions. Aquatic insect emergence is also tied to temperature, but stream temperatures are influenced by different factors than those driving air temperatures and may be less sensitive to complex terrain. Seasonal behaviors of migratory neotropical birds, and habitat and nest selection by resident species may be

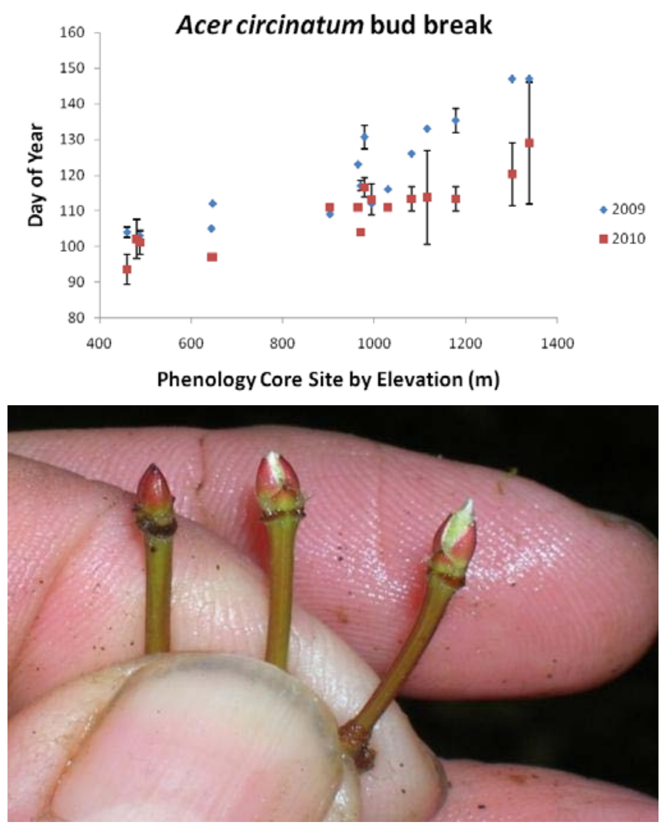

Figure II.B.11.2. Timing of budbreak of vine maple varied greatly at higher elevation sites between the two years.

regulated by endogenous mechanisms, as well as by local climate We are assessing how these varied microclimatic influences on timing of phenological events affect trophic interactions across the landscape. Phenologies of predators and prey, or producers and consumers, can become desynchronized if mobile predator species are sensitive to different phonologic cues than local prey species, affecting predation rates. We are employing a model trophic system involving producers, first-order consumers (caterpillars and aquatic insects, which have limited ranges, and microclimatic factors control their phenology), and birds, which combine an array of well-developed behaviors with great mobility and are adapted for finding good feeding stations in a spatially heterogeneous environment. We are addressing the following questions:

1. What local abiotic drivers (e.g., cumulative degree days, photoperiod) determine the phenology (e.g., bud break, instar development, activity of songbirds) of the biota in our model system?
2. How is the synchrony of phenologies of these biota affected by environmental conditions varying across space and time (within and between years)?
3. What is the extent of correlation between biomass of aquatic and terrestrial food sources at a site and bird fecundity (indicated by activity or the intensity of bird song in the post breeding period)?

Progress Report: Phenology and trophic interactions. We are documenting timing of species activities and distribution across the Andrews. A number of insect and bird species not formerly noted within the Andrews have been documented. We will synthesizing timing, trends and linkages among trophic levels; many of the questions we are addressing will require three or more years of data collection. However, even in the initial stages of this project interesting patterns have emerged. As expected, plant phenology, in particular leaf-out and herbaceous emergence, was highly variable spatially and differed greatly between years. Beyond expected differences with elevation and aspect, which were as great as a full month for leaf-out of some species, there was obvious microsite variation at the scale of tens of meters. Winter and spring weather differed sharply between years one and two, as did timing of bud break and leaf development for focal plant species (Figure II.B.11.2). Although only indicative of the high degree of inter-annual variability, we noted that for some target plant species budbreak and leaf emergence dates were up to one month earlier in 2009 than at the same sites in an early phenology study in 1971. Phenocams have been installed in treetops to provide high frequency sampling of

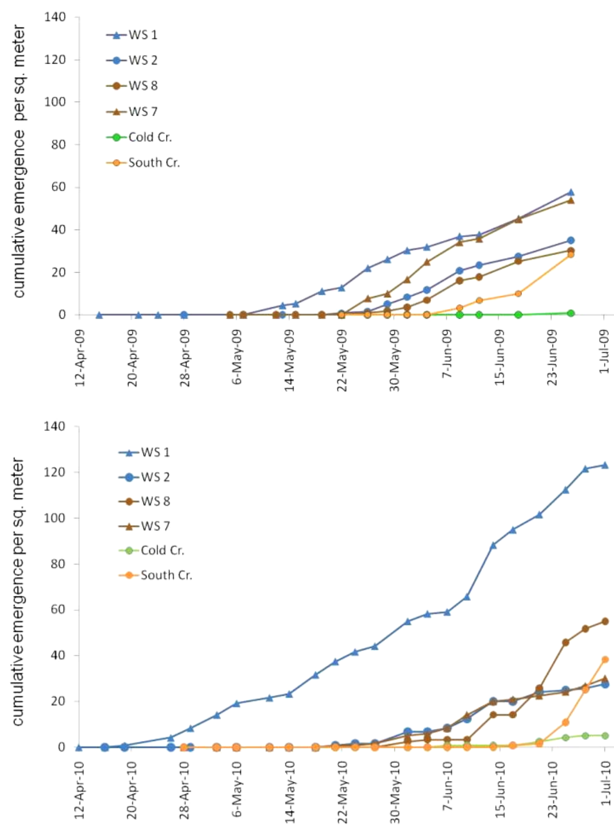

Figure II.B.11.3. Timing and rates of emergence of aquatic macroinvertebrates, showing differing responses of taxa to year to year climatic variability.

overstory and for field verification of remote sensing portion of phenology, being conducted by graduate student Kevin Briggs.

Trends in springtime aquatic insect emergence showed a relationship between site temperatures, site elevation and adult insect emergence rates, with lower elevation sites having earlier peaks of emergence (Figure II.B.11.3). In addition, within sites there was an increase in emergence rate and taxa richness over the sampling period. Most samples from core sites had a taxa richness and diversity, but at the one very cold spring-fed stream (Site 5), taxa were slower to emerge and community composition differed substantially from the other sites.

Flying insect activity levels (number of individuals captured per day) are also being assessed at core sites (Fig. II.B.11.4). In 2009, taxa richness and numbers of individuals captured were lower in early May than later in the spring, during late May or mid June. An in-depth examination of samples collected in mid-June showed no apparent relationship between insect activity levels and site elevation or adjacent forest age. Comparison of insect activity with other biophysical factors across sites is underway.

Primary bird species being studied at the Andrews Forest include hermit warbler (a migrant), winter wren (partial migrant) and chesnut backed chickadee (resident). Initial results from graduate student Sarah Frey's intensive bird sampling and occupancy modeling indicate that bird distributions are highly dynamic even within the breeding season (Figure II.B.11.5). We are seeing evidence for within-season movement which tends to occur along elevational gradients and away from sites with higher variability of temperatures over the sampling season. Songmeters have been installed at the Core sites to expand the sampling timeframes. They are able to record bird songs 20 minutes of each hour for automated identification by Computer Science collaborators.

We are examining the extent to which these birds are tracking temperatures or availability of other resources by conducting Phenology Pulses, involving Citizen Scientists and teachers. In these pulses, we are able to sample additional sites (beyond the weekly core sites) to quantify availability of insects as forage for the birds and associated plant phenophases (Figures II.B.11.6 and II.B.11.7)

Figure II.B.11.4. Malaise traps capture flying insects at core phenology sites. Photo of *Anaspis* beetle (*Coleoptera: Scraptiidae*) which are common.

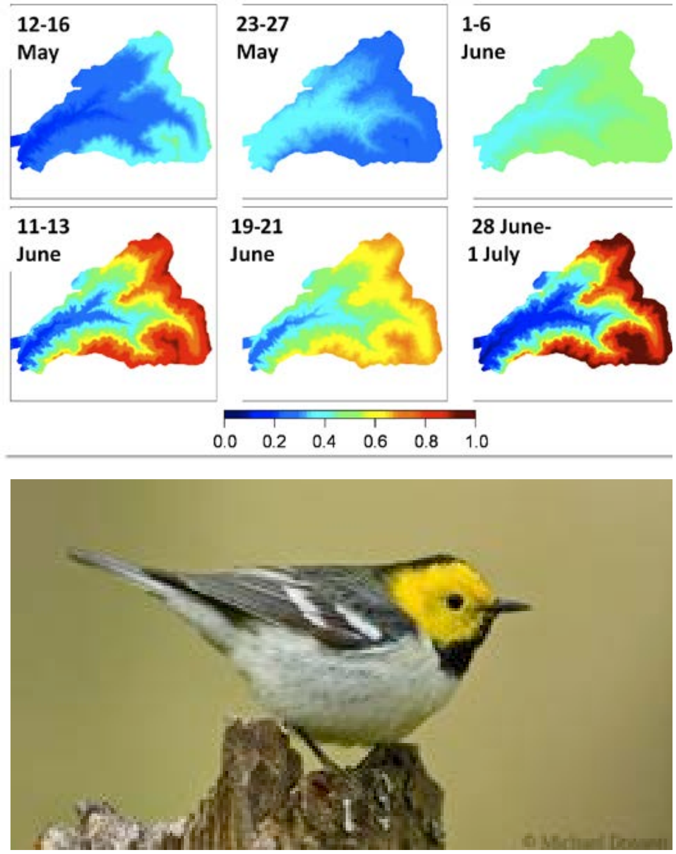

Figure II.B.11.5. Occupancy probability for Hermit Warbler in spring 2010. Note cold period late May.

Figure II.B.11.6. Adult aphids on maple leaf during Phenology Pulse.

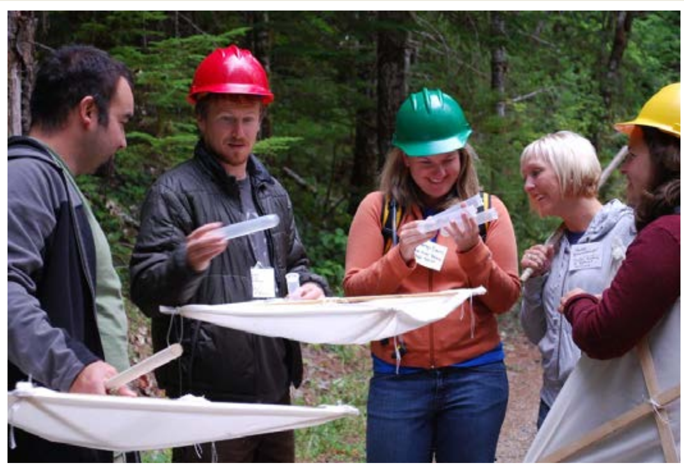

Figure II.B.11.7. Phenology Pulse: Teachers and citizen scientists collecting insect and plant phenology data.

People:

PIs: Sherri Johnson, Mark Schulze, Matthew Betts, Judy Li

Collaborators: Kari O'Connell (for Teachers as Researchers)

Students: Sarah Frey

Other Personnel: Jay Sexton, Ari DeMarco, Bill Gerth

Associated Projects:

LTER6 Projects:
- LTER6 goals
- The LTER6 Digital Forest project
- The LTER6 Climate project

Related Projects:

Selected Publications:

Li, J.L., S.L. Johnson and J.B. Sobota. 2011. Three responses to small changes in stream temperature by fall-emerging aquatic insects. Journal of the North American Benthological Society 30: 474-484 (doi: 10.1899/10-024.1)

Databases: Field work is conducted April-June each year and temperature sensors remain at sites throughout the year. Data collection started mid-spring 2009.Metadata for each group is online and initial year temperature and insect data for have been provided to data managers
SA025 -Insect Activity Phenology for aquatic and terrestrial sampling at Andrews Experimental Forest
HT006 -Stream and air temperature within the phenology network at the Andrews Experimental Forest
TV075 -Vegetative Phenology observations at the Andrews Experimental Forest
SA024- Bird Arrival and Activity Phenology at the Andrews Experimental Forest

II.B.12. Integrated Research: Carbon and Water Cycle Processes within a Small Watershed: Role of Complex Terrain

Project objectives and relationship to LTER6 goals: The overall objective of this multidisciplinary project is to better understand the influences of complex terrain on the sensitivity of carbon and water cycle processes to environmental drivers at different scales (LTER6 Goal I, objective 2). The specific objectives are to: 1) measure and model stocks and fluxes of carbon and water on a nested range of spatial and temporal scales, 2) identify environmental controls and sensitivities of processes to the controllers on these scales, and 3) test the hypothesis that the sensitivity of carbon and water cycle processes to environmental drivers is lower at the basin scale than at the average plot scale. This project is also test-bed for new measurement approaches, sensors and sensor network technologies, data visualization approaches, as well as a case study for developing new telecommunications and data management and analysis tools to realize our Cyber-Forest vision for the entire site (Section 4 and Figure 4.1 of the LTER6 proposal).

Figure II.B.12.1. A network of sensors on a 37m tower and an echydrological sensor network in WS1 provide high-spatial- and temporal-resolution environmental data that are conveyed by telemetry to the Andrews HQ and uploaded incrementally to the Andrews database. (M.S. student Scott Allen is shown in foreground)

Abstract: The majority of work for this integrated study is concentrated in WS1 where we have installed towers for meteorological measurements and a "ridge-to-ridge" ecohydrological sensor network (Figure II.B.12.1; also see link to FEEL, below). In the first half of LTER6 we focus primarily on carbon cycle processes, combining existing data from the network of 131-remeasurement plots, new measurements to quantify respiration and DOC losses and soil properties, and the 2008 LiDAR reconnaissance to construct a complete carbon budget at the plot and basin scales (Figure II.B.12.2). In the second half of LTER6 we will place more emphasis on water cycle processes. The measurements, along with downscaled climate projections from the LTER6 Climate project, will be used to parameterize and calibrate two ecohydrological simulation models – VELMA (Visualizing Ecosystems and Land Management Assessments) and RHYSSys (Regional Hydro-Ecological Simulation System). The models will be used to examine the relationships between environmental drivers and ecological processes at different spatial and temporal scales.

Figure II.B.12.2. PhD student Kristin Peterson is combining data from long-term remeasurement plots, LiDAR, spatial extrapolations of microclimate and new field measurements to quantify the spatial variability in above-ground biomass and productivity and potential forcing factors.

Progress Report:

Carbon and Water Cycle Processes: A network of plots have been established in WS1 for new measurements to complement long-term measurements as well as the existing sensor network (Figure II.B.12.3). These are co-located with long-term vegetation plots (installed in the early 1960s, shown as "biometrics" plots and colored green in the figure). With the combined sources of information, we're making good progress in characterizing the terrestrial component of spatial and temporal variability in the carbon budget. The entire team produced a framework for analyzing the complete carbon budget, with identification of uncertainties, and PhD student Kristin Peterson has created maps to show change in above-ground biomass and productivity since the small watershed was harvested in the late 1960s (Figure II.B.12.4.). Interesting results are 1) the spatial variability in current aboveground biomass is very high considering that this is an even-aged stand dominated by a single species; 2) the locations of productivity "hotspots" have shifted over the 40-year development of the stand, 3) current biomass distribution is unrelated to spatial variation in radiation, elevation or temperature, but appears to be correlated with soil rockiness. Undergraduate researcher Dustin Quandt has sampled Dissolved Organic Carbon (DOC) losses in plots with a range of productivity levels. Between December 2010 and April 2011 he found no significant change over time in DOC losses, although there was substantial spatial variability that appears positively correlated with productivity. We will soon compare the time series of terrestrial DOC losses with DOC from long-term stream samples and will compare what? with estimates of stream metabolism from other Andrews studies. Two full years of litterfall collections at high spatial density are nearly complete and are being used to calculate net productivity as well as constituting a component of the carbon cycle study. So far we've detected no statistically significant difference in litterfall as a function of canopy cover, likely because of high variance. Soil samples are currently being analyzed for light and heavy carbon fractions. A Picarro carbon isotope analyzer is installed at base of the tower and is continuously collecting information on isotopic composition of atmospheric CO2, to be used for analyses in the second half of

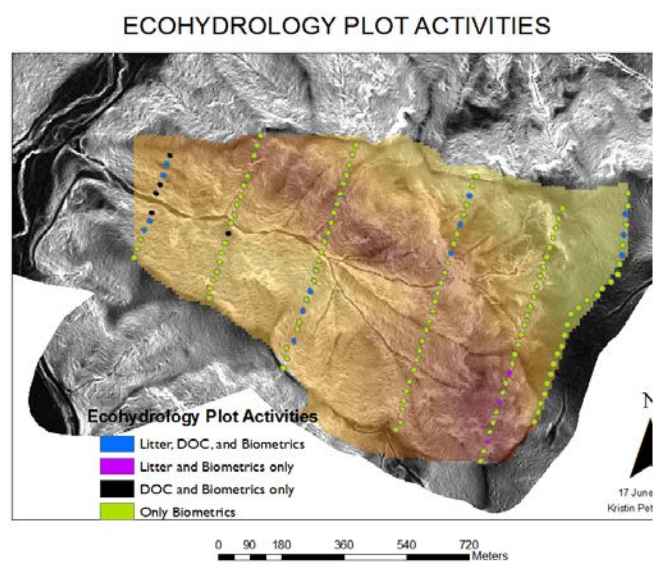

Figure II.B.12.3. Map of locations of new measurements in WS1 for this project. Map by Peterson, 2011.

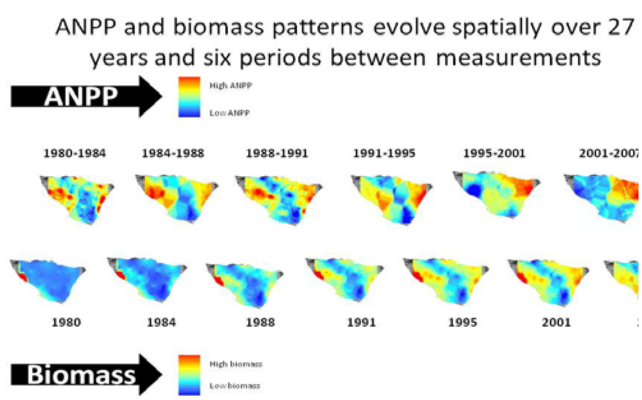

Figure II.B.12.4.. Biomass and productivity distribution in WS01, extrapolated from a dense network of permanent plots. Peterson et al, 2011.

this project. Meanwhile, MS student Scott Allen is characterizing spatial variability in rainfall interception by the canopy, and subsequent evaporation. His data show that significantly greater interception losses on the south-facing slope compared with the north-facing slope (Figure II.B.12.5), suggesting potential differences in precipitation inputs to the soil with respect to aspect. Scott is currently developing a model of anticipated variation in rainfall interception across the watershed that will be contrasted with maps of spatial variability in productivity. He is also working to reconcile these results with observations showing no net difference in the H or O isotopic composition of throughfall, and with earlier observations by Dr. Holly Barnard that showed no difference in the isotopic composition of stem water in various slope positions or aspects in this watershed. Future work will include a comprehensive analysis of 96 soil water sensors in the "ridge to ridge" transect and integration of the productivity and rainfall analyses.

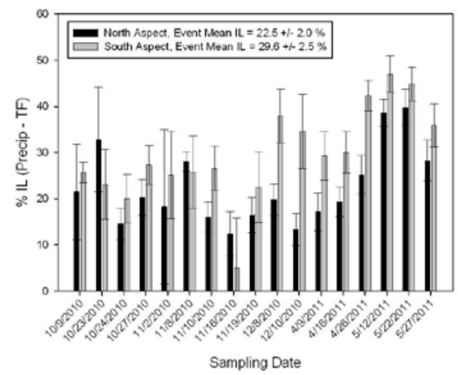

Figure II.B.12.5. Percentage of incoming precipitation (i.e., "interception losses", or IL) that evaporated from the canopy on N vs S facing slopes in WS1. Allen et al. 2011.

Visualizations of watershed processes:

This project's extensive sensor and modeling data provides an ideal opportunity for collaboration with an interdisciplinary project recently funded by NSF and led by Judy Cushing of the Evergreen State University, Visualization of Terrestrial-Aquatic Systems (VISTAS). VISTAS is developing visual analytics for large, complex environmental problems spanning spatio-temporal scales and thus help scientists understand multi-scale relationships, develop new hypotheses, and explain results. The goal of VISTAS is to help scientists display & interpret very large data sets.

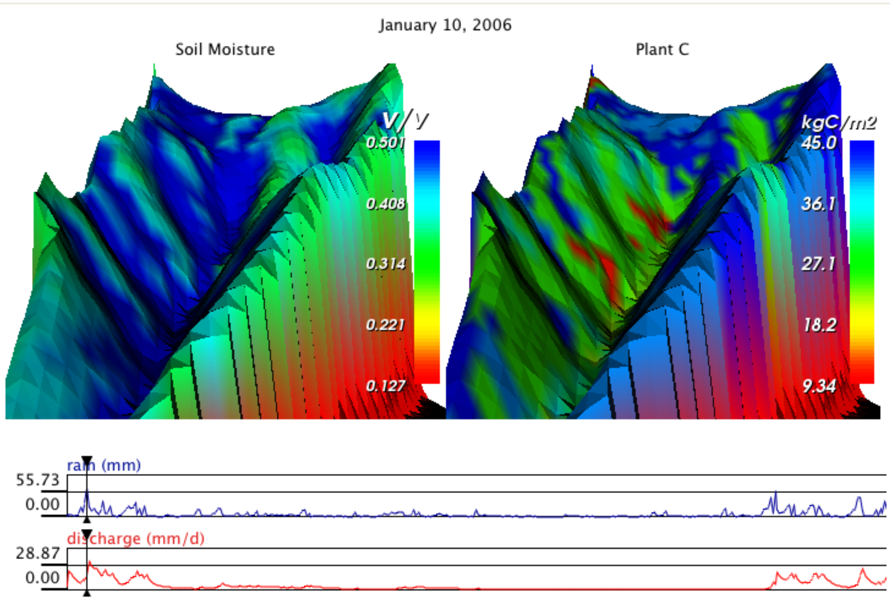

Figure II.B.12.6. Modeled soil moisture patterns for WS1 visualized on 3D topographic data. (Visualization by Nik Molnar using model output from the VELMA model; data courtesy of Bob McKane).

Personnel:

PIs: Barbara Bond, Kate Lajtha, Bob McKane, Sherri Johnson, Tom Spies, Mark Harmon, Phil Sollins, Julia Jones, Chris Thomas, Jeff McDonnell

Collaborators: Rupert Seidl, Judy Cushing, Nik Molnar, Dominique Bachelet, Christina Tague

Students: Kristin Peterson, Scott Allen, Adam Kennedy, Dustin Quandt, Elizabeth Garcia, Nelli Chizhikova

Technicians: Jay Sexton, John Moreau, Fred Bierlmaier

Associated Projects:

- LTER6 Projects:
  - LTER6 goals
  - The LTER6 Digital Forest project
  - The LTER6 Climate project
  - The LTER6 Modeling project
- Related Projects:
  - DIRT (http://andrewsforest.oregonstate.edu/research/related/dirt.cfm)
  - FEEL (the Forest Ecophysiology and Ecohydrology Transect; http://oregonstate.edu/feel/)
  - iLAND (http://iland.boku.ac.at/tiki-index.php)
  - RHESSys (http://fiesta.bren.ucsb.edu/~rhessys/)
  - VISTAS (http://blogs.evergreen.edu/vistas/)

Databases

TW003 - Sap flow measurements to estimate overstory water use in small watersheds at the Andrews Experimental Forest
TW006 - Ecohydrology and Ecophysiology in Watershed 1 at the Andrews Experimental Forest
TW007 - Sapflow in Watershed 1 in the Andrews Experimental Forest
MV001 - Airshed tower data in Watershed 1 in the Andrews Experimental Forest
GEO12 – Landslide Inventory (1953-2000)
MS027, MS028, MS029- Monthly temperature and precipitation Grids
TP072- Pacific Northwest Biomass Component Equation Library
TP073- Plant Succession and Biomass Dynamics
TP119 – Vegetation History and Classification on Watershed 1 (1959-1960)
SP026 – Soil Survey Spatial Dataset

Selected Publications

Moore, G.W., J.A. Jones and B.J. Bond. 2011. How soil moisture mediates the influence of transpiration on streamflow on hourly to interannual scales in a forested catchment Hydrological Processes. Accepted for publication.

Phillips, C.L., N. Nickerson, D. Risk, and B.J. Bond. 2011. Interpreting diel hysteresis between soil respiration and temperature. *Global Change Biology*. 17(1)515-527.

Phillips, C.L., N. Nickerson, D. Risk, Z. Kayler, C. Anderson, B. Bond, and A. Mix. 2010. Soil moisture effects on the carbon isotope composition of soil respiration. *Rapid Communications in Mass Spectrometry*. Accepted for Publication.

Barnard, H.R., C.B. Graham, W.J. VanVerseveld, J.R. Brooks, B.J. Bond, J.J. McDonnell. 2010. Examining hillslope transpiration controls of diel streamflow using a steady-state irrigation experiment. *Ecohydrology*. Accepted for Publication.

Moore, G.W., B.J. Bond, J.A. Jones, and F.C. Meinzer. 2010. Thermal-dissipation sap flow sensors may not yield consistent sap-flux estimates over multiple years. *Trees: Structure and Function* 24(1): 165-174. (Pub #4274)

Kayler, Z.E., L.Ganio, M. Hauck, T.G. Pypker, E.W. Sulzman, A.C. Mix and B.J. Bond. 2009. Bias and uncertainty of d13CO2 isotopic mixing models. *Oecologia* DOI 10.1007/s00442-009-1531-6. (Pub #4581)

Kayler, Z.E., E.W. Sulzman, W.D. Rugh, A.C. Mix, and B.J. Bond. 2009. Characterizing the impact of diffusive and advective soil gas transport on the measurement and interpretation of the isotopic signal of soil respiration. *Soil Biology and Biochemistry* doi:10.1016/j.soilbio.2009.11.022. (Pub #4577).

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Pypker, T.G., M. Hauck, E.W. Sulzman, M.H. Unsworth, A.C. Mix, Z. Kayler, D. Conklin, A. Kennedy, H.R. Barnard, C. Phillips and B.J. Bond. 2008. Toward using ^{13}C of ecosystem respiration to monitor canopy physiology in complex terrain. *Oecologia* DOI 10.1007/s00442-008-1154-3.

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II.B.13. Integrated Research: Potential Effects of Future Change

Project objectives and relationship to LTER6 goals: A critical objective of LTER6 is to integrate our knowledge from previous LTER work and current studies to evaluate how our system – considering all three drivers and all three responders of the Central Question – might react to scenarios of future climate change (Goal II, objective 4). This task can only be achieved by using simulation models. However, it is not our intention to try to use models to predict the future. Instead, we aim to conduct "desk top" experiments with models to better understand the potential behavior of complex systems and to test hypotheses that cannot be approached in field experiments. Most of the models we plan to employ for this part of the study have been used in the past at our site, and some are being developed at our site specifically.

Abstract: During LTER6 we are particularly interested in examining the interactions among our drivers (climate, land use and disturbance), as well as the influence of multiple drivers on responders. We hypothesize that the impacts of regional climate change on our ecosystem will be strongly influenced by local topography and canopy cover and that indirect impacts of climate change, because of disturbances, will be more important than direct effects of climate (Goal II, objective 2). To examine the influence of multiple drivers on responders, we will, for example, examine how the interactions of climate change, disturbance, and land-use (defined by the scenarios that were presented in the proposal but subject to some modification) will force changes in carbon and nutrient dynamics. We will start by comparing the sensitivity of responders to single drivers and then progress to combinations of drivers. We will also examine scenarios in which the disturbance driver is dependent on climate, expecting this will lead to the largest response. Comparisons between responders will be "controlled" by using common datasets to drive models, with all future scenarios such as climate and disturbance history as well as other driving variables. For each responder examined we will contrast the mean response and the spatial and short-term temporal variability of the response under future change scenarios (i.e., treatment) relative to that of the current situation (i.e., control). When models predict the same ecosystem responders, their predictions will be compared to gain insights on uncertainty. We will examine a range of potential future responses to changes in our three system drivers using multiple scenarios. The AOGCM simulations described in the IPCC Fourth Assessment Report provide a basis for projecting general climatic changes in our region (although we will use more recent assessments if they become available). Over the next 100 years these projections indicate an overall mean increase in temperature, with temperatures increasing in both summer and winter. While mean annual precipitation may not change or increase slightly, precipitation variability will likely increase. Given projected temperature and precipitation seasonal patterns, it is also likely that the Andrews Forest will experience a longer dry season. We will use a combination of synthetic climate data and downscaled AOGCM simulations of future climate data (derived from the Climate project of the LTER6 program) produced under one or more of the IPCC emissions scenario. We will contrast these climate scenarios with two extreme cases: 1) a continuation of the current climate mean and variability and 2) rapid change, a halving in the time for the IPCC Fourth Assessment Report projected changes to occur. Given that interactions between topography and large-scale weather patterns influence how climate is expressed locally, we will translate these regional scale changes to a local level using PRISM-related models.

Progress Report:

Up to this point the main emphasis has been to lay the ground work for analyzes to be conducted in the second half of LTER6. This includes the development and testing of the simulation models to be used in this effort, the development and testing of an inter-model comparison protocol as well as a critical examination of the databases required to conduct these analyzes. The majority of progress has been made in the model development and testing as described in more detail below. We have had success in conducting one limited inter-model comparison for two of the potential models to be used in the analysis. Our examination of database needs, indicates that development of a climate database for the entire Blue River watershed will be essential and a strategy to achieve this task has been developed and will be implemented over the next year. LiDAR-based estimates of the spatial distribution of live biomass are likely to be the only way to check how models predict live carbon stores over landscapes. Work on the Digital Forest has provided this important validation dataset for the Andrews Experimental Forest, and additional LiDAR data to be gathered in the next year will provide data for most of the Blue River basin.

LandCarb: Most of the features required for conducting the proposed analyses have been added to the LandCarb model. This includes the addition of wood products so that complete carbon balances can be calculated when timber harvest occurs, an algorithm to schedule future harvests that responds to landscape condition (e.g., forest age), ability to output results in a spatial format so that maps of responses can be produced. The model can now import spatial information on land-use and disturbance history, climate, soils, and species distributions so as to portray a specific landscape. The addition of a fire disturbance module that spreads fires throughout the landscape by reacting to topography, year-specific climatic conditions, and fuel loads is planned for summer 2011.

As the Landcarb model was developed, its comparability to another model, Standcarb, was checked. Our intention is to have two related models that have very similar processes, parameters, and predictions. The point of the two models is to be able to examine carbon dynamics in detail and at a small spatial extent (e.g., tree to tree interactions) and also examine general trends over a large spatial extent without the computational burdens of using the detailed model. Initial comparisons of the models indicate they predict very similar trends, which eliminates any possible disconnect as spatial extent is changed (Figure II.B.13.1). Preliminary testing of the model predictions involved comparisons to old-growth carbon stores data from the Andrews Experimental Forest as well as growth patterns of live carbon from Forest Inventory and Analysis databases and models. This indicated that soil carbon was being under-predicted significantly, a problem that was related to an overestimate of the soil decomposition rate-constant; a highly uncertain parameter in any carbon

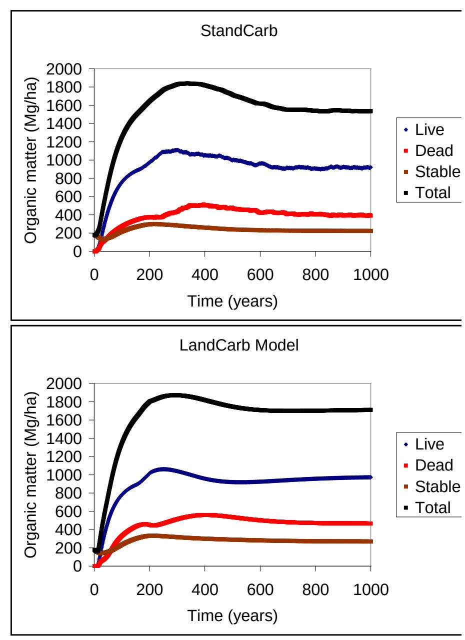

Figure II.B.13.1. Comparison of simulation predictions of carbon stores for StandCarb with that of LandCarb. The two simulations were not calibrated against each other. StandCarb is a highly stochastic model of individual trees, whereas LandCarb is a largely deterministic model using populations of trees.

model. Comparisons to live carbon accumulation for the first 100 years following stand replacing disturbance were very close.

The LandCarb model has been used in several projected related to the LTER6 goals that have allowed us to test how it is performing. The first was an analysis of the potential impacts of biomass fuels on carbon balances of forest (Mitchell et al in review). The second analyzed the potential impact of the Northwest Forest Plan of 1992 (Krankina et al in preparation). We have also been collaborating with the Oregon Department of Forestry by using LandCarb to estimate changes in forest-related carbon stores and balances with one of the study areas centered on the Andrews Experimental Forest landscape. Finally, the LandCarb model is being used as the computational "engine" for an on-line forest sector carbon calculator (http://landcarb.forestry.oregonstate.edu/) that allows policy makers and forest managers to explore how management and disturbance influence the dynamics of carbon in the forest (Figure II.B.13.2).

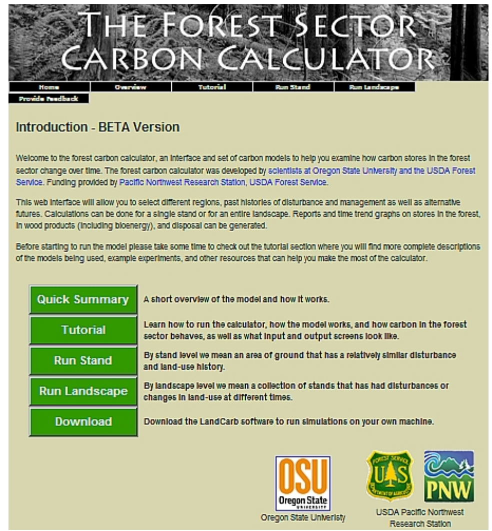

Figure II.B.13.2. Main page of the Forest Sector Carbon Calculator, a system based on the LandCarb model. This interface allows users to explore how disturbance and management influence the carbon dynamics of forest systems.

iLAND: The individual-based forest landscape and disturbance model (iLand) was recently developed by Rupert Seidl, an Andrews LTER collaborator, to address how changing climate and disturbance regimes might influence forest ecosystem dynamics and consequently the provision of ecosystem services and is thus a highly relevant tool for the research questions at HJ Andrews under LTER 6.Forest ecosystems are modeled from the perspective of complex adaptive systems in iLand (Seidl et al. 2011a, Seidl and Rammer 2011), with ecosystem dynamics an emerging property of interactions between agents and processes across multiple scales. The core agents modeled in iLand are individual trees (Grimm et al. 2005). Their spatially explicit competition for light, water, and nutrients is simulated based on ecological field theory, accounting for each individual's ability to locally compete for these resources (cf. Berger et al. 2008). Generalized physiological principles are applied to derive tree growth and mortality from these captured resources. iLand applies a radiation use efficiency approach to derive primary production (Medlyn et al. 2003). Response functions to daily weather conditions are used to account for environmental effects on resource utilization efficiency. The model furthermore employs a cascading sequence of allometric ratios to calculate allocation to tree compartments (Landsberg and Waring 1997), with environmental factors affecting the allocation to root vs. shoot biomass as well as to height vs. diameter growth. Utilizing an individuals' carbon budget, tree mortality is simulated probabilistically for trees experiencing carbon starvation (Güneralp and Gertner 2003). The fate of dead organic matter is tracked in a decomposition module, that distinguishes standing and downed deadwood, litter, and soil organic matter pools (Kätterer and Andrén 2001, Magnani et al. 2007). iLand thus simulates process-driven estimates of the C exchange between forest landscapes and the atmosphere.

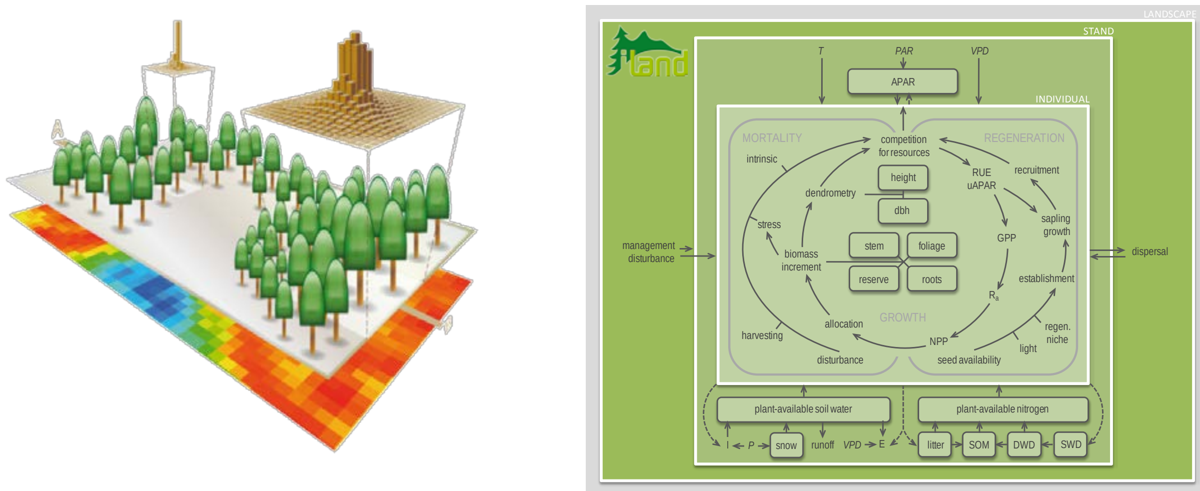

Figure II.B.13.4: iLand is a dynamic, process-based forest landscape model. The left panel illustrates the light interference patterns modeled for every individual tree, and their aggregation to a continuous field of light competition in every timestep in the model. The right panel highlights the main processes modeled in iLand and their respective scales. Source: Seidl et al. (2011a).

To scale from individual trees to forest landscapes, iLand simplifies the competitive influence between trees to size- and species-specific interference patterns pre-computed via ray tracing (Canham et al. 1988). It furthermore harnesses a hierarchical multi-scale approach, in which higher level processes (e.g. water availability at the stand scale, disturbances at the landscape scale) constrain lower level dynamics (e.g. growth at the level of individuals) (Wu and David 2002). This model design allows us to simulate individual-based forest dynamics at the scale of the HJ Andrews watershed in a computationally efficient manner. At the landscape scale, modeled spatial processes include seed dispersal and disturbance processes, the latter modeled by means of a cellular automaton approach. Spatially explicit seed dispersal kernels are used to calculate seed distribution over the landscape (Lischke et al. 2006), and a species' success in establishing at a new site is calculated using a phenology-based approach (Nitschke and Innes 2008). Spatially explicit wildfire and windthrow modules are currently in development (Seidl et al. 2011b).

To rigorously test a multi-scale simulation model such as iLand, the variety of documented long-term datasets at the HJ Andrews has proved invaluable. To evaluate model performance from the individual tree level all the way to the landscape level we made use of the HJ Andrews long-term vegetation plot data, soil inventory, detailed climate data, disturbance history information, and Lidar data. The conducted suite of tests showed that iLand's scalable approach to model individual-tree competition was able to simulate the complex light competition regime in old-growth stands at the HJ Andrews (Figure II.B.13.5). They furthermore revealed the ability of the model to simulate forest C cycle processes (Figure II.B.13.6), and the spatial distribution of species within the landscape (Figure II.B.13.7) with satisfactorily accuracy. Addressing Goal I within the LTER 6 proposal, iLand is currently applied to unravel the drivers of spatial heterogeneity in the carbon storage at the HJ Andrews. Due to its high spatial and process resolution iLand is an important addition to the HJ Andrews simulation model arsenal in addressing this issue. In the near future, the model will also be used to address the impact of climate change on vegetation dynamics at the HJ Andrews (Goal II under LTER 6). iLand was developed by Rupert Seidl (supported by a EU Marie Curie Fellowship) in close collaboration with HJ Andrews PI Tom Spies, with further input from collaborates at the University of Natural Resources and Life Sciences (BOKU) Vienna, Austria, Portland State University, Portland, Oregon, Oregon State University, Corvallis, Oregon, and the HJ Andrews community.

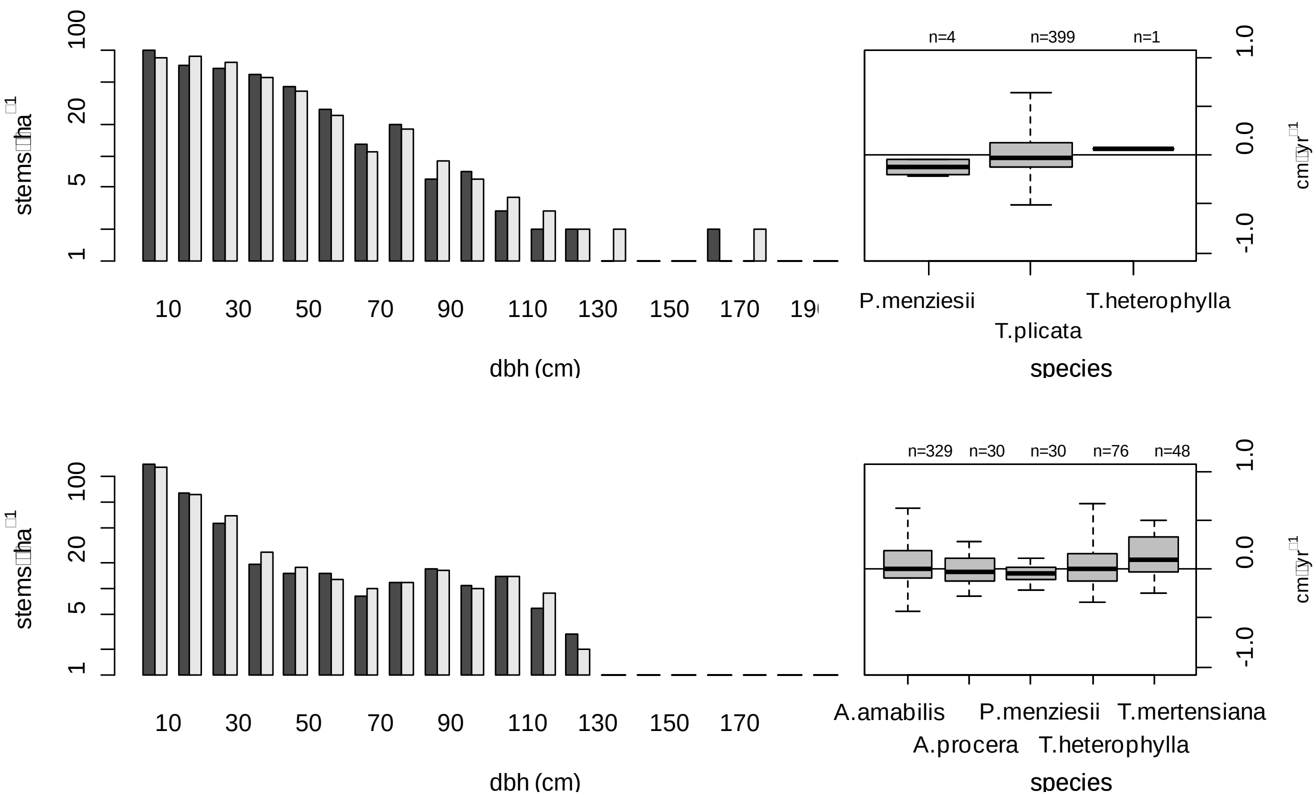

Figure II.B.13.5: Observed (dark grey) versus simulated (light grey) diameter distribution for HJ Andrews old-growth reference stands 20 (upper panels) and 22 (lower panels) at the end of the 22 to 24 year observation period. Boxplots indicate the species-specific individual-tree diameter increment residuals. Source: Seidl et al. (2011a).

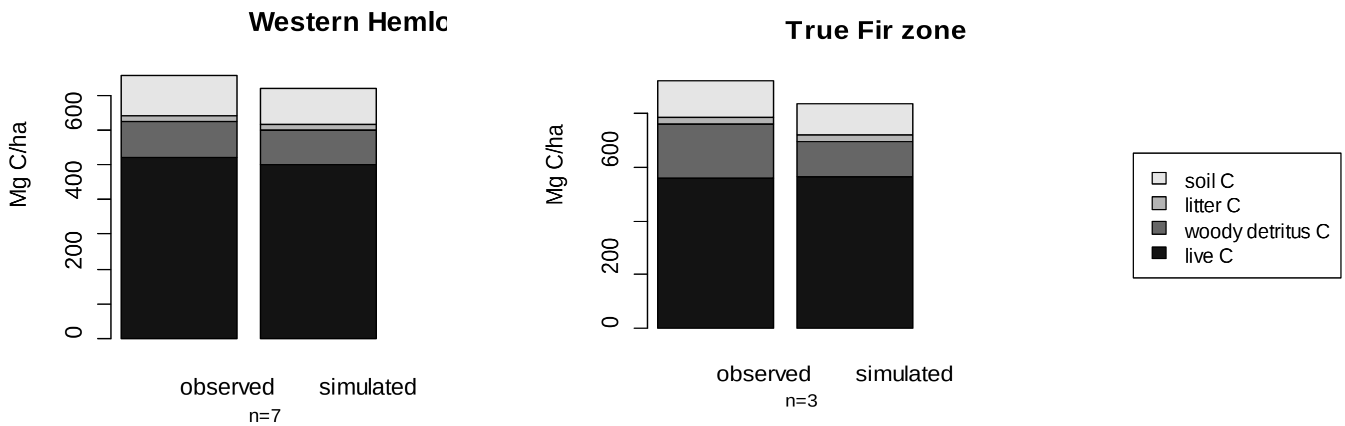

Figure II.B.13.6: Comparing observed carbon storage in HJ Andrews reference stands of different vegetation zones to iLand model results after a 500 year undisturbed model run. Observed reference data are from Smithwick et al. (2002).

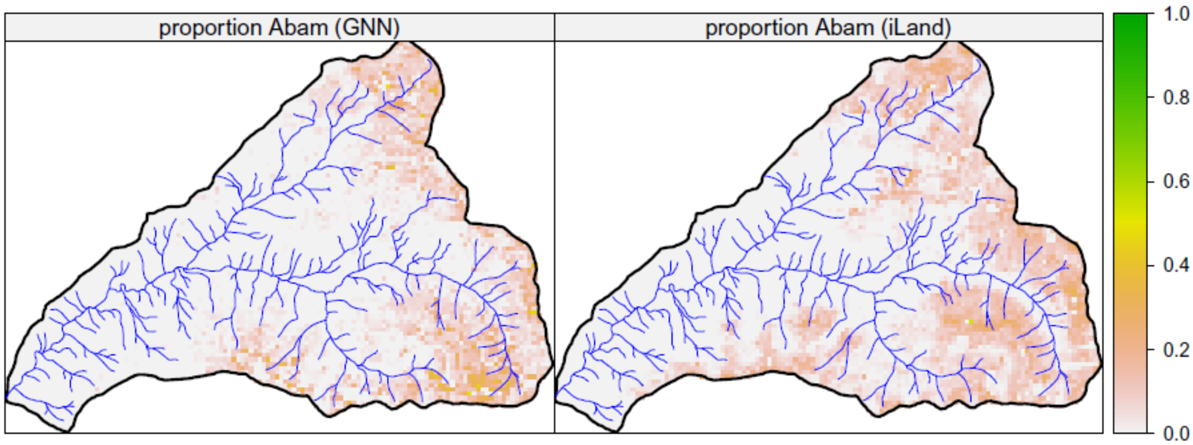

Figure II.B.13.7: Example for the evaluation of the simulated species composition at the HJ Andrews experimental forest. Simulation results from the individual-based forest landscape and disturbance model (iLand) after a 500 year simulation run are compared to a the gradient nearest neighbor (GNN) imputation of inventory data (Ohmann and Gregory 2002) for the high elevation species *Abies amabilis*.

People:

PIs: Mark Harmon, Sherri Johnson, Bob McKane, Sarah Shafer, and Tom Spies

Collaborators: Rupert Seidl,

Students: none

Other Personnel: Frank Schnekenburg

Associated Projects:

LTER6 Projects:
- LTER6 goals
- The LTER6 Digital Forest project
- The LTER6 Climate project

Related Projects:

iLAND (http://iland.boku.ac.at/tiki-index.php)

RHESSys (http://fiesta.bren.ucsb.edu/~rhessys/)

http://landcarb.forestry.oregonstate.edu/

Selected Publications

Krankina, O. N., M. E. Harmon, F. Schnekenberger, and C. A. Sierra. In preparation. Response of forest carbon stores to the Northwest Forest Plan of 1992.

Mitchell, S. R., M. E. Harmon, K. B. O'Connell, and F. Schnekenberger. In review. The optimal role of forests in climate change mitigation: Bioenergy production or carbon sequestration? Nature Climate Change.

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Magnani, F., Mencuccini, M., Borghetti, M., Berbigier, P., Berninger, F., Delzon, S., Grelle, A., Hari, P., Jarvis, P.G., Kolari, P., Kowalski, A.S., Lankreijer, H., Law, B.E., Lindroth, A., Loustau, D., Manca, G., Moncrieff, J.B., Rayment, M., Tedeschi, V., Valentini, R., Grace, J., 2007. The human footprint in the carbon cycle of temperate and boreal forests. Nature 447, 848-850.

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Seidl, R., P.M. Fernandes, T.F. Fonseca, F. Gillet, A.M. Jönsson, K. Merganicova, S. Netherer, A. Arpaci, J.D. Bontemps, H. Bugmann, J.R. Gonzalez-Olabarria, P. Lasch, C. Meredieu, F. Moreira, M.J. Schelhaas, and F. Mohren. 2011b. Modelling natural disturbances in forest ecosystems: a review. Ecological Modelling 222, 903-924.

Smithwick, E. H., Harmon, M.E., Remillard, S.M., Acker, S.A., Franklin, J.F. 2002. Potential upper bounds of carbon stores in forests of the Pacific Northwest. Ecol. Appl. 12, 1303-1317.

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II.B.14. Integrated Research: Intensifying Connections with Society and Social Sciences

Project objectives and relationship to LTER6 goals: Goal III of the LTER6 proposal moves the HJ Andrews research program to a closer examination of the interactions of human and a complex terrain through increasing integration among the LTER ecological science program, the social sciences, and society. Although Goal III is explicitly defined in the proposal, and we hold ourselves accountable for accomplishing the Goal, we acknowledged in the original proposal that we were allocating no funds from the core budget to this activity. Instead, we are relying on opportunistic funding, supplements to the LTER grant, and collaborations with other organizations or groups to accomplish this work. These projects access LTER data, scientists, and/or research sites.

Figure II.B.14.1. Participants in the cross-site MALS project met at the HJA in June 2011 to share progress and discuss future plans. The group visited the adjacent town of Blue River, Oregon, which has seen great social change due to change in logging on federal land and a dramatic decrease in jobs. Photos by Gary Kofinas.

Abstract: Humans are powerful agents in the ecological processes we study, both as responders and as drivers, but in order to understand the societal context of the Andrews Forest program we must take a broad view that extends into local communities and the region. The social components of our research include the science community, local communities and institutions, natural resource policies, and management activities. This work focuses on two questions: (1) How do vulnerabilities and capacities influence how local communities and institutions adapt to climate and social change? (2) How do social linkages among social components and participation in knowledge sharing influence the adaptive behaviors of local communities and institutions? The Maps and Locals project (Figure 1), an LTER cross-site collaboration that was simulated by an LNO-funded workshop in Luquillo, has provided a foundation for this component of LTER6. The social component of the Andrews program is also strongly linked to, and benefits from, participation by LTER PIs in several new and exciting interdisciplinary projects that connect natural resources with humans. These include the Portland-Vancouver ULTRA-Ex (Urban Long-term Research Areas-Experimental: Lach, Spies, and Bond are co-Is); the NSF-funded Willamette Water 2100 Project, anchored by the Envision model platform that connects human and natural processes (Bolte and Bond are co-Is), and the NOAA funded Climate Decision Support Consortium (Lach is a PI, Bond is a co-I). In addition, ongoing and separately-funded research by Denise Lach and Brent Steel is revealing how LTER scientists, managers, and the public view the role of scientists as partners with the public in knowledge-sharing. Graduate student Monica Hubbard has conducted studies to understand how understanding of climate change affects water management decisions.

Progress Report: We currently have three ongoing projects related to the hypotheses of Goal III. The first is a comparative cross-site project characterizing the interactive processes in land-use and social change (MALs). The HJ Andrews is also part of the initial project to create an Urban Long-Term Urban Research Area (ULTRA) in the Portland, OR-Vancouver, WA area where social scientists are exploring ways to operationalize ecosystem services in urban settings. Finally, in a small, pilot study researchers and managers at HJ Andrews are working with ENVISION, an agent-based model developed by OSU and UO scientists, to determine if long-term data produced, stored, and managed by the HJ Andrews team can be used to develop simulations of future landscapes for use in decision making.

Previous social science research in the basin conducted before and during the LTER 5 period found: (1) extreme polarization between rural and urban residents in the basin with urban residents strongly opposed to traditional forms of resource extraction and use (e.g., clear-cutting and grazing on public lands; see Smith and Steel, 1995); (2) high levels of distrust among rural and urban residents concerning public land management agencies (e.g., USDA Forest Service and Bureau of Land Management; see Shindler et al., 1996); (3) high levels of political activity among interest groups (e.g., environmental and industry related groups) leading to "pluralist pluralysis" resulting in much court action and policy stalemate (Steel, et al., 1996); and (4), a strong preference among citizens, resource managers and interest groups to more directly involve HJ Andrews and other scientists into natural resource management to help resolve differences in the management of public lands (Lach, et al., 2003).

Past surveys of area residents indicates a fair amount of interest in forest management issues and willingness to get involved in collaborative decision-making processes (Wright 2000) although there was a general lack of confidence in resource management agencies, with local agency staff viewed far more favorably than agency policy (Shindler and Mallon 2006). The 2005 survey also found that residents have varying levels of ecological knowledge – knowledge of terms is relatively high while knowledge of ecological processes is low (Shindler and Mallon 2006). The results of this context-specific research are critical to understanding how decisions are being made about natural resources as well as how to help community members, ecologists, and managers work together to make effective decisions.

MALs: Social science researchers at HJ Andrews are participating in a comparative cross-site endeavor, the Maps and Locals (MALs) project. The project, begun in 2009, asked the 14 participating LTER sites to identify the processes driving long-term social change at the sites and characterize the appropriate temporal and geographical scales at which these processes should be studied. Two common methods were used to conduct these projects: (1) a GIS-based assessment of land cover/land use change over time, and (2) collection of local knowledge related to land use change.

In 2009/2010, student and faculty researchers identified data for the HJ Andrews and surrounding area to construct maps of land use/vegetative cover at three different points in time (1938, 1992, and 2001). We were unable to locate maps for the three time periods derived from the same data set so data from two different data sets were used: USFS historical land cover (1938) and National Land Cover Database (1992 and 2001). The data were re-sampled, re-projected, and rasters clipped from the NLCD files to create a new series of maps that utilized the same landscape classification scheme. Clark University graduate students compared the rate of change in time period one (1938-1992) to time period two (1992-2001). We found that misleading results were produced because landscape changes on the map could be the result of actual changes in vegetative cover or an artifact of the different data sets used in constructing the maps.

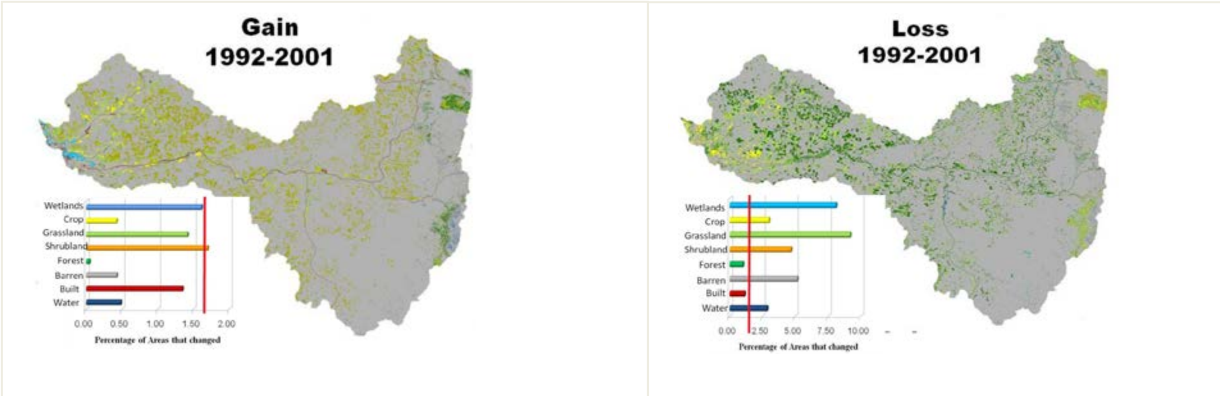

Figure II.B.14.2.. Gains and losses of various land use categories between 1992 and 2001, evaluated as part of the MALS project. Inman 2011.

Beginning in summer 2011, long- time residents of the McKenzie River Valley were interviewed to develop a catalog of local knowledge regarding perceived land cover/land use changes that have occurred over the past fifty years or so. The major finding from this research is that residents recognize and can discuss in relatively sophisticated ways several drivers of changes including a globalizing economy, shifts in policy and regulation, and technology advances, all of which contributed to swiftly changing forest ownership, management, and practices. However, they experience and talk most emotionally and personally about the resulting social changes – loss of living wage jobs, out-migration of families and resulting loss of schools, in-migration of retirees with different values and expectations for the landscape. They report a feedback between changes in the landscape and social institutions that appears to be driving continued and possibly even increasing landscape change. One interesting note from this research is that as the demographics shift in the valley, the "local knowledge" holders are increasingly new comers, drawn to the valley for aesthetics and other values not particularly related to jobs or community. There is little understanding of the values, expectations, or knowledge held in this emerging local knowledge with an accompanying decreased ability of federal land managers to interact, communicate, or work with a public that has shifted so dramatically.

Portland/Vancouver ULTRA: The Portland-Vancouver Urban Long Term Research Area (ULTRA-Ex) is a multidisciplinary project aimed at understanding the feedbacks between human and natural systems in urban settings. The ULTRA-Ex project is seeking to answer the overarching question: How do human governance and biophysical systems respond interactively to both press and pulse disturbances in urban socio-ecological systems? HJ Andrews personnel are assisting in managing data for the ULTRA and working with social and policy scientists at the Institute for Natural Resources at OSU in examining how alternative land use planning strategies affect the provision of ecosystem services in response to different disturbance factors. The conceptual model for the ULTRA echoes the model used in the LTER 6 proposal but is applied to an explicitly urban setting.

For more information:
Institute for Natural Resources: http://oregonstate.edu/inr/projects
Portland-Vancouver Urban Long Term Research Area (ULTRA-Ex): http://www.fsl.orst.edu/eco-p/ultra/

ENVISION: *Envision* is a GIS-based tool for scenario-based community and regional planning and environmental assessments. *Envision* combines a spatially-explicit polygon-based representation of a landscape, a set of application-define policies (decision rules) defining alternative scenario strategies, landscape change models, and models of ecological, social and economic services to simulate land use change and provide decision-makers, planners, and the public with information about resulting effects on indices of valued products of the landscape. Over an 18 month period, a proof-of-concept application of *Envision* was created to demonstrate its use as platform for exploring climate change implications on alternative future landscapes in the vicinity of the H.J. Andrews Experimental Forest in the McKenzie river watershed east of Eugene, Oregon (Figure 3). The 480,000 acre (195,000 hectare) study area is montane, largely rural and dominated by coniferous forests, much of which occurs on publicly managed land. In addition to being an experimental forest of the U.S. Forest Service, the Andrews, which sits at the center of the larger study area, has also been home since the early 1980s to a National Science Foundation-funded Long Term Ecological Research station. Investigators there have been and continue to be actively involved in climate change research, exploring biophysical, geochemical and socio-cultural dimensions of climate change effects. While the facets of climate change research are many, this small proof-of-concept effort with focused on making meaningful progress in linking the capacities of agent-based models to explore and test a large number of future trajectories for a study area with empirically-based models that estimate effects on two key environmental responses: changes in carbon storage and responses of fish communities as climate change occurs. The primary human-induced landscape changes addressed in this effort are varying rates and patterns of forest harvests and new rural residences and recreational resorts.

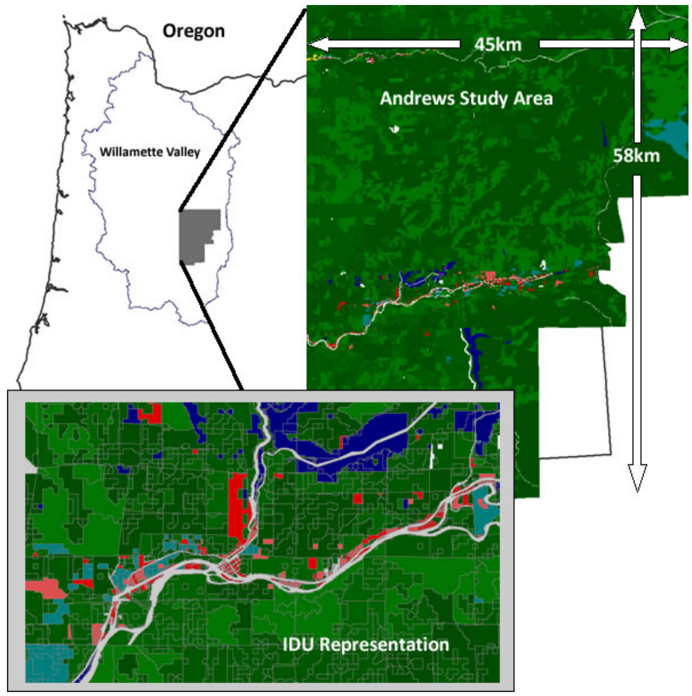

Figure II.B.14.3.. Context map for the *Envision Andrews* project.http://envision.bioe.orst.edu/StudyAreas/Andrews/andrews.htm

People:

PIs: Denise Lach, Hannah Gosnell, John Bolte, Dave Hulse, Stan Gregory

Collaborators: Sally Duncan, Brent Steel

Students: Myrica McCune (undergraduate), Tim Inman (MS, Public Policy, 2011), Monica Hubbard (PhD, Environmental Science)

Associated Projects:

LTER6 Projects:
LTER6 goals

Related Projects:

- PDX/VAN ULTRA (http://www.fsl.orst.edu/eco-p/ultra/)
- Willamette Water 2100 (http://water.oregonstate.edu/ww2100/) and stakeholder involvement (http://water.oregonstate.edu/ww2100/stakeholder-involvement)
- PNW Climate Decision Support Consortium (http://pnwclimate.org)
- Maps and Locals Project: Bonanza Creek (http://www.lter.uaf.edu/bnz_MALS.cfm)
- Oregon's Integrated Water Resources Strategy: March 30, 2010 Briefer (http://www.oregon.gov/OWRD/LAW/docs/IWRS/03_30_2010_Briefer.pdf?ga=t)
- Envision home page (http://envision.bioe.orst.edu/)

Databases

We are currently working to get data from MALs project into archives

Selected Publications

Inman, Tim. 2011. Local Perceptions of Social-Ecological Change on the McKenzie: Implications for Resilience. (MS Thesis, Oregon State University)

Lach, Denise, Peter List, Brent S. Steel, and Bruce Shindler. 2003. Advocacy and Credibility of Ecological Scientists in Resource Decision-Making: A Regional Study. *Bioscience* 53(2003): 171-179.

Shindler, B., and A. Mallon. 2006. Public acceptance of disturbance-based forest management: a study of the Blue River Landscape Strategy in Oregon's Central Cascades Adaptive Management Area. Final Project Report, Agreement # 05-CR-1061801-013. USDA Forest Service, Pacific Northwest Research Station and Oregon State University, Department of Forest Resources, Corvallis, Oregon, USA.

Shindler, Bruce, Brent S. Steel and Peter List. 1996. Public Judgments of Adaptive Management: An Initial Response from Forest Communities. *Journal of Forestry* 94(1996): 4-12.

Smith, Courtland, and Brent S. Steel. 1995. Core-Periphery Relationships of Resource-Based Communities. *Journal of Community Development and Society* 26(1995): 52-70.

Steel, Brent, Denise Lach, and Rebecca Warner. 2009. Science and Scientists in the US Environmental Process. *Science and Society* 1(2): 171-188. Available online at:http://science-society.com/journal/publications.

Steel, Brent, Denise Lach, and Vijay Satyal. 2006. Ideology and Scientific Credibility: Environmental Policy in the Pacific Northwest. *Public Understanding of Science* 14: 1-15.

Steel, Brent, Peter List, Denise Lach, and Bruce Shindler. 2004. The Role of Scientists in the Environmental Policy Process: A Case Study from the American West. *Environmental Science and Policy* 7(1): 1-13.

Steel, Brent S., John Pierce and Nicholas P. Lovrich. 1996. Resources and Strategies of Interest Groups and Industry Representatives in Federal Forest Policy. *Social Science Journal* 33(1996): 401-421.

III. Information Management and Technology

III.A. Information Management Philosophy and Objectives

The general philosophy for Andrews LTER Information Management (IM) is that all LTER research data will be archived and openly available for the indefinite future. The primary goals are 1) to preserve high-quality and well-documented data collections that are both secure and accessible, 2) to serve the Andrews and broader community through the development and management of informational products and tools, and 3) to participate and provide leadership at the LTER Network level. The following objectives illustrate how aspects of the primary goals are achieved.

- Assure data preservation through the direction and maintenance of a long-term data repository, the Forest Science Data Bank (FSDB), assure high quality metadata and data products through adherence to LTER best practices for data quality assurance and management, and provide security through regular maintenance and backup procedures.
- Assure the public availability of Andrews data through commitment to a data release and access policy, which generally provides access to data within two years of collection.
- Provide web access to Andrews data and publications, research programs and projects, site and personnel information, education and outreach programs, community events and other information through development and maintenance of the Andrews LTER web pages and interfaces.
- Assure service to the Andrews community through IM Team participation and reporting at Andrews LTER monthly meetings, the inclusion of IM Team representation on the Andrews Executive Committee, and regular interactions with community members.
- Provide leadership to the LTER Network through participation or leadership roles in the development of network information systems that promote the discovery, use, and integration of LTER data, both within the network and globally.

III.B. People and Institutions

Information Management is an essential component of the Andrews LTER program and benefits from an institutional partnership between the Oregon State University College of Forestry (COF) and the USFS Pacific Northwest Research Station (PNW). The current Andrews LTER Information Management Team reflects this long-term partnership: Don Henshaw (Team Leader, PNW), Suzanne Remillard (Database/Web Developer, LTER/COF), Theresa Valentine (GIS Specialist, PNW), and Fred Bierlmaier (Andrews Forest System Administrator, LTER/COF).

Two other field technicians (1 PNW, 1 LTER/COF) serve IM roles in supporting data loggers and field computers used in routine data collection, describing collection methods, and providing data. A PNW administrative assistant tracks Andrews publications and maintains the LTER bibliography. NSF supplements are used on occasion to contract for specific application development.

III.C. The Andrews LTER Information Management System

III.C.1. Information System: The Andrews LTER Information Management Team has developed an information system to support the collection, management, and curation of a rich and diverse collection of environmental data. The Forest Science Data Bank (FSDB) is a long-term data repository, which is supported by the LTER in partnership with the PNW and COF, and is the central component of the information system. The FSDB includes over 200 active and legacy study databases and features a highly-structured metadata database. Other components of the information system include a generic, metadata-driven quality control system, an administrative interface for LTER members, data submission tools, and dynamic web pages for discovery and access to data and informational products. The information system manages study databases and research publications, and extensions to include the image library and Andrews-related museum collections are being considered.

III.C.2. FSDB study data and metadata: The FSDB contains "signature" and other LTER-related data sets from the Andrews Forest. All LTER data sets are routinely placed on-line based on the terms of our data access policy (section III.D). The FSDB has also opportunistically captured other important data sets from OSU and the Forest Service, and continues to house significant legacy data collections that are not available on-line, due to priority status or quality control issues.

Metadata are established in compliance with the LTER metadata standard, the Ecological Metadata Language (EML), and follow LTER "best practice" recommendations. Software tools are used to map elements from the relational metadata database into EML, and similarly map ESRI metadata from the FGDC spatial standard into EML. EML metadata are regularly harvested from the Andrews LTER into the central metadata repository (Metacat) at the LTER Network Office (LNO), which assures that Andrews data is available for network-wide data searches. EML files are easily mapped into the NBII Biological Data Profile metadata standard using stylesheet software at the LNO and discoverable through the NBII clearinghouse.

III.C.3. Quality control system: This system consists of a set of simple procedures that provide generic metadata-driven data validation. A desktop control program reads the relevant metadata for validating any given data table and generates appropriate validation code. The control program executes the generated code and records any problems in the metadata description of the data table in an error report. Validation includes checks of the primary key for nulls and duplicates (entity integrity), checks versus listed numeric ranges or enumerated codes (domain integrity), and database rules. Rules are typically specific to individual databases and often have been "discovered" with the help of database owners. Generic rules are employed in time-series contexts, but most rules are only shared occasionally. A working group within the LTER Network is currently using a similar approach to construct an "EML congruency checker" that could ultimately provide EML-driven metadata and data validation.

III.C.4. Administrative interface: An improved administrative interface has been implemented that allows interactive site member submission of study metadata, managing of personnel profiles, and managing research projects including an online project application form. This interface is designed to improve the efficiency of IM operations by reducing the amount of staff time dedicated to the update of study metadata and personal information. Planned extensions of the interface will allow the entry of publication citations as well.

III.C.5. Data submission: The IM team has developed a web page to provide instructions and other references to facilitate submission of study data from site PIs, graduate students, and other researchers. Instructions are available to assist a data provider in entering study metadata using the administrative interface and describing spatial entities. A spreadsheet template is also provided to capture specific entity and attribute information. Desktop software tools allow the import of the template (Excel) into the metadata framework and allow additional editing of the metadata. The information system draws upon a local controlled vocabulary for both place and theme keywords and a reference list of common units of measurement to promote consistency of data set descriptions and to avoid redundant descriptions of site locations.

III.C.6. Web pages*:* Andrews LTER personnel maintain and update extensive web pages describing the Andrews Forest, ongoing LTER and related research, research collaborations with management, over 160 databases, bibliography (including pdf documents for many publications), education and outreach activities, arts and humanities, and personnel (http://andrewsforest.oregonstate.edu/). Web pages are dynamic using ColdFusion software with navigation bars and page templates provided through the production database (SQLServer). A web site search engine is employed and a web interface permits searching for data and publications by person, theme keyword, simple search strings and other options.

The metadata database is accessed dynamically to build web pages for describing individual study databases and creating text files for download. Caching of large datasets has been implemented to increase the performance of the download process. Downloads are tracked through a user registration system. Web page development has been an important activity for our site as it provides integration of our many research products and provides a primary source of site information for users within and outside our research community.

III.C.7. System Administration:

III.C.7.1 System administration and hardware at Oregon State University: The COF Forestry Computing Resources (FCR) provides system administration support for LTER campus computer servers through agreements with LTER and PNW. Production and development web servers (IIS, UNIX, and LINUX), production and development database servers (MS SQLServer), shared file server directories, and two tape backup servers are directly used by the LTER and supported through FCR. Refer to the FCR description of network systems (http://helpdesk.forestry.oregonstate.edu/about-our-network).

III.C.7.2. System administration and hardware at the Andrews site: The on-site Andrews LTER system administrator maintains the site Local Area Network (LAN), local web server, wireless LAN, spread spectrum and radio telemetry communication network, telephone communications, and local personal computers. A wireless LAN is installed with access points linking the conference room and classroom, dormitories, cafeteria, shop, and director's residence to the wired LAN with a wireless bridge.

III.C.7.3. Backup policies: General backup procedures are maintained and implemented through agreements with OSU College of Forestry. To read more about backup policies, see system administration description:
http://andrewsforest.oregonstate.edu/research/component/infomgt/summary.cfm?sum=sysad11&topnav=63

Non-electronic storage: Paper record storage is greatly reduced from historic levels, but raw data collection records, a publication reprint library, photographic slides and aerial photos are inventoried. Scanning is proceeding.

III.D. DATA ACCESS POLICY AND ONLINE DATA

The Andrews LTER data access policy (http://andrewsforest.oregonstate.edu/data/access.cfm?topnav=98) is modeled after the LTER network data policy (http://www.lternet.edu/data/netpolicy.html) and includes three sections: the release policy for data products, user registration requirements for accessing data, and the licensing agreement specifying conditions for data use.

Data and information derived from publicly-funded research in the Andrews Experimental Forest, totally or partially from National Science Foundation LTER funds, or Partner Agency or Institution funds where a formal memorandum of understanding with LTER has been established, are made available online with as few restrictions as possible on a nondiscriminatory basis. Andrews LTER scientists make every effort to release data in a timely fashion and with attention to accurate and complete metadata.

While the intention of the Andrews LTER policy is to promote maximum availability for ecological data, resource constraints have led to establishing criteria for prioritizing data for release. Primary observations collected for core research activities directly supported by LTER funding receive the highest priority for data release. Data collected with partial LTER support or where the LTER program has added value to resulting data products will also receive high priority for release. Other types of data including student thesis data, schoolyard LTER data, or non-LTER data that was acquired for LTER research may be ranked at a lower priority. Legacy data will be released as resources become available.

Online data: Online LTER databases include:

- 160 LTER databases representing 950 data tables or spatial entities
- Half (78 databases) contain long-term data (>10 years)
- 13,350 LTER data files have been provided or downloaded over 25 years (1986-2010)

Tracking of data set use has been ongoing since the mid-1980s (see Table III.1). The nature and scope of data use tracking has matured over time and is summarized online: http://andrewsforest.oregonstate.edu/research/component/infomgt/summary.cfm?sum=datause11.

Table III.1. Andrews LTER data use over 25 years. The IM Team believes that increasing numbers of data downloads are primarily due to easier data access and greater demand for this data, however, increased downloads also reflect greater numbers of online data tables and improved data use tracking. IM Team downloads for checking or testing have been excluded.

Research Area	Number of Fulfilled Requests/Downloads of LTER Data Tables (1986-2010)				
	1986-1990	1991-1995	1996-2000	2001-2005	2006-2010
Climate	15	150	200	1030	3050
Hydrology	10	50	130	755	2090
Vegetation	15	30	60	640	1150
Carbon/Nutrients	5	5	40	420	740
Biodiversity	0	5	55	395	670
Soils	0	0	15	255	450
Disturbance	5	10	25	160	415
Stream-Forest	0	5	15	70	235
Total Downloads	50	255	540	3725	8800
LTER Databases online	0	20	50	130	160

III.E. Andrews IM Accomplishments and Activities in LTER6, 2008-2010

***III.E.1. Data set creation and updates**:* Thus far in the LTER 6 funding cycle, the IM team has placed over 20 new study databases online including new LTER 6 databases, newly documented spatial databases, and legacy data sets that have been migrated into the information system. The new web pages now feature the ability to browse on "signature" data sets (see Table III.2), which represent long-term core research. Several signature climate, hydrology, and vegetation data sets are specifically maintained and updated by the IM Team and technical staff. Some examples of recent data product development of note are:

- The USGS streamflow record has been reconstructed from old strip chart and punch tape records from 1949 to 1986 at hourly time steps. This entire hourly record will be placed online in summer 2011 (as part of study HF004).
- The long-term stream chemistry record has been enhanced to include value-added entities for mean monthly nutrient concentrations and monthly nutrient outflow (flux).
- A series of long-term tree remeasurement and mortality study and understory vegetation study databases from the Andrews and throughout the PNW region are under redesign. The redesign will standardize database entity structures, attribute names, and biomass and primary production calculation for five or more existing FSDB databases. This redesign will allow the integration of vegetation data collections and the use of standard applications to create the derived and value-added data required by site scientists.

***III.E.2. Bibliography**:* The Andrews bibliography has been migrated from legacy Procite software into the metadata database where it can be directly managed from the administrative interface and is easily searchable through the web interface. All LTER publications and library documents have been scanned (into pdf files) for online access, and scanning of remaining Andrews publications is underway. Additionally, publication abstracts are now searchable to improve discovery of Andrews publications. http://andrewsforest.oregonstate.edu/lter/pubs.cfm?frameURL=http://andlter.forestry.oregonstate.edu/ltermeta/ltersearch/Bibliography.aspx?topnav=11

***III.E.3. Information system development**:* The Andrews LTER web pages have been recently updated and redesigned. A new search interface for databases and publications was written (in LINQ) to be faster and more efficient. A web-based tool, the administrative interface, was designed and implemented to allow researchers and site members to update and edit study metadata and manage their personnel information. This interface also provides project registration forms, which are required for conducting research at the Andrews site. The interface was coded (ASP.NET) through a contract with Business Solutions Group (BSG) at OSU who hire and train student programmers and development engineers.

A web-based tool that generates the metadata standard EML from the SQLServer metadata database has been greatly enhanced to better conform to LTER best practices for EML. The tool uses style sheet transformations (XSLT) to convert SQL native-XML into EML and was originally described in DataBits (http://databits.lternet.edu/spring-2007/generating-eml-relational-database-management-system-rdbms). This is an important improvement for Andrews metadata to ensure compliance with PASTA architecture being developed at LNO, and particularly new LNO tools for checking congruency of site data with their EML description. This work was funded through the special 2010 LTER supplement for information management.

Data from sensors in the field are increasingly being collected using radio telemetry to stream high-temporal resolution data to the Headquarters base station. As the wireless communication capabilities expand, so does the need for better management of streaming data. Currently much of the climate station and stream gauging station data is available near realtime and provisional data are made available daily. Standardizing the capture and quality screening of all streaming data will allow the system to provide immediate access to many additional data streams. SQLServer procedures have been developed (2011) to pull streaming climate data from four benchmark weather stations, provide initial data limits checking, and place in archival entity structures. These procedures serve as the prototype for handling streaming data and efficiently providing access without information manager intervention.

Other previously developed tools are still maintained including a lodging and conference room use reservation system, streamflow summary tool (FLOW), climate data summary tool (GLITCH), analytical lab management system (CCAL), and multiple online forms for registration, reservations, and requests.

III.E.4. Spatial data activities: The GIS data have been converted from coverage to shape file format and projected from NAD27 datum to NAD83 datum. This process was necessary to meet US Forest Service GIS data standards, to provide data readable by Open Source software, and to keep current with ESRI software products. Providing data in the NAD83 datum was necessary to match existing data with the new LiDAR data and to integrate with on-line data sources for imagery (Google Maps and Bing Maps). Data downloads will now contain both NAD27 and NAD83 datasets, along with FGDC and EML metadata.

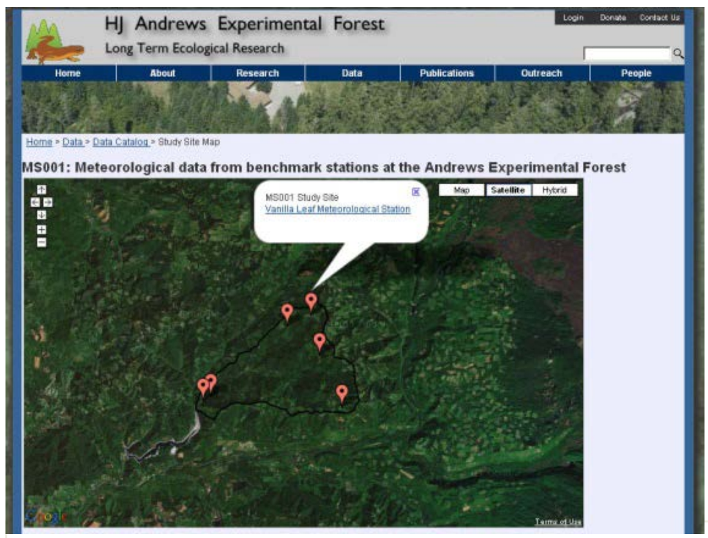

Figure III.E.4.1. A Google Maps application developed to dynamically display site locations associated with LTER databases.

A “place keyword” table provides coordinate, elevation, and descriptive information for all Andrews study sites, and serves as a means to search databases by location. Recently, this data table has been enhanced through programs developed to extract this information from GIS systems. A Google Maps application (Fig. III.E.4.1) was developed to dynamically display site locations associated with databases through pop-up windows and imagery.

Annual GPS sorties have also been used to improve study site and infrastructure spatial coordinates and elevations at the Andrews site. These sorties occur over a 2 to 3 day period when optimal satellite coverage is available, and participants use precision GPS units and take digital photographs at each site. Retiree volunteers have been invaluable in locating and documenting historic measurement sites. The resulting data have been critical in conducting analysis in conjunction with LiDAR data, and in assuring documentation and protection of sites.

A new Andrews paper map and brochure is currently in press and also available online as a map service. Detailed LiDAR information provided an opportunity to correct and update out-of-date topography, roads and streams. The back of the map is designed as a brochure, with information about research, local points of interest, and recreational opportunities. Web users can view GIS information with the map as a backdrop in ArcGIS, or print a custom map on the new site plotter.

III.E.5. Planning: The Andrews IM advisory committee includes the IM Team, the Andrews Forest director (currently, Schulze), the research coordinator (currently, DiGregorio), and a signatory PI (currently, Johnson). The committee serves as a means to provide annual reviews of IM activities and reports to the HJA Exec committee. The committee has been active the past two years in guiding IM efforts to improve efficiency, prepare for the 2011 site review, address the data access and release policies, and identify and prioritize signature data for update and placement online. An ad hoc web content and design committee has also been active to guide the redesign of the web site.

III.E.6. Technology: LiDAR was flown for the Andrews in 2008. Products include processed point clouds, both 1-meter bare-earth and vegetation Digital Elevation Models (DEM), and intensity grids. Several researchers and students are integrating LiDAR data into their projects.

A wireless communications network is under development at the Andrews (http://andrewsforest.oregonstate.edu/pubs/pdf/pub4433.pdf) and two radio towers will be constructed at the Roswell Mountain and RS20 Ridge locations. One acre of second-growth forest was cleared at RS20 Ridge to provide line-of-site to Roswell Mountain and back to the Andrews Headquarters (HDQTRS). The radio towers will be the backbone for site wireless communication and support pairs of direct line-of-site 5.8 GHz radios with Ethernet bridges between HDQTRS and RS20 and RS20 and Roswell. Two additional radio pairs are planned from RS20 to WS1 treetop and WS1 treetop to WS1 Airshed tower. The WS1 Airshed tower will support an 802.11 Wi-Fi access point. The RS20 tower has been constructed and Roswell Tower will be built once access is open in summer 2011. The radios will be battery-powered by a 2.5 kW solar array (12 210-watt panels) to assure enough power to allow for year-round operation even at the seasonally inaccessible Roswell Mountain site.

The new communication network will improve efficiency and bandwidth to the existing radio telemetry network. The existing network includes four benchmark weather stations and several stream gauging stations linked to headquarters via radio telemetry. Measurement data is transmitted hourly, displayed graphically online, and provided as provisional data for download. This original telemetry system is based on FCC-licensed VHF radios operating at 151 MHz, but will no longer be supported for Campbell dataloggers. A telemetry system based on 900 megahertz spread spectrum radios is also in use at the WS1 “cyber watershed”. The new network will provide more efficient streaming of data and internet access near the Airshed Tower, and opens the possibility for additional internet access points throughout the forest.

A list of recent technology upgrades and enhancements of existing tools is available online: http://andrewsforest.oregonstate.edu/research/component/infomgt/summary.cfm?sum=imact11

III.F. LTER NETWORK-LEVEL IM ACTIVITIES

Andrews Information Managers are active at the LTER network level with Henshaw (co-Chair IM Committee, 2009-Present), Valentine (chair GIS subcommittee, 2003-2010), and Remillard (IM Executive Committee, 2008-Present). A complete summary of all IM network-level activities is available online: http://andrewsforest.oregonstate.edu/research/component/infomgt/summary.cfm?sum=network11.

The Andrews also populates network-wide databases. EML for all on-line data sets is harvested to LNO on a regular schedule into the NIS metadata catalog. ClimDB/HydroDB is updated at least annually for several climate and gauging stations. PersonnelDB, SiteDB, and the All-site Bibliography are updated episodically. All units of measurement in use within Andrews data are now part of the Units dictionary and web service.

III.G. Impact

Perhaps the greatest impact is demonstrated through the persistence and growth of the Forest Science Data Bank. The FSDB was established in 1980 and has been largely funded and operated by LTER personnel since the mid-1990s. The FSDB has opportunistically acquired non-LTER data and includes well over 250 databases with more than 170 databases on-line (mostly LTER). A stable computing environment and information system with desirable features such as adherence to national metadata standards have allowed the FSDB to expand its LTER data resource holdings into a regional data center. Holdings now include key US Forest Service Research data (e.g., Research Natural Areas and Experimental Forests), USFS campaign data (e.g., Demonstration of Ecosystem Management Options (DEMO) and Mount St. Helens), National Forest System data (Young Stand Study), OSU CoF data (e.g., OSU MacDonald Forest), and the Long-Term Permanent Vegetation Plot Network (OSU, PNW, UW). NSF-funded grants in ecosystem informatics such as the IGERT and summer institute (EISI) programs have broadened campus-wide perspectives on information management and cyberinfrastructure issues, and Andrews data has been essential in student projects (e.g., quality control of high-volume streaming data, visualization software on species diversity). There have been over six thousand documented downloads of data from FSDB in the past three years.

The IM Team has recently participated in writing data management plans for proposals or in working with funded grants to establish IM protocols or make use of the FSDB. Examples include the NSF-funded exploratory Portland-Vancouver ULTRA, NSF-funded Willamette Water 2100, USDA-funded Regional Approaches to Climate Change in Pacific Northwest Agriculture (REACCH), and other proposals including NSF Macrosystems Biology. The IM Team has participated in DataONE, NEON, and ILTER workshops, and has served on NSF review teams.

The Andrews IM Team was the primary developer for the ClimDB/HydroDB data harvester and warehouse. The Andrews was well-suited to establish the hydrology component and combine the early ClimDB prototype LTER climate data with 15 additional USFS sites with streamflow data. The impact of ClimDB/HydroDB is evident in participation from 44 sites (LTER, USFS, Taiwan) contributing over 11 million daily measurement values and over 20,000 documented downloads or graphical views since 2003. The web page, http://climhy.lternet.edu/, averages over 25 visitor sessions per day.

Other recent demonstrations of impact are as follows:

- The Andrews IM team conducts yearly training and outreach to graduate students, IGERT, and Eco-Informatics Summer Institute students. The team meets one-on-one with students to help them understand the importance of managing their data and contributing to the long-term records of the Andrews LTER. Team members have conducted training and outreach internationally and nationally at conferences and workshops.
- The Andrews LTER received ARRA funding to assemble a stream chemistry database, StreamChemDB, which originally included 10 USFS Experimental Forests sites (5 of which are LTER) and has been expanded to include multiple additional LTER sites. The early prototype is being used by the researchers and will be tested by a larger group in LNO-sponsored webinar and workshop this fall.

- Valentine leads a local Spatial Data Committee, which meets monthly with USFS, USGS, EPA, and OSU participants to present and discuss current GIS issues.
- Other outreach and training:
    - Valentine demonstrated LTERmapS at the 2010 ESRI International User Conference in the Forest Service booth and at the Andrews Annual LTER Symposium.
    - Henshaw was an instructor and participant in the ILTER East Asian Pacific "2nd Analytical Workshop on Dynamic Plot Database Analysis" in Kuala Lumpur, Malaysia, July 19-22, 2010. Participants included international students and researchers from Malaysia, Vietnam, Korea, and Taiwan.
    - Henshaw was a guest speaker at the Coastal and Estuarine Research Federation's 20th Biennial Conference in Nov 2009 and participated with the Salmon Data Access Working Group to present lessons learned in LTER Information Management and current IM activities and innovations.

IV. Site Management, Organization and Communications

IV.A. Management Philosophy and Overview

We manage the Andrews Forest as a regional, national, and international research and educational resource in keeping with the site's designation as a LTER site, a Forest Service Experimental Forest, and a UNESCO Man and the Biosphere Reserve. The Andrews LTER program is the highly visible focal point among a large number of research and educational activities. The open sharing of data from ongoing and long-term studies, funded through LTER and USFS PNW, provides a platform that attracts broad interest, encourages new studies and results in leveraging of research dollars in new ways.

IV.B. Institutional Cooperation

The H.J. Andrews Experimental Forest is run cooperatively by Oregon State University, the Pacific Northwest Research Station of the US Forest Service, and the Willamette National Forest. Top administrators from all three of these organizations form a "Partners Group" which meets annually with the HJA Leadership to ensure that the organization provides maximum benefits for all.

IV.C. Organizational Structure, Decision-making and Policies

IV.C.1. Leadership and decision-making. The AND Executive Committee is responsible for decision-making. This group meets monthly and governs by consensus after seeking input from the broader Andrews Forest science community. The Executive Committee is composed of scientists from multiple disciplines and the partner institutions of OSU and PNW and includes prior LTER leaders (Fig. IV.C.1). The Executive Committee is chaired by the lead PI (Bond) and includes the four signatory co-PIs. Also serving on the Executive Committee is the Andrews Forest Director (Schulze), our Social Science representative (Lach), the lead of the Andrews Information Management Team (Henshaw), and a rotating researcher from the list of Senior Personnel (Nolin) so that newer scientists will get leadership experience. Two Graduate Student Representatives (currently Monica Hubbard and Sarah Frey) with overlapping two-year terms serve as liaisons between AND leadership and students.

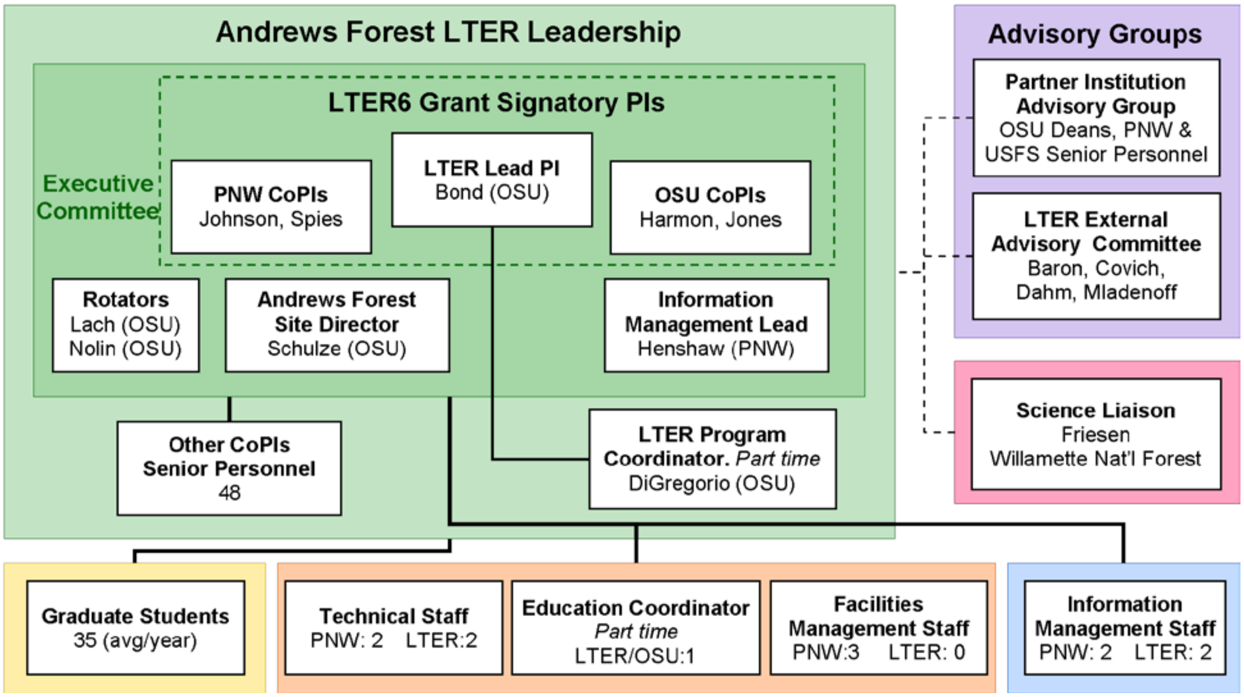

Figure IV.C.1. Organizational structure of the administration, leadership, and staffing of the Andrews Forest LTER Program. Oregon State University and the USDA Forest Service Pacific Northwest Research Station (PNW) personnel play various roles throughout the leadership organization. Connecting lines do not necessarily denote supervision, but rather oversight, advice, and other forms of cooperative effort. Graduate student numbers are shown as the average number per year supported by LTER and LTER-related funding.

IV.C.2. Personnel. AND researchers are an interdisciplinary group who come from a variety of institutions and agencies. The majority of scientists are faculty at OSU, affiliated with 15 departments in five Colleges. Our immediate science community also includes researchers from US Forest Service Pacific Northwest Research Station, USGS Biological Resources Division, EPA Western Ecology Division, as well as from University of Oregon, Western Oregon University, University of Washington, University of Idaho, and Portland State University.

IV.C.3. The Scientific Advisory Committee*:* The Andrews LTER has several Advisory Groups (Figure 3.1). A local Partner Advisory Group facilitates communication among PIs and Deans of OSU Colleges, Station Director and Line Officers of PNW, and Forest Supervisor and Science Liaison from the Willamette National Forest. The Executive Committee meets with this group once a year to discuss common goals, new directions, funding possibilities and outreach efforts. The LTER External Advisory Committee pulls in national experts to meet with PIs once a year. These Advisors provide broad input and guidance on Andrews LTER research direction as well as financial, institutional and tactical perspectives. Current members of the committee are Jill Baron (USGS), Alan Covich (University of Georgia), Cliff Dahm (University of New Mexico) and David Mladenoff (University of Wisconsin).

IV.C.4. Leadership development and transition. The philosophy of the Andrews Forest LTER program is to nurture leadership-development at all levels. One of the ways we do this is by encouraging students and post doctoral trainees to participate in mentoring activities – e.g. most graduate students typically mentor undergraduates. Another way is by providing junior personnel with leadership and decision-making experience by being a graduate student representative or a rotating member of the AND Executive Committee.

Our current policy is to have a change of lead-PI concurrent with the midterm review of each proposal cycle. This frequency of turnover provides fresh perspectives and energy, and turnover at the midterm provides time for the new PI to become intimately familiar with the program before becoming immersed in a renewal proposal. Unfortunately, university politics and resources do not always coincide with the policies and desires of research groups within the university. It took longer than we would have liked to establish a mechanism to identify the lead-PI for LTER7, but we're quite pleased that the Dean of the OSU College of Forestry has agreed commit an endowed chair position, the Ruth H. Spaniol Chair of Renewable Resources, to provide for the LTER lead-PI for the coming funding cycle. The position description is being approved by OSU's Office of Human Resources as of June, 2011. OSU requires that all search committees for new faculty include a committee member who has been trained as a search advocate to enhance diversity recruitment; Julia Jones will serve in that capacity on our search committee. We anticipate advertising for the position as a national search by midsummer, 2011, and hope to have the new lead-PI on board by the spring or early summer of 2012. In the mean time, the current lead-PI and very experienced leadership team are well able to keep the system moving forward.

IV.C.5. New AND researchers. With the upcoming retirement of Fred Swanson at the end of 2011, Dr. Steve Wondzell of PNW Olympia Lab will be moving to Corvallis and joining the Andrews Forest research team. Steve did his PhD at the Andrews and afterwards extended his research on hyporheic processes throughout the Andrews stream network. In addition, during the first half of LTER6, we've been happy to welcome a social scientist (Dr. Hannah Gosnell), a soil scientist (Dr. Julie Pett-Ridge), an aquatic ecologist (Dr. Dana Warren), a computer scientist (Dr. Ron Metoyer), an atmospheric scientist (Dr. Christof Thomas), a soil biologist (former AND graduate student Stephanie Yarwood), and a Forestry Extension specialist (Dr. Brad Withrow-Robinson) to our group of active professorial-level scientists. Our growing humanities program has produced collaborations with environmental ethicist Dr. Kathleen Dean Moore and poet Mr. Charles Goodrich. In addition, we've developed new collaborations with researchers from other institutions, including a climate modeler (Dr. Dominique Bachelet), a computer scientist (Dr. Judy Cushing) and an ecosystems modeler (Dr. Christina Tague), and we "welcomed back" a remote sensing expert (Dr. Warren Cohen) who hasn't worked with us in a while. We are sorry to have lost two outstanding young scientists, Drs. Eric Seabloom and Elizabeth Borer, from our program because they were recruited by another university, but we remain connected via participation in NUTNET, an experimental research network they established while at AND, and as Seabloom and Borer have become involved with Cedar Creek they help to strengthen intersite linkages.

IV.C.6. Enhancing and supporting diversity. In our last midterm review, the review committee advised us to enhance the participation by females in the top leadership of our site. Six years later, we note that the top leadership of the Andrews LTER site is predominantly female, including the lead PI, two of the four co-PIs, and two of the four non-PI members of the Executive Committee. One of our co-PIs is of partial Native American heritage. We actively seek and support diversity at all levels and of all types in our research community, and although we have no legal way of documenting the specific backgrounds and characteristics of all of our students, we are proud of the diverse community we are developing at AND. Both of our LTER6-funded REU students (Nick Curcio and Sarah Perez-Sanz) this year are from under-represented groups; our LTER-funded graduate students all come from underrepresented groups, Ricardo Gonzalez is from Ecuador, Tuan Pham is from Vietnam, and

Kristin Peterson is a female from a low-income family. Students from low-income and underprivileged communities are preferentially recruited to our Schoolyard LTER, Canopy Connections and Ecosystem Informatics REU programs (see separate reports). Through collaboration with the OSU-MANRRS (Minorities in Agriculture, Natural Resources and Related Sciences) Chapter, minority students from across the university visit the Andrews for a tour and overnight visit, and the Inner City Youth Program out of Portland has been a regular education user of the site. AND PIs share a common commitment to promoting and supporting diversity individually. One is using LTER funds to supporting an undergraduate female student from Mexico and a graduate student who was originally from Kenya and is now an American citizen. Another is supporting two Spanish-speaking postdoctoral trainees, one from Spain and another from Chile. The Andrews community includes and supports a range of sexual and gender preferences, including at least one student who went through a gender transformation while working with us.

Figure IV.C.6. OSU Minorities in Agriculture, Natural Resources and Related Sciences (MANRRS) overnight field trip to the Andrews Forest, November 2010.

IV.D. COMMUNICATIONS

The AND Web site (http://andrewsforest.oregonstate.edu/) serves as a primary mode of communication. Notices about meetings and minutes from meetings are distributed and posted on web pages (http://andrewsforest.oregonstate.edu/lter/pubs/mtgnotes.cfm?topnav=42). In addition we communicate with a range of audiences and through a variety of media, including the following:

Ad Hoc and standing committees: climate committee, graduate student representatives, web page committee, others as needed.

Monthly and semi-monthly meetings: AND Executive Committee; HJA monthly meeting (2-hour meeting open to all and covers business, site news, data management, communications, graduate student business and a "science hour" of current research). The Central Cascades Adaptive Management Partnership (CCAMP), which includes representatives from AND leadership and federal land management agencies, meets several times per year.

***Annual meetings*:** Annual PI meeting (discussions of LTER research progress; budget reports; planning for supplements and the coming year); annual or semi-annual graduate student social with senior researchers; spring symposium (the AND equivalent of an all-scientists meeting, but also open to the public and outside science community), HJA Day (an annual field day aimed at science generalists and the public with lunch included – in 2011 this event drew about 150 participants, including a local county commissioner and a large number of representatives from federal agencies).

The Andrews Forest Newsletter**:** Published semi-annually and distributed both digitally (by email) and in hard copy (via mail) highlights the programs and people at the Forest. Past issues are available on the web at: http://andrewsforest.oregonstate.edu/lter/pubs/newsletter.cfm?topnav=170

Press releases**:** Andrews research is frequently highlighted on local television and radio stations (including KVAL, KZEI, KLCC) and in local newspapers (including the Oregonian, the Bend Bulletin) and magazines (including frequent articles in Terra, the research magazine for Oregon State University).

IV.E. PROGRAM SUPPORT.

The PNW Station provides substantial resources to continue long term measurements, contribute to data management, and maintain the facilities at the Andrews Headquarters. The Willamette National Forest maintains roads, fire safety control and law enforcement throughout the site; periodic contributions to invasive species monitoring and control, project NEPA analysis, trail design and maintenance, and silvicultural planning also support the research mission. The LTER grant provides most of the core funding for LTER research and educational activities and the infrastructure to support them; however several other sources supplement this basic support. In 2011, the sources of support for the AND LTER program and infrastructure were as follows: $940K/year LTER grant, $575K/year PNW Research Station, NSF Supplements ($80K), two NSF FSML Awards ($307K and $350K), OSU TRF Funds ($10K), and OSU Foundation Accounts ($140K). The LTER grant is currently leveraged about 1:6 by funding for LTER-related research through other grants and contracts (defined as projects that use the Andrews Forest Site, use Andrews Forest data, or depend on significant collaborations with Andrews LTER research) is currently about six times greater than the core funding for the LTER project. The National Science Foundation is the primary source of resources, but significant resources also come from other federal agencies, as indicated in the pie chart at right (the "pie" includes

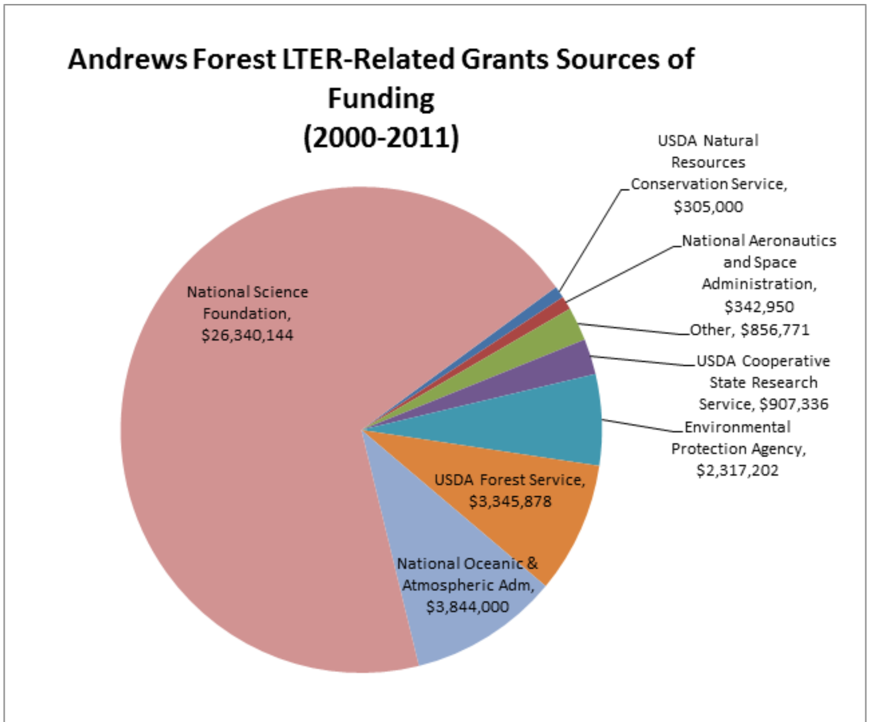

Figure IV.E.1. Andrews Forest LTER-Related Grants Sources of Funding (Cumulative, 2000-2011).

the core LTER grant and supplements). This "leveraged" funding has increased substantially in recent years.

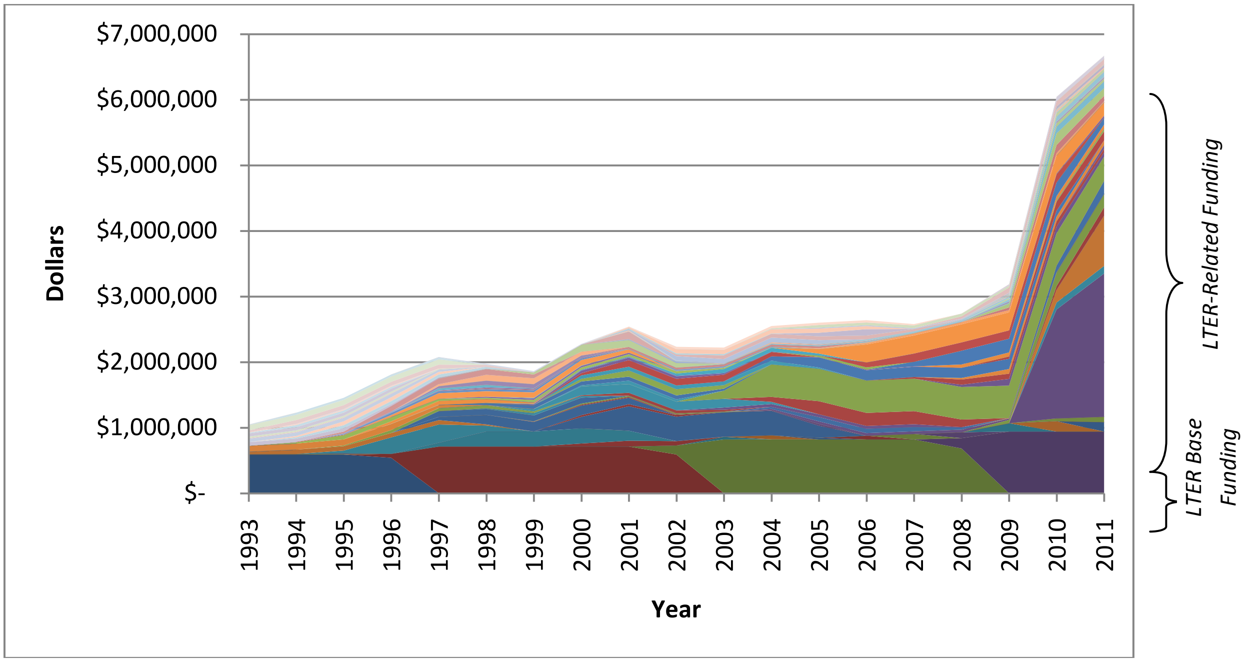

Figure IV.E.2. LTER and LTER-Related Funding for the Andrews Forest Program (1993 – 2011). * note: the colors in this figure are not related to specific sources of funding, as shown in Figure V.E.1. Instead, each colored polygon indicates a particular grant or contract. The dramatic increases in "LTER-related" funding since 2009 are partly due to an increase in the number of Andrews-related grants and contracts, but primarily to two very large grants that are strongly connected with the Andrews Forest Program but also extend well beyond our program.

V. Cross-site, Regional, and International Activities

V.A. Cross-site and Network-level Activities

Researchers at the Andrews Forest LTER are actively involved in many cross-site studies with other LTER sites, both as leaders and participants. Many of the cross-site collaborations also involve scientists from USFS Experimental Forests, biological field stations and other sites of long term research. Current major projects are:

- Climate and Hydrological Database Project (CLIMDB/HYDRODB)
- Synthesis of Stream Chemistry Trends and Responses to Disturbances
- Lotic Intersite Nitrogen eXperiment (LINX)
- Long-term Intersite Decomposition Experiment Team (LIDET)
- Detritus Input and Removal Treatments (DIRT)
- NSF Microbial Observatories (MO)
- Maps and Locals (MALS; funded by supplements and described in detail earlier in this report)
- Engaging arts/humanities in LTER programs (see Section VI of this report for more details)

The LTER Network facilitates cross-site workshops and communications through small, competitive grants. The following LTER working groups were *initiated by* Andrews Forest scientists:

- A Data Synthesis Working Group: Disappearing Snow in the Western US: Ecosystem Implications for the Rain-Snow Transition Zone. Anne Nolin. $25,360. 2011.
- Socio-ecological resilience of water supplies to land use and climate change: contrasting resilience in regions of the US and Canada. Julia Jones. $12,000. 2011.
- Development of a hydrochemical database – StreamchemDB. Sherri Johnson. $21,365. 2011.
- Soil organic matter dynamics: a cross-ecosystem approach. Kate Lajtha. $12,000. 2010.
- LTERMaps Internet Mapping Workshop. Theresa Valentine. $5,000. 2010.
- Engaging Arts/Humanities in Future Scenarios Work. Fred Swanson. $12,000. 2010.
- Hydrologic effects from ecosystem responses to climate change and land use change. Julia Jones. $12,000. 2010.

Andrews Forest scientists are *participants* in these LTER working groups:

- Future Scenarios of Landscape Change (Sherri Johnson, Tom Spies, Stan Gregory)
- Forecasting rates of stream leaf litter decomposition in response to inland climate change (Sherri Johnson, Lydia Zeglin)
- Quantifying Uncertainty in Ecosystem Studies (Mark Harmon)
- Developing protocols for cross-site research on Local Ecological Knowledge and social-ecological systems (Denise Lach, Hannah Gossnell)
- Workshop to promote synthesis products from the EcoTrends project (Barbara Bond)
- Develop an LTER NIS Best Practices for Designing and Writing Workflow Scripts in the PASTA Framework (Don Henshaw, Suzanne Remillard)

- Finding the Data: Enhancing the Utility of the LTER Controlled Vocabulary (Suzanne Remillard)
- Drupal Environmental Information Management System workshop: Data applications (Theresa Valentine)

In addition, Andrews scientists are involved in a variety of ad hoc collaborations that facilitate connections across LTER sites. For example, Andrews scientist Mathew Betts and colleagues have established parallel studies at Hubbard Brook LTER which sample birds across gradients in elevation. They are collaborating with computer scientists to use new algorithms to find factors most likely to be responsible for bird distributions across these gradients.

V.B. NETWORK-LEVEL ACTIVITIES

Since the inception of the LTER, AND scientists have made substantial contributions to LTER Network management and activities, and that tradition continues into the first half of LTER6. All three of the Information Management specialists contribute to LNO committees, often in leadership roles. These are detailed in the IM section (Section IV) of this report. In addition, Kari O'Connell serves on the LNO Education Committee, Sherri Johnson serves on the LTER Network Coordination Committee, Lina DiGregorio serves on the Communications Committee, and Barbara Bond serves on the Network Information Science Advisory Committee (NISAC).

AND scientists are also actively leading and/or participating in several of the papers that are currently in development for the forthcoming special issue of *BioScience* that will focus on LTER science (names of AND scientists are underlined):

Ecosystem Controls on Streamflow Response to Land-use Change, Climate Change, and Climate Variability at Long-Term Ecological Research Sites. Julia A. Jones, Irena F. Creed, Kendra L. Hatcher, Robert J. Warren, Mary Beth Adams, Melinda H. Benson, Emery Boose, Warren Brown, John L. Campbell, Alan Covich, David W. Clow, Clifford N. Dahm, Kelly Elder, Chelcy R. Ford, Nancy B. Grimm, Donald L. Henshaw, Kelli L. Larson, Evan S. Miles, Kathleen M. Miles, Stephen Sebestyen, Adam T. Spargo, Asa Stone, James M. Vose, Mark W. Williams.

Science and Society: The Role of Long-Term Studies in Environmental Stewardship. C.T. Driscoll, K.F. Lambert, F.S. Chapin, III, D. Nowak, T. Spies, F.J. Swanson, D.B. Kittredge, Jr., C. M. Hart

Scenario studies as a synthetic and integrative research activity for LTER. Jonathan Thompson, Arnheim Weik, Frederick Swanson, Stephen Carpenter, Nancy Fresco, Stuart Chapin, Thomas Spies, Theresa Hollingsworh, David R. Foster

V.C. REGIONAL ACTIVITIES

The Andrews Forest LTER program and scientists have long history in the study of biota and ecological and geophysical processes across the Pacific Northwest to test science concepts beyond the confines of the Andrews Forest and to explore ecological and socio-ecological phenomena operating at larger scales. This collection of regional studies is central to our research program (some of these are shown in Figure V.C.1). Some studies capitalize on the regional network of research sites (e.g., Experimental Forests and Research Natural Areas) crossing the strong west-to-east environmental gradient characteristic of the region (e.g., decomposition studies by Harmon) and other studies evaluate large geographic areas (e.g., the Willamette River Basin Futures project in which the Andrews Forest has a role). The Andrews Forest

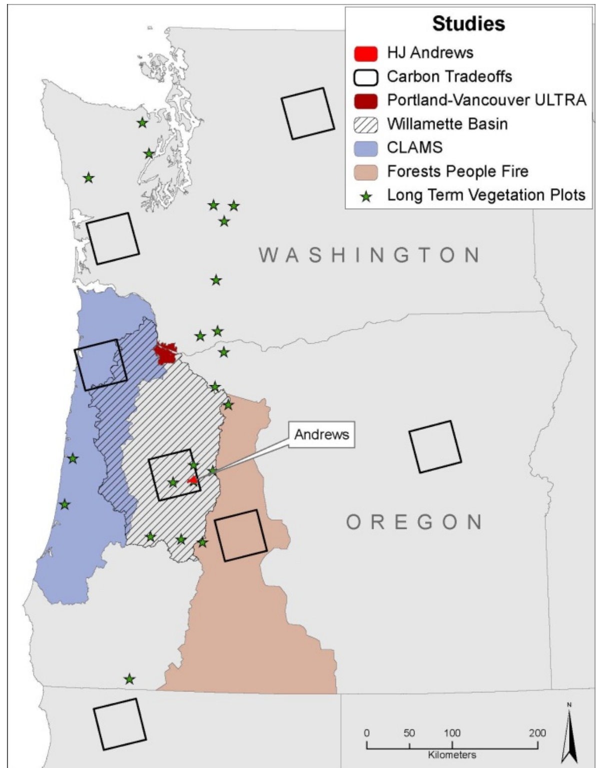

Figure V.C. 1. Some of the regional studies associated with the Andrews LTER

is also a prominent partner in three newly-funded projects: 1) The Portland-Vancouver Urban Long-term Research Area Experimental (ULTRA-Ex) project—a 2-year project funded by the National Science Foundation; 2) The Willamette Water 2100 project—a 5-year interdisciplinary project funded by the National Science Foundation to anticipate water scarcity in our region in response to climate and land use change; and 3) The Climate Decision Support Consortium, funded by the National Oceanic and Atmospheric Administration to serve as the one of the sites for NOAA's Regional Integrated Sciences and Assessments (RISA) program. We also continue to conduct research using Forest Service Inventory plots and our network of long-term vegetation plots (See Vegetation Component) and experimental watersheds arrayed north-south along the Cascade Range. Most of the regional program of work is done in collaboration or partnership with others. Although relatively little of the LTER budget goes toward these regional activities, the Andrews group is placing increasing emphasis on research at broad scales because many ecological and socio-ecological questions associated with global change and mountainous topography (Goals I, II, and III) cannot be addressed without considering ecological and social variation and processes that operate across a wide range of spatial scales.

Regional Research Connections and Partnerships. The following is a list of regional scale projects and landscape-scale ecosystems studies within the Pacific Northwest Region. The Andrews LTER contributes to these efforts in various ways (e.g. data sharing, study design and analysis and writing and interpretation) and the knowledge and information that these efforts produce and communicate contribute to meeting LTER goals and objectives.

- Portland Urban Long-term Research Site (PDX Ultra-Ex) http://www.fsl.orst.edu/eco-p/ultra/
- Tradeoffs Among Carbon and Other Ecosystem Services Associated with Forest Management Practices. NASA Carbon Cycle Program. http://carbon-tradeoffs.forestry.oregonstate.edu/
- Forests People Fire (FPF). Study funded by NSF Coupled Natural Human Systems http://www.fsl.orst.edu/eco-p/coupled-systems/index.html
- Northwest Forest Plan Vegetation Monitoring-15 year Report. http://www.reo.gov/monitoring/reports/15yr-report/index.shtml
- PNW Climate Decision Support Consortium http://pnwclimate.org/
- Willamette Water 2100 http://water.oregonstate.edu/ww2100/

V.D. International Activities

The H.J. Andrews LTER has been actively engaged in international LTER work, from active cross-site collaborative research to being instrumental in the establishment of international LTER sites in Asia, South America, and Central Europe, and to participation in the US ILTER Committee. Countries and activities include:

V.D.1. Lajtha: Hungary, Germany, New Zealand. Kate Lajtha initiated the DIRT (Detrital Input and Removal Treatments) experiment at the H.J. Andrews Experimental Forest in 1997, and maintains and coordinates cross-site DIRT analyses and syntheses, including the 20-year anniversary sampling of the original DIRT site at the Harvard Forest LTER. Many findings and experiments from the DIRT project are directly relevant to other long-term data needs of the LTER network, such as long-term data on soil respiration and soil solution chemistry. Lajtha co-chaired a meeting to coordinate the networking of central European ILTER sites in 1999, and many of those collaborations are active today. With International Supplement funding, she and a postdoc established the Hungarian DIRT site in 2001 in collaboration with colleagues from Debrecen University (Fig. V.D.1.1). Lajtha's graduate student, Kim Townsend, received funding in 2011 through the Critical Zone Exploration Network (http://www.czen.org/) which is funded by NSF to conduct the 10th year anniversary sampling at that site this summer. German colleagues established a DIRT site in 2003, and are already publishing the first cross-site papers from that research.

Figure V.D.1.1. Bruce Caldwell showing US and Hungarian graduate students soil structure from the Hungarian DIRT experiment

Figure V.D.1.2. Andesitic soils from New Zealand

Lajtha traveled to New Zealand with International Supplement funds to initiate a collaboration involving Dr. Troy Baisden and other scientists at The National Isotope Centre, GNS Science, and the Andrews LTER watershed group. There are many common features in forests of New Zealand and the Pacific Northwest, including volcanic soils, low N deposition, and a temperate climate. The soils at the Andrews are complex mixes of Andisols and andic Inceptisols, with characteristics that are unique to andic soils. Andisols are found around the world, but are common on the North Island of New Zealand, thus making ecological comparisons between New Zealand and PNW ecosystems highly relevant (Fig. V.D.1.2). The gauged watersheds of New Zealand are ideal for testing the generality of hypotheses generated in the small watersheds of the Andrews, and Dr. Baisden can add to our water analyses by dating the C in DOM using accelerator mass spectrometry (AMS) at GNS Science, and also can examine molecular properties of DOM using pyrolysis mass spectrometry. These analyses will allow us to examine the sources of DOC to streams, and allow us to understand mechanisms of destabilization of SOM in different seasons and under differing climate scenarios, a central goal of both LTER6 and the DIRT LTREB award.

Selected publications:

Klotzbücher, T., S. Strohmeier, K. Kaiser, R. Bowden, K. Lajtha, H. Ohm, K. Kalbitz. 2012. Effect of litter input on lignin stability and microbial communities in soils under temperate deciduous forests. Global Change Biology, in review.

Sollins, P., M. Kramer, M. Kleber, K. Lajtha, C. Swanston, T. Filley, A. Aufdenkampe, R. Wagai, R. Bowden. 2009. Organic C and N stabilization across soils of contrasting mineralogy: further evidence from sequential density fractionation. Biogeochemistry 96: 209-231.

Tóth, J.A., K. Lajtha, Z. Kotroczó, Z. Krakomperger, B. Caldwell, R. Bowden, M. Papp. 2007. The Effect of Climate Change on Soil Organic Matter Decomposition. Acta Silv. Lign. Hung., 3: 75-85.

Horváth, L., E. Führer and K. Lajtha. 2006. Nitric oxide and nitrous oxide emission from Hungarian forests: link with atmospheric N deposition. Atmospheric Environment 40: 7786–7795.

Holub, S.M., K. Lajtha, J.D.H. Spears, J.A. Tóth, S.E. Crow, B.A.Caldwell, M. Papp, and P.T. Nagy. 2005. Organic matter manipulations have little effect on gross and net nitrogen transformations in two temperate forest mineral soils in the U.S.A and central Europe. Forest Ecology and Management 214:320-330.

Lajtha, K. and K. Vanderbilt, eds. 2000. Cooperation in Long Term Ecological Research in Central and Eastern Europe: Proceedings of the ILTER Regional Workshop, 22-25 June, 1999, Budapest, Hungary. Oregon State University, Corvallis, OR.

V.D.2. McDonnell: UK, Japan, Sweden. As part of his LTER research, Jeff McDonnell has collaborated with scientists from the United Kingdom, Canada, Sweden, Switzerland, Japan and Germany. Chief among his collaborations has been his participation in North-Watch, and international inter-catchment comparison program. This program aims to improve the understanding of the sensitivity of northern catchments to climate change using both hydrological and biogeochemical response data. The catchments are located Sweden (Krycklan), Scotland (Mharcaidh, Girnock and Strontian), the United States (Sleepers River, Hubbard Brook and HJ Andrews) and Canada (Catamaran, Dorset and Wolf Creek).

During 2008, Dr. McDonnell collaborated with Takahiro Sayama (University of Kyoto, Japan) to develop a new time-space accounting scheme (T-SAS) that simulates the pre-event and event water fractions, mean residence time, and spatial source of streamflow at the watershed scale. They used data from Watershed 10 at HJ Andrews and the well-studied Maimai catchment in New Zealand. The T-SAS approach links the dynamics of residence time and time-space sources of flow at the watershed scale and may be a useful framework for other distributed rainfall-runoff models.

Jeff McDonnell also worked with Jan Seibert (University of Zurich, Switzerland and Stockholm University, Sweden) to improve upon the traditional paired-watershed approach to understanding land-change and land-use effects on rainfall-runoff dynamics. Using data from two headwater catchments at the Andrews and then scaling up to the larger Lookout watershed, McDonnell and Seibert tested a model-based change-detection approach that included model and parameter uncertainty. Their results were published in Hydrological Sciences Journal in 2010.

International Collaborators: Genevieve Ali, University of Aberdeen, UK, Timothy Burt, University of Durham, UK, Takahiro Sayama, Kyoto University, Japan, Matthias Ritter, University of Freiburg, Germany, Doerthe Tetzlaff, University of Aberdeen, UK Sean K. Carey, Carleton University, Canada, Jan Seibert, University of Zurich, Switzerland & Stockholm University, Sweden, Chris Soulsby, University of Aberdeen, UK.\, Jim Buttle, Trent University, Canada, Hjalmar Laudon, Forest Ecology and Management, SLU, Sweden, Daniel Ciassie, Fisheries and Oceans, Canada, Mike Kennedy, University of Aberdeen, UK, Kevin Devito, University of Alberta, Canada, John W. Pomeroy, University of Saskatchewan, Canada

Selected publications:

Ali G, D. Tetzlaff, C. Soulsby, J.J. McDonnell and R. Capell, 2011. Catchment classification, catchment similarity indices and catchment exemplars: a cross-regional approach. Advances in Water Resources Research, in review.

Carey, S.K., D. Tetzlaff, J. Seibert, C. Soulsby, J. Buttle, H. Laudon, J.J. McDonnell, K. McGuire, D. Caissie, J. Shanley, M. Kennedy, K. Devito and J. Pomeroy, 2010. Inter-comparison of hydro-climatic regimes across northern catchments: synchronicity, resistance and resilience. Hydrological Processes, DOI: 10.1002/hyp.7880.

Kruitbos, L., D. Tetzlaff, C. Soulsby, J. Buttle, S. Carey, H. Laudon, J.J. McDonnell, K. McGuire, J. Seibert, R. Cunjak and J. Shanley, 2011. Hydroclimatic and hydrochemical controls on Plecoptera (stonefly) diversity and distribution in northern freshwater ecosystems, Hydrobiologia, in review.

Laudon, H, D. Tetzlaff, C. Soulsby, S. Carey, J. Seibert, J. Buttle, J. Shanley, J.J. McDonnell and K. McGuire, 2011. Seasonality and synchroneity of water and dissolved organic carbon fluxes in mid- to high latitude catchments. Global Biogeochemical Cycles, in review.

Sayama, T. and J.J. McDonnell, 2009. A new time-space accounting scheme for to understand predicting streamwater residence time and hydrograph source components in catchments. Water Resources Research 45, W07401, doi:10.1029/2008WR007549.

Seibert, J.; McDonnell, J.J. 2010. Land-cover impacts on streamflow: a change-detection modelling approach that incorporates parameter uncertainty. Hydrological Sciences Journal. 55(3): 316-332.

Seibert, J. and J.J, McDonnell 2010. Change detection modeling to assess the effect of forest harvesting and road construction on peak flow. Hydrological Sciences Journal, 55(3): 316-332.

V.D.3. Miller: Asia (Japan, South Korea, Thailand). Jeff Miller's research uses Lepidoptera for bioinventory and climate change studies. His scale of interest is Pan-Pacific. The current goals of his ILTER work in Asia are to 1) designate permanent study sites for the acquisition of repeated measures on species richness and abundance, 2) delimit the taxonomic scope to an identical set of Family units across all sites, 3) standardize sampling protocols among sites in Asia and US LTER sites, 4) establish and coordinate fundamental database structures, and 5) develop benchmark indices relative to temporal and spatial patterns in the distribution and abundance of taxa. In 2002 Miller traveled to Taiwan on an international supplement grant and has visited Taiwan at least once every year between 2004 and 2011. He has established collaborations with numerous scientists at National Taiwan University and The Taiwan Forestry Institute. One book is in progress.

Selected publications:

Miller, J.C. 2010. Insects and Relatives, pp. 270-274, *In*: Chapter 7: Oregon's Fish and Wildlife In A Changing Environment, Oregon Climate Change Research Institute (2010), Oregon Climate Assessment Report, K.D. Dello and P.W. Mote (eds). College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, OR.

Miller, J.C. 2009. International Collaboration On Biodiversity Research: A Practical, Conceptual, and Empirical Perspective. Naresuan Phayao Journal 2:1-12. Naresuan Phayao University.

V.D.4. Bond: Argentina and Chile.

Figure V.D.4.1. Some of the participants from the tri-national meeting in Bariloche, Argentina; January 2009.

International collaborations between AND and colleagues in Argentina have been ongoing for over a decade, and have recently expanded to include Chile as well. With partial support from LTER supplement funds, a tri-national meeting was conducted in Bariloche, Argentina, in January 2009. The supplement supported travel by Barbara Bond and other senior PIs from the US to attend the meeting, and a second supplement provided support for six additional U.S. scientists. Four AND faculty (Barbara Bond, Mark Harmon, Mathew Betts, Elizabeth Borer) and one PhD student (Carlos Sierra) participated in the meeting. This meeting was designed to stimulate cooperation among different groups of ecologists in Argentina to develop a strategy to develop an ILTER program for one or more sites in northern Patagonia, and it was also designed to stimulate collaborations between US and Argentine scientists. It was highly successful on both counts (Austin 2009). At this meeting, Dr. Claudio Ghersa of the University of Buenos Aires was selected as the Argentine representative to lead the next phase of the Argentine ILTER effort.

In September, 2009, Bond and Julia Jones led a workshop titled, “ILTER in Northern Patagonia: Developing a strategy for coordinating plans for Argentina and Chile” at the All Scientists Meeting to broaden LTER participation in these activities, and the LTER Network office provided travel support for two international colleagues to participate in this meeting—one from Argentina and one from Chile. An important outcome from this meeting was development of a collaboration with Dr. Chris Anderson of North Texas University. Anderson has a long-standing international collaboration with a different set of prominent ecologists in Chile.

With separate funding from NSF, Ghersa visited Bond in the US in June 2010 to plan a special session for the fourth annual Bi-national (Chile and Argentina) Ecology Conference in Buenos Aires. This meeting took place on August 13, 2010, as a round-table discussion and was attended by 15 ecologists from the U.S., Chile and Argentina; the support for Bond’s travel to this meeting came from the remaining funds in our 2009 international supplement. A smaller group of about 10 people (including Bond and Anderson) met the following day to craft strategies for continuing the collaboration. Action plans from this meeting were: 1) to submit to Oregon State University a pre-proposal for an NSF-PIRE proposal to forward the collaboration (Bond and Ghersa); 2) to resubmit to NSF in 2011 a revised version of a PASI proposal (a version submitted in 2010 was not funded but a resubmission was encouraged) (Chris Anderson, Bond, others); 3) to write a manuscript based on concepts in the PASI proposal (Anderson, others); 4) to continue the momentum of this group through annual or semi-annual meetings (Ghersa). Unfortunately, the PIRE opportunity was not offered that year, and NSF did not allow Anderson to resubmit a revised PASI proposal in a consecutive year, but good progress is being made on other fronts. The manuscript (#3) is nearly complete and should be submitted by the end of this summer. Ghersa will be again visiting Bond in the US in July 2012 to plan the next meeting (#4). As many others in the U.S. LTER network have observed previously, there are considerable political, institutional and national (Argentina/Chile) barriers to overcome before ILTER sites can be established in this region, but we are encouraged that our progress is steady.

Bond is also continuing long-term research collaborations with colleagues in Argentina. The broad goal of these research activities is to compare the ecophysiology of vegetation in the climatically similar regions of the Pacific Northwest and northern Patagonia. Since the beginning of LTER6, this work has produced four publications.

Selected publications:

Austin, Amy T. 2009. Planning for connections in the long-term in Patagonia. (Pub No: 4511).

Gyenge, M.-E. Fernández, J. Licata, M. Wiegandt, B.J. Bond T.M. Schlichter, and B.J. Bond. (2011). Uso del agua y productividad de los bosques nativos e implantados en el N.O. de la Patagonia: aproximaciones desde la ecohidrología y la ecofisiología. Ecofisiología de Plantas Leñosas. Accepted for publication.

Fernández, M.E., J.A. Licata, J.E. Gyenge, T.M. Schlichter and B.J. Bond. 2008. Belowground interactions for water between trees and grasses in a temperate semiarid agroforestry system. Agroforestry Systems DOI 10.1007/s10457-008-9119-4.

Licata, J.A., T.G. Pypker, M. Weigandt, M.H. Unsworth, J.E. Gyenge, M.-E. Fernández, T.M. Schlichter, and B.J. Bond. 2011. Decreased rainfall interception balances increased transpiration in exotic ponderosa plantations compared with native cypress stands in Patagonia, Argentina ***Ecohydrology*** 4:83-93

Licata, J.A., J.E. Gyenge, M.E. Fernández, T.M. Schlichter and B.J. Bond. 2008. Increased water use by ponderosa pine plantations in northwestern Patagonia, Argentina compared with native forest vegetation. Forest Ecology and Management 255(3):753-764

International Collaborators in Argentina: Tomás Schlicter, Instituto Nacional de Tecnología Agropecuaria, Argentina, María Elena Fernandez, Instituto Nacional de Tecnología Agropecuaria, Argentina, Julián Licata, Instituto Nacional de Tecnología Agropecuaria, Argentina, Javier Gyenge, Instituto Nacional de Tecnología Agropecuaria, Argentina, Amy Austin, Univeristy of Buenos Aires, Argentina, Roberto Fernández, University of Buenos Aires, Argentina, Claudio Ghersa, University of Buenos Aires, Argentina, Chris Anderson, North Texas University, U.S.

V.D.5. Swanson, Jones, Johnson: Japan LTER. Members of the Andrews Forest LTER program have collaborated with Japanese colleagues central to the Japan LTER program (JaLTER) since the early 1980s with activities centered on collaborative research on watershed processes and landscape dynamics, environmental science education for graduate students, and operations of LTER programs at site and network scales. Activities of the past two years include 1.) hosting several groups of graduate students from Universities of Tokyo and Hokkaido, 2.) collaborating with geography professor S. Takaoka (Senshu Univ., Tokyo) in a study of long-term meadow dynamics in the Andrews Forest and vicinity, 3.) co-hosting a Korean post doc who came to us via JaLTER/Hokkaido University connections where he did his PhD, 4.) several visits to Japan by senior Andrews faculty, most recently (2010) by Jones and Swanson to teach in an international graduate student field course that is part of JaLTER, and 5.) an Andrews PhD student (a Japanese and English speaking Korean majoring in water resources) is attending the 2011 version of this field course. This is a self-sustaining collaboration based on numerous inter-personal contacts and shared institutional interests.

Selected publications:

Kasahara, T. 2000. Geomorphic controls on hyporheic exchange flow in mountain streams, Oregon. Corvallis, OR: Oregon State University. 103 p. M.S. thesis.

Kasahara, T.; Wondzell, S. M. 2003 . Geomorphic controls on hyporheic exchange flow in mountain streams. Water Resources Research. 39(1): 1005, doi:10.1029/2002WR001386.

Shibata, H.; Sugawara, O.; Toyoshima, H.; Wondzell, S. M.; Nakamura, F.; Kasahara, T.; Swanson, F. J.; Sasa, K. 2004. Nitrogen dynamics in the hyporheic zone of a forested stream during a small storm, Hokkaido, Japan. Biogeochemistry. 69: 83-104.

Takaoka, S. 2008. Developing ESD (Education for Sustainable Development) from a local perspective: a case study of forest management in the Pacific Northwest region of USA. Chiri. 53(11): 97-104. [In Japanese].

Takaoka, S.; Swanson, F. J. 2008. Change in extent of meadows and shrub fields in the central western Cascade Range, Oregon. Professional Geographer. 60(4): 1-14.

VI. Education and Outreach Activities

VI.A. Education/Outreach Overview

The Andrews Forest Program includes a very broad spectrum of education and outreach activities with multiple objectives and funding sources, as summarized below. Since 2008, we have averaged 1,300 visitors annually in addition to Andrews Forest Researchers; these include classes from 18 national and international universities and colleges, K-12 classes from 21 Oregon schools/programs, and numerous management, education and research workshop and conferences. As with the Research Program, many of the education activities are interrelated and at some point in the past have had direct contributions from Andrews LTER. For the sake of the midterm evaluation, we've attempted to clarify which programs have received some direct contribution or support from the AND LTER since 2008 by showing them in bold typeface in the table below. Most of this support comes from supplements to the core budget.

<table>
<tr><th colspan="3">Andrews Forest Education and Outreach Activities
(titles in bold are supported directly by LTER funds)</th></tr>
<tr><td>K-12 Students and Teachers</td><td>Schoolyard LTER: Teachers as Researchers
Research Experience for Teachers (RET)
Canopy Connections
Outdoor School, McKenzie School District
LTER Faculty Involvement in Schools
Science & Math Investigative Learning Experiences (SMILE)
Teaching Ecoplexity (LTER cross-site)
Researcher-Teacher Partnerships (NASA)
AND LTER Children's Book</td><td>
Canopy Connections students. By Katie Nussbaum.</td></tr>
<tr><td>Undergraduate and Graduate</td><td>Research Experience for Undergraduates (REU)
Ecoinformatics Summer Institute
Pollination Biology
Andrews Forest LTER REUs
Undergraduate Student Researchers and Workers
Masters and PhD Students
Andrews LTER Graduate Student Research Awards
Andrews LTER Graduate Student GRA Support Awards
EcoInformatics IGERT, OSU
Environmental Leadership Program, University of Oregon
Ruth Spaniol Writing Retreats for Graduate Students
Undergraduate/graduate classes and courses</td><td>
Undergraduate Student at the Andrews. By Lina DiGregorio</td></tr>
</table>

Outreach and Continuing Education	Post-doctoral trainees Field Workshops and Tours of the Andrews Forest **HJA Day annual field tour** Visiting Scholars Program Research-Management Partnership Workshops and Tours organized by Central Cascades Adaptive Management Program (CCAMP) OSU Extension and Outreach Partnerships	 *HJA Day. By Lina DiGregorio*

<u>VI.B. EDUCATION/OUTREACH CLOSEUPS: K-12</u>

Figure VI.B.1. A Teachers as Researchers participant measures bud break of Douglas fir at the Andrews Forest as part of the Andrews phenology study.

VI.B.1. Schoolyard LTER: "Teachers as Researchers" (TaR). This is our primary "LTER-funded" education activity. The goal of this project is to increase high school and middle school teachers' understanding of environmental science research by involving them in projects directly related to Andrews LTER research and to expand their capacity to engage their students in similar field-based science inquiry. Teachers work with Andrews LTER scientists, and some of the teachers who have been in the program in a previous year serve as "mentor-teachers" in subsequent years. The program has served 42 teachers and 4,400 students from a wide range of schools. Participants came from small rural schools, urban inter city schools, alternative schools, and charter schools. Many of the participants teach in Title I Schools (4 out of 11 in 2011) and those with high populations of English Language Learners. The program is structured around three 2-day workshops. For the first time in 2001, one of the workshops at the Andrews site and was scheduled to take place concurrent with field campaigns that are part of the LTER6 "Phenology" project (Fig. VI.B.1). The project effectiveness is evaluated through workshop evaluations and formal evaluation of courses taught by Dr. O'Connell. The assessments indicate that engaging teachers with Andrews LTER researchers increased teachers' enthusiasm, knowledge and skills about environmental science-based inquiry. One teacher reported that, "I really appreciated having the opportunity to interact with various researchers. It was helpful to learn about current research they were conducting and then being able to brainstorm ways to apply similar field techniques at the high school level. I gained ideas about practical field inquiry studies I could do with my students from each researcher." Another teacher reported that, "…because once we experienced [field-based research], we became much more confident in actually doing it with our students."

VI.B.2. Research Experience for Teachers (RET): The Andrews LTER K-12 education program aims to offer a progression of experiences that increase high school and middle school teachers' understanding of environmental science research by involving them in projects directly related to LTER research, and to expand their capacity to involve their students in similar field-based science inquiry. Many of the RETs are recruited from our main Schoolyard LTER activity (the Teacher as Researchers (TaR) project) and many of them subsequently serve as teacher-leaders in the TaR and other teacher professional development projects. The RETs become intensely involved in individual research projects, and they are also exposed to our broader research program. Past RETs Kurt Cox, Jeff Mitchell, Jill Semlick, and Rima Givot all made significant contributions to the TaR project.

In 2010, Rima Givot worked with researchers studying insect and plant community ecology in the NUTNET (nutrient network) plots in meadows at the Andrews Forest. Givot also helped design a NutNet-based tool for pre-college science education that can be used at NutNet sites around the world. The most recent RET, Molly Charnes, worked with the LTER6 phenology project on monitoring insect and plant phenology and micro-climate variability across the Andrews complex terrain. Charnes helped tie Andrews LTER phenology project to teachers and students (including her own) by developing lesson plans for student phenology projects in the schoolyard and developing a phenology trail and plot for students and teachers visiting the Andrews Forest.

Research for Teachers (RET) participant, Rima Givot, holds a display tank at the Andrews Forest.

VI.B.3. Canopy Connections. Canopy Connections is an experiential learning program for Oregon middle school classes developed by three partner institutions: University of Oregon Environmental Leadership Program, The Pacific Tree Climbing Institute, and the US Forest Service PNW Station (Fig VI.B.3). The Pacific Northwest is home to some magnificent old-growth forests. Unfortunately, many local children have never had the opportunity to explore this enchanting ecosystem first-hand. In response, the Canopy Connections Team develops a unique fieldtrip experience—one that gives middle-school students an opportunity to climb into the canopy of an old-growth forest. The mission is to inspire a sense of wonder and respect for our natural world through a curriculum that integrates science, art, creative writing. Not only does the program enrich the curriculum for regional K-12 schools, the program provides excellent training in ecology and science education for a cohort of 9 undergraduate and graduate Environmental Science students each year.

Since the first full season of the program in 2009, 450 students have participated in the program. Recruitment of classes prioritizes schools with a high proportion students receiving free and reduced lunch. Although funded by private donations, foundations and the USFS More-Kids-in-the-Woods program, Canopy Connections leverages the investment in LTER research as an effective mechanism for communicating ecological insights to beginning science students.

Table VI.B.3.1. Involvement of Oregon K-12 classes in the Canopy Connections experiential education program.

School	Year	Participants
McKenzie River School District Outdoor School	2008	20
Fern Ridge Middle School	2009	18
Kelly Middle School	2009	19
Kelly Middle School	2009	16
McKenzie Elementary School	2009	15
McKenzie Middle School	2009	17
Rachel Carson - Churchill School	2009	12
Spencer Butte Middle School	2009	10

School	Year	Participants
Fern Ridge Middle School	2010	24
Kelly Middle School	2010	48
Kelly Middle School	2010	24
Lincoln Middle School	2010	24
McKenzie Middle School	2010	24
Northwest Youth Corps	2010	12
Sandy High School	2010	24
Ashbrook Independent School	2011	24
Eugene Waldorf School	2011	24
Fern Ridge Middle School	2011	24
McKenzie Middle School	2011	24
Ridgeline Middle School	2011	24
Roosevelt Middle School	2011	19
Spencer's Butte Middle School	2011	24

Figure VI.B.3. Canopy Connections Participants in the trees and on the ground taking notes after the climb.

VI.B.4. Teaching Ecoplexity. AND participates in the cross-site project, Ecoplexity: Teaching ecological complexity. More information about this project is available at http://www.ecoplexity.org/cross_site.

VI.B.5. Researcher-Teacher Partnerships (NASA). Leveraging the success of the Andrews Schoolyard program, "Teachers as Researchers", director Kari O'Connell has recently received funding from NASA to expand the project. More information is at http://www.cof.orst.edu/onrep/Climate_Institute.shtml

VI.B.6 AND LTER Children's Book. "Ellie's Log" *(Figure VI.B.6)* is a book written for middle school children by Andrews scientist Judith Li, with illustrations by M.L. Herring. The book is currently in press and we expect it to be released in spring, 2012.

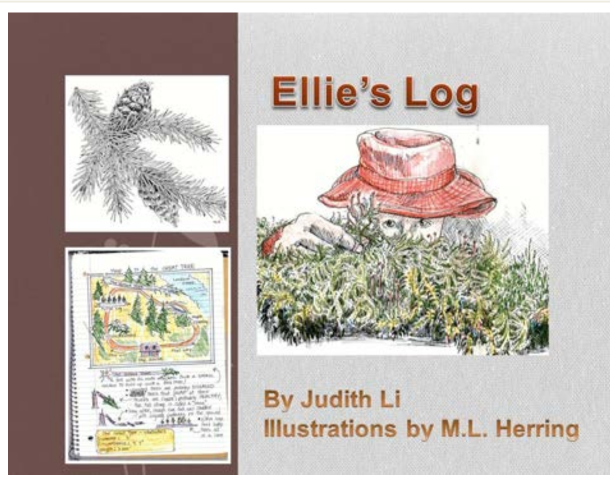

Figure VI.B.6. Illustrations from Ellie's Log, the AND LTER Children's Book

VI.C. EDUCATION/OUTREACH CLOSEUPS: UNDERGRADUATE AND GRADUATE

VI.C.1. Research Experience for Undergraduates (REU)

VI.C.1.1. Ecoinformatics Summer Institute (EISI) led by Desiree Tullos, PI, Julia Jones, Tom Dietterich, co-PIs; Matt Cox, coordinator). The EISI summer institute is an NSF-funded REU program intended for undergraduates who are considering graduate study or a professional career in environmental science, computer science, or mathematics. The program is a 10-week field program based at the HJ Andrews Experimental Forest and the OSU campus in Corvallis, Oregon, that provides opportunities for team-based, interdisciplinary research linking ecology, engineering, mathematics and computer science. Over the course of the summers of 2007 to present, the EISI has hosted a total of 60 undergraduate students from all over the U.S., Puerto Rico, and Haiti , where they have worked with faculty mentors on research projects that advance knowledge and understanding of old-growth forests, streams, and other native ecosystems. Example projects include: (1) engineered log jams: connecting fish habitat to wood in streams using advanced imaging technology and visualization; (2) moths and meadows: species distribution models and insect emergence models and field sampling to understand species sensitivity to topography, vegetation and, climate; (3) wood dynamics: modeling and mapping how large wood has moved in streams over the past 40 years and how stream channels have responded; and (4) ecohydrology: modeling and measuring diel fluctuations in streams and their connection to hydrologic flowpaths. Of the 60 students in the EISI from 2007-2011, 10 (17%) have been minority students. http://eco-informatics.engr.oregonstate.edu/

VI.C.1.2. Pollination Biology. The NSF-funded Pollination Biology REU is led by Sujaya Rao and Andrews scientist Andy Moldenke. It is hosted by the Department of Crop and Soil Science at Oregon State University. The H.J. Andrews Experimental Forest is one of the primary field sites for students in this project. This 10-week program provides undergraduates with experience in cross-disciplinary research in pollination biology in natural and manipulated ecosystems. For more information about this project see http://cropandsoil.oregonstate.edu/reu.

Figure VI.C.3.1. Andrews LTER REUs Nick Curcio (left) works on soil studies in Watershed 1 at the Andrews Forest, and Sarah Perez-Sanz (right) in the tree canopy to set up temperature dataloggers for the phenology project. Andrews Forest undergraduate worker, Ashley Pacelli (right), inspects an understory plant for insects as part of the phenology project.

VI.C.1.3. Andrews Forest LTER REUs. Each year the Andrews Forest LTER grant funds two REU students who work closely with Andrews researchers (Fig. VI.C.3.1). In 2011, Andrews PIs Julie Pett-Ridge and Markus Kleber are working with REU Nick Curcio on dissolved silica fluxes. Nick is currently a sophomore at OSU pursuing a B.S. in Environmental Science. PIs Mark Schulze, Sherri Johnson, and Matthew Betts are working with REU Sarah Perez-Sanz on the LTER6 phenology project. For a full list of REU students involved at the Andrews Forest see Table VI.C.2.

VI.C.2. Undergraduate Student Researchers and Workers

Undergraduate student researchers and workers are an integral part of the education and research program at the Andrews Forest. Each year, the AND provides research and training opportunities for more than 40 undergraduate students (Table VI.C.2). Students are part of long-term vegetation plots monitoring program, which includes forest plots that have been measured since the early 1900s. The bird component of the phenology project trains student interns to be rugged field researchers and proficient point-count samplers capable of identifying all resident and migrant forest bird species song and call. The phenology project as whole has provided ecological work experience for recent graduates who are preparing for graduate studies (Fig. VI.C.1). Undergraduate students also make major contributions to the Water and Carbon cycling processes project in Watershed 1. The research-management partnership through CCAMP has provided opportunities for students and recent graduates to learn vegetation sampling techniques and silvicultural principles while monitoring forest response to several management treatments (uneven-age management of young forest stands, meadow restoration, using landscape-scale disturbance processes to guide management of young and mature forests) grounded in findings from AND LTER Research. The annual field campaigns for the DIRT and NUTNET plots provide valuable field experiences for students. All students who work at the Andrews Forest are trained in field and lab techniques and safety.

Table VI.C.2. Undergraduate students involved with the Andrews Forest program during LTER6.

Name	Project	Job Type	Year	PI-employer
Creel, Hana	Legacy data reconstruction: Lookout Creek streamflow; Mack Creek climatic data	Student Worker	2008-2010	Don Henshaw
Chi, Emily	Canopy Connections	student project	2009	Kathryn Lynch
Lee, Mackenzie	Canopy Connections	student project	2009	Kathryn Lynch
Orton, Kali	Canopy Connections	student project	2009	Kathryn Lynch
Royer, Tommy	Canopy Connections	student project	2009	Kathryn Lynch
Simas, Molly	Canopy Connections	student project	2009	Kathryn Lynch
Ward, Alex	Canopy Connections	student project	2009	Kathryn Lynch
Zimmer-Stucky, Jasmine	Canopy Connections	student project	2009	Kathryn Lynch
Zwickey, Kara	Canopy Connections	student project	2009	Kathryn Lynch
McKenzie, Brian	Fire Frequency and LIDAR	EISI Student 2009	2009	Enrique Thomann, Jorge Ramirez
Ngeow, Andrew	Fire Frequency and LIDAR	EISI Student 2009	2009	Enrique Thomann, Jorge Ramirez
Thomas, Dylan	Fire Frequency and LIDAR	EISI Student 2009	2009	Enrique Thomann, Jorge Ramirez

Name	Project	Job Type	Year	PI-employer
Amstutz, Amanda	Moths and Meadows: Data Collection, Metapopulations, and Species Distribution Modeling	EISI Student 2009	2009	Tom Dietterich, Jorge Ramirez, Weng-Keen Wong
Lapidus, Julie	Moths and Meadows: Data Collection, Metapopulations, and Species Distribution Modeling	EISI Student 2009	2009	Tom Dietterich, Jorge Ramirez, Weng-Keen Wong
Moss, Eli	Moths and Meadows: Data Collection, Metapopulations, and Species Distribution Modeling	EISI Student 2009	2009	Tom Dietterich, Jorge Ramirez, Weng-Keen Wong
Rojas, Jose	Moths and Meadows: Data Collection, Metapopulations, and Species Distribution Modeling	EISI Student 2009	2009	Tom Dietterich, Jorge Ramirez, Weng-Keen Wong
Winerip, Michelle	Moths and Meadows: Data Collection, Metapopulations, and Species Distribution Modeling	EISI Student 2009	2009	Tom Dietterich, Jorge Ramirez, Weng-Keen Wong
Naegele, Alex	Storm Analysis using Tensor Field Visualization	EISI Student 2009	2009	Julia Jones, Jorge Ramirez
Navarrete, Raymundo	Storm Analysis using Tensor Field Visualization	EISI Student 2009	2009	Julia Jones, Jorge Ramirez
Zdyrski, Andrew	Storm Analysis using Tensor Field Visualization	EISI Student 2009	2009	Julia Jones, Jorge Ramirez
Kilanowski, Allyssa	Vegetation Response to burning of slash piles in a meadow restoration experiment at Bunchgrass Ridge, Oregon	volunteer/intern	2009	Charlie Halpern, UW
Bartley, Merideth	Water Storage	EISI Student 2009	2009	John Selker
Dawson, Ben	Water Storage	EISI Student 2009	2009	John Selker
Do, Hoan-Vu	Wood in Streams	EISI Student 2009	2009	Desiree Tullos
Gillick, Jonathan	Wood in Streams	EISI Student 2009	2009	Desiree Tullos
Reeb, Gregory	Wood in Streams	EISI Student 2009	2009	Desiree Tullos
Sell, Scott	DIRT	REU/Field assistant	2009-2010	Kate Lajtha
Valentine, Lewis	Legacy data reconstruction: Lookout Creek and Coyote Creek streamflow	Student Worker	2009-2010	Don Henshaw
McCune, Myrica	Maps and Locals (MALs): A Cross-Site LTER Comparative Study of Land-Cover and Land-Use Change with Spatial Analysis and Local Ecological Knowledge	Student Worker	2009-2010	Hannah Gosnell, Denise Lach
Jackson, Even	bird phenology	field assistant	2010	Betts, Frey, Hadley
Lewis, Debbie	bird phenology	field assistant	2010	Betts, Frey, Hadley
Smith, Lauren	bird phenology	field assistant	2010	Betts, Frey, Hadley
Stagner, Joshua	bird phenology	field assistant	2010	Betts, Frey, Hadley
Duncan, Marissa	Canopy Connections	student project	2010	Kathryn Lynch
Graciosa, Melissa	Canopy Connections	student project	2010	Kathryn Lynch
Griesser, Kimber	Canopy Connections	student project	2010	Kathryn Lynch
Heckman, Morgan	Canopy Connections	student project	2010	Kathryn Lynch
Lauderback, Haley	Canopy Connections	student project	2010	Kathryn Lynch
Lee, Johanna	Canopy Connections	student project	2010	Kathryn Lynch
Long, Maggie	Canopy Connections	student project	2010	Kathryn Lynch
Warners, Laura	Canopy Connections	student project	2010	Kathryn Lynch

Name	Project	Job Type	Year	PI-employer
Quandt, Dustin	DOC sampling and analysis in WS 1	undergraduate worker	2010	Barbara Bond
Albright, Jason	Ecohydrology of the Andrews Forest	EISI student 2010	2010	Julia Jones, Jorge Ramirez
Gustafson, Nathaniel	Ecohydrology of the Andrews Forest	EISI student 2010	2010	Julia Jones, Jorge Ramirez
Nelson, Michaeline	Ecohydrology of the Andrews Forest	EISI student 2010	2010	Julia Jones, Jorge Ramirez
Rodriguez-Cardona Bianca	Ecohydrology of the Andrews Forest	EISI student 2010	2010	Julia Jones, Jorge Ramirez
Shughrue, Christopher	Ecohydrology of the Andrews Forest	EISI student 2010	2010	Julia Jones, Jorge Ramirez
Ausland, Hayden	Ecological modeling of emergent vegetation for sustaining wetlands in high wave energy coastal environment	EISI student 2010	2010	Desiree Tullos, Dan Cox, Denny Albert
Laguna, Sean	Ecological modeling of emergent vegetation for sustaining wetlands in high wave energy coastal environment	EISI student 2010	2010	Desiree Tullos, Dan Cox, Denny Albert
Calderon, Andrew	Moth and Meadows of the Andrews Forest	EISI student 2010	2010	Julia Jones, Jorge Ramirez, Tom Dietterich, Weng-Keen Wong
Goldman, Evan	Moth and Meadows of the Andrews Forest	EISI student 2010	2010	Julia Jones, Jorge Ramirez, Tom Dietterich, Weng-Keen Wong
O'Neill, Molly	Moth and Meadows of the Andrews Forest	EISI student 2010	2010	Julia Jones, Jorge Ramirez, Tom Dietterich, Weng-Keen Wong
Poblacion, Olivia	Moth and Meadows of the Andrews Forest	EISI student 2010	2010	Julia Jones, Jorge Ramirez, Tom Dietterich, Weng-Keen Wong
Showalter, Clay	Moth and Meadows of the Andrews Forest	EISI student 2010	2010	Julia Jones, Jorge Ramirez, Tom Dietterich, Weng-Keen Wong
Childs, Erin	Moth and Meadows/Steven Highland	EISI student 2010	2010	Julia Jones, Jorge Ramirez, Tom Dietterich, Weng-Keen Wong
DeMarco, Ari	Plant and Insect Phenology	Student Worker	2010	Sherri Johnson, Jay Sexton, Mark Schulze
Blankenship, Dillon	REU Site Program on Pollination Biology at OSU	REU	2010	Andy Moldenke, Sandy DeBano, Sujaya Rao
Bonner, Stephanie	REU Site Program on Pollination Biology at OSU	REU	2010	Andy Moldenke, Sandy DeBano, Sujaya Rao
Galbraith, Sara	REU Site Program on Pollination Biology at OSU	REU	2010	Andy Moldenke, Sandy DeBano, Sujaya Rao
Gonzalez, Natalie	REU Site Program on Pollination Biology at OSU	REU	2010	Andy Moldenke, Sandy DeBano, Sujaya Rao
Peyton, Cheryl	REU Site Program on Pollination Biology at OSU	REU	2010	Andy Moldenke, Sandy DeBano, Sujaya Rao
Snodgrass, Dusten	REU Site Program on Pollination Biology at OSU	REU	2010	Andy Moldenke, Sandy DeBano, Sujaya Rao
Strohm, Chris	REU Site Program on Pollination Biology at OSU	REU	2010	Andy Moldenke, Sandy DeBano, Sujaya Rao
Thomas, Sophie	REU Site Program on Pollination Biology at OSU	REU	2010	Andy Moldenke, Sandy DeBano, Sujaya Rao
Tubbesing, Carmen	REU Site Program on Pollination	REU	2010	Andy Moldenke, Sandy

Name	Project	Job Type	Year	PI-employer
	Biology at OSU			DeBano, Sujaya Rao
Fetter, David	Velocity distributions and fish use of engineered log jams	EISI student 2010	2010	Desiree Tullos, Eugene Zhang, Matt Cox
Rice, William	Velocity distributions and fish use of engineered log jams	EISI student 2010	2010	Desiree Tullos, Eugene Zhang, Matt Cox
Somerville, Virginia	Velocity distributions and fish use of engineered log jams	EISI student 2010	2010	Desiree Tullos, Eugene Zhang, Matt Cox
Sell, Scott	DIRT and WS1 carbon study	undergraduate worker	2010-2011	Kate Lajtha
Curcio, Nick	Andrews REU	REU	2011	Julie Pett-Ridge
Perez-Sans, Sarah	Andrews REU	REU	2011	Mark Schulze
Bonady, Devon	Canopy Connections	student project	2011	Kathryn Lynch
Dahlstrom-Eckman, Azul	Canopy Connections	student project	2011	Kathryn Lynch
Foster, Maddison	Canopy Connections	student project	2011	Kathryn Lynch
Guasco, Sky	Canopy Connections	student project	2011	Kathryn Lynch
Hubbard, Ariella	Canopy Connections	student project	2011	Kathryn Lynch
Levy, Sami	Canopy Connections	student project	2011	Kathryn Lynch
Linz, Christa	Canopy Connections	student project	2011	Kathryn Lynch
Poole, Mark	Canopy Connections	student project	2011	Kathryn Lynch
Schlotterbeck, Devon	Canopy Connections	student project	2011	Kathryn Lynch
Sims, Paul	canopy cover measurements in WS 1	undergraduate worker	2011	Barbara Bond
Fashena, Zed	DIRT	undergraduate worker	2011	Kate Lajtha
Gibson, Yvette	DIRT	undergraduate worker	2011	Kate Lajtha
Dougan, Jackson Olson	DOC chemistry of HJA streams expanding to Willamette Basin	Honors Thesis	2011	Kate Lajtha
Christina Richardson	Ecohydrology	EISI Student 2011	2011	Julia Jones, Jorge Ramirez
Emily Neal	Ecohydrology	EISI Student 2011	2011	Julia Jones, Jorge Ramirez
Stephenson Dorval	Ecohydrology	EISI Student 2011	2011	Julia Jones, Jorge Ramirez
Jennifer Lee	Velocity distributions and fish use of engineered log jams	EISI Student 2011	2011	Desiree Tullos, Eugene Zhang, Matt Cox
John Vivio	Velocity distributions and fish use of engineered log jams	EISI Student 2011	2011	Desiree Tullos, Eugene Zhang, Matt Cox
Kristen Shearer	Velocity distributions and fish use of engineered log jams	EISI Student 2011	2011	Desiree Tullos, Eugene Zhang, Matt Cox
Camila Matamala-Ost	Moths and Meadows	EISI Student 2011	2011	Julia Jones, Jorge Ramirez, Tom Dietterich, Weng-Keen Wong
Christopher Mattioli	Moths and Meadows	EISI Student 2011	2011	Julia Jones, Jorge Ramirez, Tom Dietterich, Weng-Keen Wong
Elizabeth Cowdery	Moths and Meadows	EISI Student 2011	2011	Julia Jones, Jorge Ramirez, Tom Dietterich, Weng-Keen Wong
Grace Zalenski	Moths and Meadows	EISI Student 2011	2011	Julia Jones, Jorge Ramirez, Tom Dietterich, Weng-Keen Wong

Name	Project	Job Type	Year	PI-employer
Roy Adams	Moths and Meadows	EISI Student 2011	2011	Julia Jones, Jorge Ramirez, Tom Dietterich, Weng-Keen Wong
Ryan Smith	Moths and Meadows	EISI Student 2011	2011	Julia Jones, Jorge Ramirez, Tom Dietterich, Weng-Keen Wong
Ashe, Sean	Phenology Birds Project	undergraduate worker	2011	Matthew Betts, Sarah Frey, Adam Hadley, Mark Schulze
Bartelt, April	Phenology Birds Project	undergraduate worker	2011	Matthew Betts, Sarah Frey, Adam Hadley, Mark Schulze
Pacelli, Ashley	Phenology Birds Project	undergraduate worker	2011	Matthew Betts, Sarah Frey, Adam Hadley, Mark Schulze
Villar, Marcel	Phenology Birds Project	undergraduate worker	2011	Matthew Betts, Sarah Frey, Adam Hadley, Mark Schulze
Cole, Tristan	REU Site Program on Pollination Biology at OSU	REU	2011	Andy Moldenke, Sandy DeBano, Sujaya Rao
Gundersen, Knute	REU Site Program on Pollination Biology at OSU	REU	2011	Andy Moldenke, Sandy DeBano, Sujaya Rao
Kanaski, Alina	REU Site Program on Pollination Biology at OSU	REU	2011	Andy Moldenke, Sandy DeBano, Sujaya Rao
Koch, Katie	REU Site Program on Pollination Biology at OSU	REU	2011	Andy Moldenke, Sandy DeBano, Sujaya Rao
Kronin, Alyssa	REU Site Program on Pollination Biology at OSU	REU	2011	Andy Moldenke, Sandy DeBano, Sujaya Rao
Luttermoser, Tim	REU Site Program on Pollination Biology at OSU	REU	2011	Andy Moldenke, Sandy DeBano, Sujaya Rao
Monier, Samantha	REU Site Program on Pollination Biology at OSU	REU	2011	Andy Moldenke, Sandy DeBano, Sujaya Rao
Tiffany Harper	REU Site Program on Pollination Biology at OSU	REU	2011	Andy Moldenke, Sandy DeBano, Sujaya Rao
Wilson, Stephanie	REU Site Program on Pollination Biology at OSU	REU	2011	Andy Moldenke, Sandy DeBano, Sujaya Rao
Yerby, Val	REU Site Program on Pollination Biology at OSU	REU	2011	Andy Moldenke, Sandy DeBano, Sujaya Rao
Vargas, Stephanie	Water isotopes in WS1 & WS10	undergraduate worker	2011	Kate Lajtha
Chris Miles	Wood Dynamics	EISI Student 2011	2011	Desiree Tullos, Eugene Zhang, Matt Cox
Olivia Miller	Wood Dynamics	EISI Student 2011	2011	Desiree Tullos, Eugene Zhang, Matt Cox
Sophia Potoczak	Wood Dynamics	EISI Student 2011	2011	Desiree Tullos, Eugene Zhang, Matt Cox

VI.C.3. Masters and PhD Students. The Andrews Forest LTER program provides a rich training ground for graduate students. Through the program, students are given an opportunity to connect into multiple networks, work across disciplines with other Andrews Forest students and scientists, gain experience in scientific leadership, learn about the application of ecosystem science to natural resource policy through our research-management partnership, gain access to resources such as funding, equipment, long-term data sets and expertise, and see their science within to broader context afforded by an LTER site and the LTER network. Through the Information Management team, graduate students are given training on metadata and data management. Data from Andrews Forest graduate students is put into the Andrews Forest Databank when the student graduates. On average, about ten students associated with the Andrews program complete an MS or PhD degree each year. The number of students active in the program is currently about 40. The list of graduate students currently involved with the program is at http://andrewsforest.oregonstate.edu/lter/personnel/members.cfm?directory=grad&topnav=19

Table V1.C.3. Andrews Forest LTER Graduate Students, Theses and Dissertation Titles, 2006 – Present.

Name	Graduation Year	Thesis/Dissertation Title
Brewer, Elizabeth	2011	Response of soil microbial communities and nitrogen cycling processes to changes in vegetation inputs (Ph.D.)
Hatcher, Kendra	2011	Interacting effects of climate, forest dynamics, landforms, and river regulation on streamflow trends since 1950: examples from the Willamette Basin and forested headwater sites in the US (M.S.)
Highland, Steven	2011	The historic and contemporary ecology of western Cascade meadows: archeology, vegetation, and macromoth ecology (Ph.D.)
Inman, Tim	2011	Local Perceptions of Social-Ecological Change on the McKenzie: Implications for Resilience (M.S.)
Manore, Carrie	2011	Non-spatial and spatial models for multi-host pathogen spread in competing species with applications to BYDV and rinderpest (M.S.)
Smoluk, Alexis	2011	Geographic Distributions of Prey of the Northern Spotted Owl in the Central West Cascades, Oregon, 1988-2009 (M.S.)
Czarnomski, Nicole	2010	Influence of vegetation on streambank hydraulics (Ph.D.); Effects of harvest and roads on in-stream wood abundance in the Blue River Basin, western Cascades, Oregon (MS 2003)
Frentress, Jason	2010	Stream DOC, nitrate, chloride and SUVA response to land use during winter baseflow conditions in sub-basins of the Willamette River Basin, OR (M.S.)
Haugo, Ryan	2010	Causes and consequences of conifer invasion into Pacific Northwest grasslands (PhD);Vegetation responses to conifer encroachment in a dry, montane meadow: a chronosequence approach (MS 2006)
Huff, Julie	2010	Monitoring river restoration using fiber optic temperature measurements in a modeling framework (M.S.)
Jenkins, Stephanie	2010	Post-breeding habitat selection by songbirds in the headwaters of the Trask River, northwestern Oregon (M.S.)
Kluber, Laurel	2010	Microbial and biochemical dynamics of ectomycorrhizal mat and non-mat forest soils (Ph.D.)
McFadden, Andrew	2010	Effects of Stand Thinning on Soil Erosion Rates at Jim's Creek in the Willamette National Forest, Oregon (M.S.)
Moore, Kathleen M.	2010	Trends in streamflow from old growth forested watersheds in the western Cascades (M.S.)
Moore, Sean	2010	The effects of community composition, landscape structure, and climate on host-pathogen interactions (Ph.D.)
Rebar, Bryan	2010	Evidence, explanations, and recommendations for teachers' field trip strategies (Ph.D.)
Rice, Janine	2010	Forest-meadow dynamics in the central western Oregon Cascades: topographic, biotic, and environmental change effects (Ph.D.)
Roth, Travis	2010	Headwater stream characterization: an energy and physical approach to stream temperature using distributed temperature sensing (M.S.)
Tepley, Alan	2010	Age structure, developmental pathways, and fire regime characterization of Douglas-fir/western hemlock forests in the central western Cascades of Oregon (Ph.D.)
Adams, Jeremy	2009	Soil Transport on a Forested Hillslope: Quantifying Baseline Rates of Surface Erosion, Jim's Creek, Willamette National Forest, Oregon (M.S.)
Barnard, Holly	2009	Inter-relationships of vegetation, hydrology and micro-climate in a young, Douglas-fir forest (Ph.D.)
Burrows, Elizabeth	2009	Optimization of environmental conditions and electron flow for enhanced hydrogen production by cyanobacterial species Synechocystis sp. PCC 6803 (Ph.D.)
Graham, Christopher	2009	A macroscale measurement and modeling approach to improve understanding of the hydrology of steep, forested hillslopes (Ph.D.)

Name	Graduation Year	Thesis/Dissertation Title
Hoshaw, Robert	2009	The contribution of reflective writing to ecological awareness at the H.J. Andrews Experimental Forest (M.S.)
Kayler, Zachary	2009	The methodology, implementation,and analysis of the isotopic composition of soil respired CO2 in forest ecological research (Ph.D.)
Mitchell, Stephen	2009	The effects of forest fuel reduction on fire severity and long-term carbon storage (Ph.D.)
Phillips, Claire	2009	Distinguishing biological and physical controls on soil respiration (Ph.D.)
Rasmussen, Janet	2009	Reactive polyphenols and dissolved nitrogen in a nitrogen-limited headwater catchment, Western Cascades, Oregon, USA (M.S.)
Sierra, Carlos	2009	Environmental variability and system heterogeneity in terrestrial biogeochemical models (Ph.D. 2009); Spatial and temporal variability of carbon dynamics in a tropical forest of Colombia (MS 2006)
van Huysen, Tiffany	2009	Nitrogen and phosphorus dynamics during decomposition of multiple litter types in temperate coniferous forests (Ph.D.)
Yamamuro, Asako	2009	Aquatic insect adaptations to different flow regimes (Ph.D.)
Arthur, Aaron	2008	Thirty-five years of forest succession in southwest Oregon: Vegetation response to three distinct logging treatments (M.S.)
Blanchard, Joseph	2008	Episodic dynamics of microbial communities associated with the birth and death of ectomycorrhizal mats in old-growth Douglas-fir stands (M.S.)
Collier, Mike	2008	Demonstration of fiber optic distributed temperature sensing to differentiate cold water refuge between ground water inflows and hyporheic exchange (M.S.)
Compagnoni, Aldo	2008	Controls on Plant Species Invasions During Early Secondary Succession: The Roles of Plant Origin and Community Properties (M.S.)
Dailey, Michele	2008	Meadow Classification in the Willamette National Forest and Conifer Encroachment Patterns in the Chucksney-Grasshopper Meadow Complex, Western Cascade Range, Oregon. (M.S.)
Diaz, David	2008	Carbon cycling and priming of soil organic matter decomposition in a forest soil following glucose additions (M.S.)
Drake, Timothy	2008	Empirical modeling of windthrow occurrence in streamside buffer strips (M.S.)
Perry, Timothy	2008	Do vigorous young forests reduce streamflow? Results from up to 54 years of streamflow records in eight paired-watershed experiments in the H. J. Andrews and South Umpqua Experimental Forests (M.S.)
Sebestyen, Stephen	2008	Coupled hydrological and biogeochemical processes that control stream nitrogen and dissolved organic carbon at the Sleepers River Research Watershed
Dereszynski, Ethan	2007	A probabilistic model for anomaly detection in remote sensor streams (M.S.)
Licata, Julian	2007	Structural and physiological changes with stand age : use of a process-based model to compare carbon and water fluxes in young and old-growth Douglas-fir/western hemlock forest stands (Ph.D.)
Sobota, Daniel	2007	Linkages among Land Use, Riparian Zones, and Uptake and Transformation of Nitrate in Stream Ecosystems (PhD 2007);Fall directions and breakage of riparian trees along streams in the Pacific Northwest (MS 2003)
van Verseveld, Willem	2007	Hydro-biogeochemical coupling at the hillslope and catchment scale (Ph.D.)
Yarwood, Stephanie	2007	The link between nitrogen cycling and soil microbial community composition in forest soils of western Oregon (Ph.D.)
Benton, Bree	2006	LTER and SMILE Activity Notebook (Masters Project)
Crow, Susan	2006	Characteristics of soil organic matter in two forest soils (Ph.D.)
Frady, Charles	2006	Headwater stream macroinvertebrates of the H. J. Andrews Experimental Forest, Oregon (M.S.)
Hauck, Mark	2006	Isotopic composition of respired CO2 in a small watershed : development and testing of an automated sampling system and analysis of first year data (MS)
Jefferson, Anne	2006	Hydrology and evolution of High Cascades basaltic landscapes, McKenzie River basin, Oregon (Ph.D.)

Name	Graduation Year	Thesis/Dissertation Title
Lang, Nicole	2006	The soil seed bank of an Oregon montane meadow: consequences of conifer encroachment and implications for restoration (MS)
LaNier, Justin	2006	Changes in Hyporheic Exchange Flow Following Experimental Large Wood Removal in a Second Order, Low Gradient Stream, Chichagof Island, AK (MS)
Mallon, Angela	2006	Public acceptance of disturbance-based forest management: a study of the attentive public in the Central Cascades Adaptive Management Area (M.S.)
Mazurkiewicz, Adam	2006	Measurement and modeling the physical controls of snowmelt in the Pacific Northwest (MS)
Sheehy, Samantha	2006	Exotic Plant Species Dynamics from 1994 to 2005 on Road Networks in Forested Landscapes of Western Oregon (MS)

VI.C.4. Andrews LTER Graduate Student Research Awards

The Andrews Forest Graduate Research Grant Program provides mini-grants ($5K each) to support graduate students whose research is either 1) conducted at the HJ Andrews Experimental Forest, or 2) relevant to current Andrews Forest LTER goals, or 3) uses Andrews Forest data. Proposals from students are reviewed by the Andrews LTER Executive Committee. The 2010 awards went to Scott Allen, for his work in interpreting the isotopic signature of water vapor in a complex forested terrain, and Ricardo Gonzalez for his work in scaling metabolic processes in stream ecosystems (Fig VI.C.4). Gonzales reports, "The H.J. Andrews Graduate Research Grant is helping me to investigate how geomorphology controls stream respiration. With the grant, I have been able to plan detailed experiments that will combine information from two streams with different hydraulic conditions. These experiments are part of my Ph.D. dissertation that includes other research sites in Wyoming, Virginia and Catalonia."

Fig VI.C.4. Andrews LTER Graduate Student Research Awardee, Ricardo Gonzales, at Watershed 3 in the Andrews Forest.

VI.C.5. Andrews LTER Graduate Student GRA Support Awards

The Andrews LTER Graduate Student GRA Support Awards provide full graduate student support (stipend and tuition for MS or PhD) for one full year at OSU for each student and are awarded on a competitive basis. The students' work must be closely associated with the Andrews Forest program (conducted at the HJ Andrews Experimental Forest and/or making use of Andrews Forest data). The purpose of the award is to encourage new student research and to provide an incentive to bring new PIs into the Andrews LTER program. Proposals are submitted by a student's major professor and are reviewed by the Andrews Forest LTER Executive Committee. The 2010 GRA awards went to Warren Cohen for support of his student, Kevin Briggs, and his research titled, "Remote Sensing of Vegetation Phenology to Monitor Post-disturbance Succession and Study Interactions of Topography & Climate Change Effects," and to Ron Metoyer for support of his student, Tuan Pham, and his research titled, "Interactive Visualization of Spatial and Temporal Patterns of Diversity and Abundance in Ecological Data."

VI.C.6. EcoInformatics IGERT. AND has been the "home base"of an Integrative Graduate Education and Research Traineeship (IGERT) program in Ecosystem informatics, funded by NSF from 2003-2011. The leaders are Julia Jones, PI, Tom Dietterich (Computer Science), Enrique Thomann (Mathematics), Ed Waymire (Mathematics), and Mark Harmon, co-PIs, 2003-2011). The IGERT has funded 30 PhD students from 12 graduate programs at OSU. Projects must involve collaboration and paper-writing with a minor professor from a different discipline (e.g., mathematics for an ecology major). More than 20 of these students have successfully defended and have obtained employment as post-docs, in industry, or work in state and federal agencies. For more information about this program please see http://ecoinformatics.oregonstate.edu/.

VI.C.7. Environmental Leadership Program. The Environmental Leadership Program (ELP) is a collaborative, interdisciplinary service-learning program housed in the University of Oregon's Environmental Studies Program. Among their many projects is a long-standing partnership with AND for yearly Canopy Connections experience for middle school students (above). A new group of ELP students plans and delivers the educational part of the experience. Kathryn Lynch of the ELP leads this project. For more about the ELP see http://envs.uoregon.edu/elp_program/.

VI.C.8. Ruth Spaniol Writing Retreats for Graduate Students. The lead PI of the AND LTER, Barbara Bond, holds an endowed chair position through the OSU College of Forestry that comes with a small allocation of funds that is to be used primarily for educational purposes. Bond uses these funds, in part, to support 1-week writing retreats for students at the Andrews Forest. Students submit a proposal that explains the nature of the writing project as well as a final report afterwards. The fund pays for lodging and travel. During LTER6 four graduate students have received awards for these writing retreats: Erin Hooten who was working on an MS in Forest Genetics, Sean Moore, who was writing up his PhD in Zoology, and Jenny Dauer and April Melvin who used the retreat to focus on their collaboration on a review paper to quantify calcium fertilization effects on carbon and nitrogen cycling in forest ecosystems.

VI.C.9. Undergraduate/graduate classes and courses. A large number of classes and field courses are conducted partly or wholly at the HJA every year. For the 2010 calendar year there were 16 classes and 394 undergraduates. Courses offered by several institutions in our region use the Andrews site for a field component of a larger course. An example is the Lewis & Clark HHMI collaborative research program, led by Anne Jourdan of Lewis and Clark. A group of about 20 undergraduate and 10 high school students visited Andrews Forest June 24-26, 2011 for a "community-building exercise" that kicks off their summer program. The HHMI Collaborative Research Program (CRT), which is designed to broaden access to science, is structured around the idea of laddered research teams: each three-person team consists of a faculty member, a Lewis & Clark science major, and a high school or community college student. The primary aim is to provide students with a rigorous, lab-based experience emphasizing the collaborative nature of scientific research. In other words, participants explore what a future career as a scientist or mathematician might be like. Three graduate students from the Andrews LTER participated in the program: Steve Highland (moths), Scott Allen (ecohydrology) and Samantha Colby (arthropods). Anne Jourdan said the Andrews students "were very knowledgeable engaging educators and really provided an excellent learning experience for their teams (including the L & C faculty participants). They all contributed both as educators and community builders, joining us for activities and meals."

VI.D. EDUCATION/OUTREACH CLOSE-UPS: OUTREACH AND CONTINUING EDUCATION

VI.D.1. Post-doctoral trainees

During LTER6 there have been several post-doctoral trainees involved with the program:

Ivan Arismendi, a Postdoctoral Fellow from Chile, has worked with Sherri Johnson, Jason Dunham, and Roy Haggerty on the analysis of regional stream temperatures and development of metrics of thermal regimes (Fig. VI.D.1.).

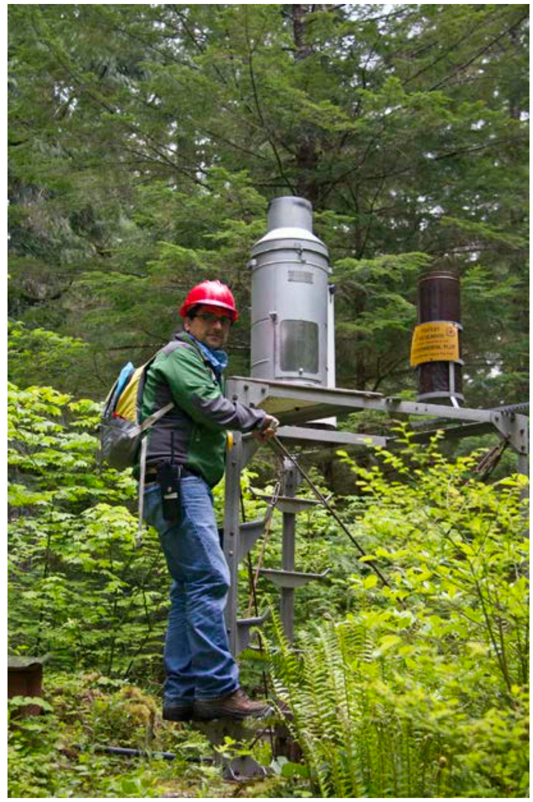

Figure VI.D.1. Post-doctoral Fellow, Ivan Arismendi, at the Watershed 2 climate station at the Andrews Forest.

Alba Argerich, a Postdoctoral Researcher from Spain, has been working with Sherri Johnson and USFS colleagues to synthesize trends in long-term stream chemistry and responses to disturbances

Effie Greathouse, a Research Associate, has been working with Sherri Johnson and the Andrews IM team on the development of the StreamChemDB database and harvester.

Rupert Seidl, was a visiting postoc (2009-2011) from the University of Natural Resources and Applied Life Sciences (BOKU) in Vienna, Austria. He developed an integrated, multi-scale, forest landscape model that we are now using to explore effects of distrubancves and climate change on forest ecosystems. http://iland.boku.ac.at/team

Anne Mezaka, a postdoctoral trainee from Latvia, has been working with long-term Andrews PI, Bruce McCune, to establish a transplant experiment to understand the influence of elevation on establishment success of a suite of epiphytic species.

VI.D.2. On-site courses, tours, workshops and meetings

The Andrews has become an important outdoor classroom for Ecology, Forestry, Hydrology, and Biology students from the Pacific Northwest. Classes from as far away and Japan and Quebec have also visited the Andrews Forest for field courses. We are beginning to expand the scope of onsite education, as evidenced by the OSU Philosophy field courses held in 2010 and 2011. During the first three years of LTER6, 18 colleges and universities held field courses at the Andrews Forest. In addition, each summer OSU has held Pollination Biology and Ecosystem Informatics REU programs, providing opportunities to 24-30 students from around the country.

Table VI.D.2.1. University and College Courses at the H.J. Andrews Experimental Forest, January 2008 – June 2011.

School	Class	Year
Central Oregon Community College	Dendrology	2008
Chemeketa Community College	Environmental Science	2008
Lewis & Clark College	Ecology	2008
Oregon State University	Field Hydrology (FE 538)	2008
Oregon State University	Snow Hydrology (GEO 483/583)	2008
Portland State University	Ecology	2008
Purdue University	Sustainability of Natural Resource Management	2008
University of Oregon	Ecology	2008
University of Oregon	Forest Biology	2008
University of Oregon	Mycology	2008
University of Washington	Ecosystem Management	2008
Willamette University	Forest Ecology and Policy	2008
Central Oregon Community College	Dendrology	2009
Chemeketa Community College	Environmental Science	2009
Hokkaido University, Japan	Forestry	2009
Lane Community College	Forest Biology	2009
Lewis & Clark College	Ecology	2009
Nihon University, Japan	Forestry	2009
Oregon State University	Field Geography of Oregon (GEO534)	2009
Oregon State University	Field Hydrology (FE 538)	2009
Oregon State University	Geomorphology & Landscape Ecology (GEO548)	2009
Portland State University	Ecology	2009
Portland State University	Ecology	2009
Portland State University	Ecology	2009
Portland State University	Methods in Field Ecology	2009
Reed College	Outdoor Recreation	2009
University of Oregon	Ecology	2009
University of Oregon	Forest Biology	2009
University of Oregon	Geology	2009
Western Oregon University	Ecology	2009
Albion College	Forest Policy	2010
Central Oregon Community College	Dendrology	2010
Chemeketa Community College	Environmental Science	2010
Hokkaido University, Japan	Forestry	2010
Lewis & Clark College	Ecology	2010
Nihon University, Japan	Forestry	2010
Oregon State University	Field Geography of Oregon (GEO534)	2010
Oregon State University	Geomorphology & Landscape Ecology (GEO548)	2010
Oregon State University	Philosophy of Nature	2010
Portland State University	Ecology	2010
Portland State University	Ecology	2010

School	Class	Year
University of Oregon	Ecology	2010
University of Oregon	Entomology	2010
University of Oregon	Forest Biology	2010
University of Quebec	Forestry	2010
Willamette University	Ecology	2010
Central Oregon Community College	Dendrology	2011
Chemeketa Community College	Biology	2011
Lewis & Clark College	Ecology	2011
Lewis & Clark College	Ecology Research Camp	2011
Nihon University, Japan	Forestry	2011
Oregon State University	Hatfield Marine Science Center REU study tour	2011
Oregon State University	Practical Reasoning	2011
Portland State University	Ecology	2011
The Evergreen State College	Field Ecology	2011
The Evergreen State College	MES Statistics	2011
University of Wisconsin - Platteville	Ecology & Landscapes	2011

Andrews Forest Researchers and Staff provide tours and field lectures to diverse audiences, including students, visiting researchers, forest managers and the interested general public. Tours are tailored to the interests of the group, providing overviews of the research program, and explaining ecosystem processes, disturbance history and forest management. We average close to 50 tours per year, reaching more than 1,000 participants.

Table VI.D.2.2. Research, Education and management tours held at the H.J. Andrews Experimental Forest, January 2008 – June 2011.

Year	Tours	Participants
2008	32	1,023
2009	53	913
2010	59	1,130
2011	28	668

The Andrews Field Station is used for regional and international workshops and conferences. The field station hosts several management workshops each year in conjunction with the Willamette National forest and the Central Cascades Adaptive Management Partnership. We also hosted a number of research conferences, including several funded through the LTER Network Office. In 2010, we hosted the Mountain Climate Research Conference, an international gathering of researchers studying climate and climate change in mountainous environments. The conference theme was closely linked to current Andrews LTER research objectives, and Andrews researchers gave several presentations at the event.

As the scope of the Andrews Forest Program expands, the facility is seeing new and diverse user groups: humanities and philosophy gatherings, community development workshops, K-12 teacher training, and a recent Network of Oregon Watershed Councils conference.

Table VI.D.2.3. Workshops and conferences held at the H.J. Andrews Experimental Forest, January 2008 – June 2011

Workshop	Year	Participants
Blue River Writers Gathering	2008	35
Carbon Management Workshop, OSU	2008	60
Ecosystem Informatics IGERT Boot Camp, OSU	2008	18
Fiber Optic DTS for Ecological Characterization, OSU	2008	50
Forest Ecosystems & Society Orientation, OSU	2008	30
Forest Resource Dept Re-organization Celebration, OSU	2008	15
Institutes for Environmental Journalism	2008	26
ONREP Teachers as Researchers Workshop	2008	35
ONREP Teachers as Researchers Workshop	2008	20
Teaching Ecological Complexity, PSU	2008	12
The Ford Family Foundation Community Leadership Program (1)	2008	35
Thinking Through Nature Conference - University of Oregon	2008	25
Three Station Climateers - Pacific Northwest Research Station	2008	32
US Geological Survey Conference on Science in OR and WA	2008	7
USFS Danger Tree Workshop	2008	60
Environmental Humanities Planning Workshop, OSU	2009	30
Forest Ecosystems & Society Orientation, OSU	2009	25
Northwest Botanical Institute Bryophyte Workshop	2009	13
ONREP Teachers as Researchers Workshop	2009	18
Region 6 USFS Digital Soil Mapping Workshop	2009	10
Teaching Ecological Complexity, PSU	2009	14
The Ford Family Foundation Community Leadership Program (2)	2009	35
USFS National Groundwater Conference Planning	2009	10
Young Stand Thinning & Diversity Tour & Workshop	2009	50
Blue River Landscape Study Planning Workshop	2010	25
Blue River Writers Gathering	2010	30
Bretz Conference (Geology), PNW Station	2010	50
Dragonfly Eyes	2010	30
Extension-Science Climate Change Workshop, OSU	2010	30
Forest Engineering, Resources & Management Orientation, OSU	2010	30
McKenzie River Ranger District Planning	2010	25
Minorities in Agriculture, Natural Resources and Related Sciences	2010	30
Modeling species response to climate change workshop, OSU	2010	18
MTNCLIM 2010 Mountain Climate Research Conference	2010	100
Northwest Botanical Institute Bryophyte Workshop	2010	12
ONREP Teachers as Researchers Workshop	2010	15
Pacific Northwest Research Station Communications	2010	16
PNW Water Resources Institute Workshop	2010	12
Stream Chemistry Database Workshop	2010	7
Teacher Counselor Education Workshop, OSU (1)	2010	16

Workshop	Year	Participants
Teacher Counselor Education Workshop, OSU (2)	2010	16
Teacher Counselor Education Workshop, OSU (3)	2010	16
The Ford Family Foundation Community Leadership Program (1)	2010	35
The Ford Family Foundation Community Leadership Program (2)	2010	35
Western Mountain Initiative, USGS, USFS & USPS	2010	30
Willamette Forest Leadership Team	2010	40
Bretz Conference (Geology), PNW Station	2011	40
LTER Humanities Working Group	2011	16
LTER Maps and Locals Workshop	2011	13
LTERMaps Internet Mapping Workshop	2011	10
ONREP Teachers as Researchers Workshop & Phenology Pulse	2011	15
Oregon Network of Watershed Councils Annual Workshop	2011	40
SMILE - Science and Math Investigative Learning Program, OSU	2011	45
The Ford Family Foundation Community Leadership Program (3)	2011	35
The Ford Family Foundation Community Leadership Program (4)	2011	35

VI.D.3. HJA Day HJA Day is the annual field gathering where we share information about research, education, and management at the HJ Andrews Experimental Forest LTER site. This year's event was held June 23, 2011, and featured field presentations from OSU Faculty, USFS PNW Scientists, and WNF staff. There were 140 attendees from a wide variety of organizations and agencies such as Oregon State University, the PNW Research Station, the Willamette National Forest, local watershed councils, the Environmental Protection Agency, citizens of the local McKenzie River community, and the Lane County Commissioner.

Figure VI.D.3. HJA Day is the annual field gathering at the Andrews Forest

VI.D.4. Research-Management Partnership. Research-management partnership activities are important to the Andrews Forest program because effects of land use on forests, streams, and landscapes are an important science focus to LTER, cooperation with land managers is essential to implementing large-scale studies, and members of the partnership share a commitment to using current science and other sources of information to develop new approaches to management that effectively meet public expectations. Important features of the partnership are long-term studies and experiments on landscape management and management of young plantation forests

The communications efforts of the research-management partnership include numerous field tours, short descriptions of applications of science findings in the land management setting, annual workshops for managers, longer publications outlining current management issues and related science findings and studies (science findings and communiques), and webpage descriptions of projects, findings, and adaptive management decisions. Communications are intended to benefit land manager users of the information, general public, students, educators, and decision makers.

These activities occur in the institutional contexts of the Cascade Center for Ecosystem Management (CCAMP), as we identified our research-management partnership in 1991, and the Central Cascades Adaptive Management Area, designated in the Northwest Forest Plan, which set Federal forest land management policy for the region in 1994.

The Andrews is part of other research management partnerships as well including the Effectiveness Monitoring Program of Region 6 of the Forest Service. This effort monitors long-term trends in vegetation and spotted owl populations across western Oregon, Washington and northern California. Andrews scientists contribute data and conduct monitoring research in support of this effort. For example, the Andrews is a demographic site for Northern Spotted Owl monitoring and a test bed for evaluating new monitoring techniques such as LiDAR.

The relationship that Andrews has with managers has itself become a subject of scientific investigation and publication:

Steel, B, P. List, D. Lach, and B. Shindler. 2004. The role of scientists in the environmental policy process: a case study from the American west. *Environmental Science & Policy* 7: 1-13.

Driscoll, C.T., K. F. Lambert, F.S. Chapin, III, D. Nowark, T.A. Spies, F.J. Swanson, D.B. Kittredge, Jr. and C.M. Hart. Submitted. Science and Society: The role of long-term studies in environmental stewardship. *BioScience*.

VI.D.5. Outreach Partnerships with Extension. In 2010 and 2011, the Andrews Forest Program initiated a strong partnership with the Forestry and Natural Resources Extension Program at Oregon State University, and this partnership is taking on a leadership role in stimulating collaboration across the larger Cooperative Extension and LTER networks. Dr. Brad Withrow-Robinson of OSU Forestry Extension and Dr. Mark Schulze, Andrews Forest Director, are leading the program. The goal is to use the communications expertise of Extension to provide a better link of communications between scientists and natural resource managers and other decisions makers, especially with respect to climate, climate change, and climate impacts on natural and managed ecosystems.

OSU Forestry Extension and AND co-hosted a week-long Climate Change Study Retreat at the Andrews Forest in August 2010 that was attended by 15 Extension educators and 11 LTER faculty. In each of 7 half-day science sessions researchers reviewed some relevant science on a wide range of topics, from climate science and modeling to projected impacts to forested systems in Oregon, The Retreat produced a set of actions and collaborative projects that will help build working relations while meeting shared objectives.

Nationally, Withrow-Robinson and Schulze are networking with other sites with similar Research-Extension partnerships (e.g., at Kellogg Biological Station) and facilitating conversations about a larger network of Research-Extension partners at national meetings. They presented these ideas at a National Workshop on Climate & Forests in May 2011 sponsored by the Society of American Foresters, and received very positive feedback from a number of research and extension colleagues. We will be presenting at the May 2012 Association of Natural Resource Extension Professionals conference in North Carolina, including a tour of the Coweeta LTER site. Our hope is to organize a working group for the 2012 LTER All Scientists Meeting to continue discussions on building a national network.

VII. Humanities

The engagement of the humanities in the Andrews Forest program, now nearly a decade long, doesn't fit neatly into any one category of activity in LTER6. It is part basic inquiry (basic humanities parallels basic science), part science journalism and public outreach, and in part an education effort. This lack of tidy fit with our goal/objective framework in no way diminishes the significance and potential impact of the Long-Term Ecological Reflections program. In the words of the mission statement of the Spring Creek Project for Ideas, Nature, and the Written Word, our humanities collaborators, we wish to: "bring together the practical wisdom of the environmental sciences, the clarity of philosophical analysis, and the creative, expressive power of the written word, to find new ways to understand and re-imagine our relation to the natural world."

Figure VII.1. Environmental philosophers, watershed scientists, poets, and medical ethicists gather in the Andrews Forest to discuss the meaning of "watershed health" in a Reflections field symposium.

Progress report for LTER6:

Long-Term Ecological Reflections is a collaboration among the Andrews Forest Long-Term Ecological Research group; the USDA Forest Service; and the Spring Creek Project, a privately-endowed program in the Department of Philosophy, Oregon State University. Like the National Science Foundation's Long-Term Ecological Research program on which it is modeled, the Long-Term Ecological Reflections program gathers reflections for generations, assembling a long-term record of changing creative responses to an ever-changing landscape and its societal context. The program is composed of these parts:

- Two Writers-in-Residence Programs: Blue River Fellowships for writers, by invitation, and Andrews Forest writer residencies, by application. Writer residencies are for creative writers whose work reflects a keen awareness of the natural world.
- **Forest Log***: An on-line journal of poems, essays, articles and other creative reflections on the Forest* presents draft and published works of the writers in residents and other participants in the Reflections program.
- Special Events: Long-Term Ecological Reflections sponsors occasional field symposia and public events that bring together writers, scientists, and humanists to explore the relation of humans to the rest of nature. Themes have included: New Metaphors of Restoration of Forests and Watersheds; The Meaning of Watershed Health; Cataclysms and Renewal: Lessons from Mount St. Helens (Fig. VII.1).
- Our findings from nearly a decade of collaboration with the humanities concern both the program and the resulting reflective thought. The idea of this unusual collaboration and the resulting works have been greeted with great enthusiasm – the writers love to come to the forest and appreciate the chance to interact with scientists; critical parts of our institutional homes, the US Forest Service, Oregon State University, and the National Science Foundation, have supported the program; public events have been well attended; the Andrews Forest science community has invested time and energy in the program; and other LTER and similar sites are beginning this type of work, though in quite different ways (e.g., Bonanza Creek LTER (Alaska) is strong on

performance arts and North Temperate Lakes (Wisconsin) emphasizes visual arts). In terms of the broader reach of this work, we hosted a workshop sponsored by the LTER Network Office at Andrews Forest in May 2011 involving a dozen LTER sites plus two other programs to discuss engagement of arts and humanities with place-based environmental science and to begin forming a network of such sites and programs for mutual support and enhanced outreach. Inter-site collaborative work is going forward with webpage development and other actions.

- Work of the writers in residence has touched on many themes, despite visiting the same small number of sites – the Reflection plots, selected to represent a range of forest experiences and also to give some common threads of experience across the now nearly 40 writers. The 200-year log decomposition experiment site set in a 500-year-old forest has been a favorite Reflection plot, where writers have sensed research that honors the dead and have viewed the commitment to studies that far exceed the lifetime of researchers as an expression of hope and humility, terms scientists would not use to describe their own work. Other topics include differences in the ways artists and scientists view the world and fascinating, though obscure relationships within the forest – nitrogen-fixing lichens and the interplay of spotted owls and barred owls. Writers speak of the losses we expect with climate change, yet find some hope in reflecting on the challenge the 500-year-old trees have weathered. The writings have appeared in high profile outlets, such as Orion and *The Atlantic*. We frequently read from these works in presentations about the forest.

People:

- PI(s): Frederick J. Swanson, Kathleen Dean Moore, Charles Goodrich
- Key Personnel: Nathaniel Brodie

Links:

http://andrewsforest.oregonstate.edu/research/related/writers.cfm?topnav=167

Selected Publications

Buntin, S.B. 2010. Dirty words on Mount St. Helens. Terrain.org. Fall/Winter (Issue 26). http://www.terrain.org/columns/26/buntin.htm.

Deming A.H. 2011. Attending to the Beautiful Mess of the World. 174-186. *In*: T. L. Fleischner (ed.). 2011. The Way of Natural History. Trinity University Press. San Antonio, TX.

Gastreich, K. 2011. Reflections from the Spring 2011 Writers Residency Andrews Forest Long Term Ecological Reflections Project:

Goodrich, C.; Moore, K. D.; Swanson, F. J. (eds). 2008. In the blast zone: catastrophe and renewal on Mount St. Helens. Corvallis, OR: Oregon State University Press. 124 p.

Hirshfield, J. 2010. Wild Ginger – Coda. Orion. p. 80.

Hirshfield, J. 2011. Lichens (poem). The Atlantic. p. 57.

Kimmerer, RW. 2011. Witness to the rain. 187-195. *In*: T. L. Fleischner (ed.). The Way of Natural History. Trinity University Press. San Antonio, TX.

Moore KD, Nelson MP (eds). 2010. Moral Ground: ethical action for a planet in peril. Trinity University Press. San Antonio, Texas. 478 p.

Moseman, MA. 2010. Variable poetic cruise: Andrews Experimental Forest.
http://www.trickhouse.org/vol11/experiment/loriandersonmoseman/indexa.htm

Nisbet, M.C.; Hixon, M.A.; Moore, K.D.; Nelson, M. 2010. Four cultures: new synergies for engaging society on climate change. Frontiers in Ecology and the Environment. 8: 329-331.

Peterson B. 2011. blog postings from period as writer-in-residence:

Sanders, S.R. 2009. Two Stones. 59-68. *In*: A Conservationist Manifesto. Indiana University Press, Bloomington.

Sanders, S.R. 2011. Mind in the forest: an intimate encounter with really old trees. Orion. November/December: 48-53. [winner of the 2010 Burroughs Society Medal for best nature essay of the year]
Sanders, S.R. 2011. Mind in the Forest. 196-212. *in*: T. L. Fleischner (ed.). The Way of Natural History. Trinity University Press. San Antonio, TX.
Swanson, F. J.; Goodrich, C.; Moore, K. D. 2008. Bridging boundaries: scientists, creative writers, and the long view of the forest. Frontiers in Ecology and the Environment. 6(9): 449-504.
Yake, B. Slough, Decay, and the Odor of Soil (poem). p. 24. Windfall: A Journal of Poetry of Place. Spring 2011.

For a list and links to writings by participating writers, including unpublished work, go to:
http://andrewsforest.oregonstate.edu/research/related/writers/template.cfm?next=wir&topnav=169

Additional writings are at:

http://andrewsforest.oregonstate.edu/research/related/writers/template.cfm?next=writings&topna

APPENDIX 1. PUBLICATIONS FROM THE AND DURING LTER6

LTER6 Pubs (as of 7/13/11)
A searchable bibliography is available on the Andrews Forest Website
http://andrewsforest.oregonstate.edu/lter/pubs.cfm?frameURL=http://andlter.forestry.oregonstate.edu/ltermeta/ltersearch/Bibliography.aspx?topnav=11

Books

Coleman, David C. 2010. Big ecology: the emergence of ecosystem science. Berkeley, CA: University of California Press. 236 p.

Deming, Alison H. 2011. Attending to the beautiful mess of the world. In: Fleischner, Thomas L., ed. The way of natural history. San Antonio, TX: Trinity University Press: 174-186.

Eisenberg, Cristina. 2010. The long view: old-growth rain forest food webs. In: Eisenberg, Cristina. The wolf's tooth: keystone predators, trophic Cascades, and biodiversity. Washington, DC: Island Press: 109-142. Chapter 5.

Johnson, K. Norman; Swanson, Frederick J. 2009. Historical context of old-growth forests in the Pacific Northwest--policy, practices, and competing worldviews. In: Spies, Thomas A.; Duncan, Sally L., eds. Old growth in a new world: a Pacific Northwest icon reexamined. Washington, DC: Covelo, CA: Island Press: 12-28. Chapter 2.

Kimmerer, Robin W. 2011. Witness to the rain. In: Fleischner, Thomas L., ed. The way of natural history. San Antonio, TX: Trinity University Press: 187-195.

Sanders, Scott R. 2011. Mind in the forest. In: Fleischner, Thomas L., ed. The way of natural history. San Antonio, TX: Trinity University Press: 196-212.

Skyrm, Kimberly M. 2009. SMILE: Elementary outdoor science adventure (EOSA). Corvallis, OR: Smile, Oregon State University. 37 p.

Swanson, Frederick J.; Chapin, F. Stuart III. 2009. Forest systems: living with long-term change. In: Chapin, F. Stuart III; Kofinas, Gary P.; Folke, Carl, eds. Principles of ecosystem stewardship: resilience-based natural resource management in a changing world. New York, NY: Springer: 149-170.

Conference Proceedings

Briggs, Forrest; Raich, Raviv; Fern, Xiaoli Z. 2009. Audio classification of bird species: a statistical manifold approach. In: Proceedings of the Ninth IEEE international conference on data mining: 51-60.

Dietterich, Thomas G. 2009. Machine learning and ecosystem informatics: challenges and opportunities. In: Zhou, Zhi-Hua; Washio, Takashi, eds. Advances in machine learning--first Asian conference on machine learning, ACML 2009. Lecture Notes in Artificial Intelligence 5828. Springer-Verlag: 1-5.

Dietterich, Thomas G. 2009. Machine learning in ecosystem informatics and sustainability. In: Proceedings of the twenty-first international joint conference on artificial intelligence (IJCAI09): 8-13.

Gooseff, Michael N.; Wondzell, Steven M.; McGlynn, Brian L. 2008. On the relationships among temporal patterns of evapo-transpiration, stream flow and riparian water levels in headwater catchments during baseflow. In: Proceedings of 36th IAH Congress: Integrating groundwater science and human well-being: 842-851.

Hutchinson, R. A.; Liu, L.-P.; Dietterich, T. G. [In press]. Incorporating boosted regression trees into ecological latent variable models. In: Proceedings of the 2011 conference of the Association for the Advancement of Artificial Intelligence.

Neal, Lawrence; Briggs, Forrest; Raich, Raviv; Fern, Xiaoli. 2011. Time-frequency segmentation of bird song in noisy acoustic environments. In: Proceedings of the 2011 International conference on acoustics, speech and signal processing: 2012-2015.

Yu, Jun; Wong, Weng-Keen; Dietterich, Tom; Jones, Julia; Betts, Matthew; Frey, Sarah; Shirley, Susan; Miller, Jeffrey; White, Matt. 2011. Multi-label classification for multi-species distribution modeling. In: Proceedings of the 28th international conference on machine learning. International Machine Learning Society: http://www.icml-2011.org/index.php.

Dissertations/Theses

Argerich, Alba. 2010. Hydrological and geomorphological controls on stream nutrient retention. Barcelona, Spain: Universitat de Barcelona. 178 p [plus annex]. Ph.D. dissertation.

Barnard, Holly Rene. 2009. Inter-relationships of vegetation, hydrology and micro-climate in a young, Douglas-fir forest. Corvallis, OR: Oregon State University. 126 p. Ph.D. dissertation.

Brewer, Elizabeth Ann. 2010. Response of soil microbial communities and nitrogen cycling processes to changes in vegetation inputs. Corvallis, OR: Oregon State University. 114 p. Ph.D. dissertation.

Frentress, Jay. 2010. Stream DOC, nitrate, chloride and SUVA response to land use during winter baseflow conditions in sub-basins of the Willamette River basin, OR. Corvallis, OR: Oregon State University. 93 p. M.S. thesis.

Graham, Christopher Brian. 2008. A macroscale measurement and modeling approach to improve understanding of the hydrology of steep, forested hillslopes. Corvallis, OR: Oregon State University. 158 p. Ph.D. dissertation.

Hatcher, Kendra L. 2011. Interacting effects of climate, forest dynamics, landforms, and river regulation on streamflow trends since 1950: examples from the Willamette Basin and forested headwater sites in the US. Corvallis, OR: Oregon State University. 239 p. M.S. thesis.

Haugo, Ryan D. 2010. Causes and consequences of conifer invasion into Pacific Northwest grasslands. Seattle, WA: University of Washington. 187 p. Ph.D. dissertation.

Highland, Steven A. 2011. The historic and contemporary ecology of western Cascade Meadows: archeology, vegetation, and macromoth ecology. Corvallis, OR: Oregon State University. 354 p. Ph.D. dissertation.

Hoshaw, Robert M. 2009. The contribution of reflective writing to ecological awareness at the H.J. Andrews Experimental Forest. Eugene, OR: University of Oregon. 94 p. M.S. thesis.

Huff, Julie A. 2009. Monitoring river restoration using fiber optic temperature measurements in a modeling framework. Corvallis, OR: Oregon State University. 124 p. M.S. thesis.

Inman, Timothy B. 2011. Local perceptions of social-ecological change on the McKenzie: implications for resilience. Corvallis, OR: Oregon State University. 156 p. M.P.P. essay.

Kayler, Zachary Eric. 2008. The methodology, implementation and analysis of the isotopic composition of soil respired CO_2 in forest ecological research. Corvallis, OR: Oregon State University. 145 p. Ph.D. dissertation.

Kluber, Laurel A. 2010. Microbial and biochemical dynamics of ectomycorrhizal mat and non-mat forest soils. Corvallis, OR: Oregon State University. 98 p. Ph.D. dissertation.

Manore, Carrie Anna. 2011. Non-spatial and spatial models for multi-host pathogen spread in competing species: applications to barley yellow dwarf virus and rinderpest. Corvallis, OR: Oregon State University. 189 p. Ph.D. dissertation.

Moore, Kathleen M. 2010. Trends in streamflow from old growth forested watersheds in the western Cascades. Corvallis, OR: Oregon State University. 220 p. M.S. research paper.

Moore, Sean M. 2010. The effects of community composition, landscape structure, and climate on host-pathogen interactions. Corvallis, OR: Oregon State University. 228 p. Ph.D. dissertation.

Phillips, Claire L. 2009. Distinguishing biological and physical controls on soil respiration. Corvallis, OR: Oregon State University. 137 p. Ph.D. dissertation.

Rasmussen, Janet K. 2009. Reactive polyphenols and dissolved nutrients in a nitrogen-limited headwater catchment, western Cascades, Oregon, USA. Corvallis, OR: Oregon State University. 92 p. M.S. thesis.

Rice, Janine M. 2009. Forest-meadow dynamics in the central western Oregon Cascades: topographic, biotic, and environmental change effects. Corvallis, OR: Oregon State University. 221 p. Ph.D. dissertation.

Roth, Travis R. 2010. Headwater stream characterization: an energy and physical approach to stream temperature using distributed temperature sensing. Corvallis, OR: Oregon State University. 85 p. M.S. thesis.

Sierra, Carlos A. 2009. Environmental variability and system heterogeneity in terrestrial biogeochemical models. Corvallis, OR: Oregon State University. 178 p. Ph.D. dissertation.

Smoluk, Alexis. 2011. Geographic distributions of prey of the northern spotted owl in the central western Cascades, Oregon, 1988-2009. Corvallis, OR: Oregon State University. 74 p. M.S. thesis.

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van Huysen, Tiffany Lee. 2009. Nitrogen and phosphorus dynamics during decomposition of multiple litter types in temperate coniferous forests. Corvallis, OR: Oregon State University. 160 p. Ph.D. dissertation.

Voltz, Thomas J. 2011. Riparian hydraulic gradient and water table dynamics in two steep headwater streams. University Park, PA: The Pennsylvania State University. 150 p. M.S. thesis.

Ward, Adam. 2011. Characterizing solute transport in coupled stream-hyporheic systems using electrical resistivity imaging. University Park, PA: The Pennsylvania State University. Ph.D. dissertation.

<u>Journals</u>

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Argerich, A.; Haggerty, R.; Martí, E.; Sabater, F.; Zarnetske, J. [In press]. The use of Resazurin as a tracer to differentiate reaches with contrasting transient storage and ecosystem respiration. Journal of Geophysical Research: Biogeosciences.

Austin, Amy T. 2009. Planning for connections in the long-term in Patagonia. New Phytologist. 182: 299-302.

Azuma, David; Monleon, Vicente J. 2011. Differences in forest area classification based on tree tally from variable- and fixed-radius plots. Canadian Journal of Forest Research. 41: 211-214.

Barnard, H. R.; Graham, C. B.; Van Verseveld, W. J.; Brooks, J. R.; Bond, B. J.; McDonnell, J. J. 2010. Mechanistic assessment of hillslope transpiration controls of diel subsurface flow: a steady-state irrigation approach. Ecohydrology. 3: 133-142.

Beaulieu, Jake J.; Tank, Jennifer L.; Hamilton, Stephen K.; [and others] [including Sherri L. Johnson]. 2011. Nitrous oxide emission from denitrification in stream and river networks. Proceeding of the National Academy of Sciences. 108(1): 214-219.

Benson, Barbara J.; Bond, Barbara J.; Hamilton, Michael P.; Monson, Russell K.; Han, Richard. 2010. Perspectives on next-generation technology for environmental sensor networks. Frontiers in Ecology and the Environment. 8(4): 193-200.

Berman, Elena S. F.; Gupta, Manish; Gabrielli, Chris; Garland, Tina. 2009. High-frequency field-deployable isotope analyzer for hydrological applications. Water Resources Research. 45(W10201): doi:10.1029/2009WR008265.

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Davis, Liane R.; Puettmann, Klaus J. 2009. Initial response of understory vegetation to three alternative thinning treatments. Journal of Sustainable Forestry. 28(8): 904-034.

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Hall, Robert O. Jr.; Tank, Jennifer L.; Sobota, Daniel J.; Mulholland, Patrick J.; O'Brien, Jonathan M.; Dodds, Walter K.; Webster, Jackson R.; Valett, H. Maurice; Poole, Geoffrey C.; Peterson, Bruce J.; Meyer, Judy L.; McDowell, William H.; Johnson, Sherri L.; Hamilton, Stephen K.; Grimm, Nancy B.; Gregory, Stanley V.; Dahm, Clifford N.; Cooper, Lee W.; Ashkenas, Linda R. ; Thomas, Suzanne M.; Sheibley, Richard W.; Potter, Jody D.; Niederlehner, B. R.; Johnson, Laura T.; Helton, Ashley M.; Crenshaw, Chelsea M.; Burgin, Amy J.; Bernot, Melody J.; Beaulieu, Jake J.; Arango, Clay P. 2009. Nitrate removal in stream ecosystems measured by ^{15}N addition experiments: total uptake. Limnology and Oceanography. 54(3): 653-665.

Harmon, Mark E.; Moreno, Adam; Domingo, James B. 2009. Effects of partial harvest on the carbon stores in Douglas-fir/western hemlock forests: a simulation study. Ecosystems. 12: 777-791.

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