Statement from Dr. Mark E. Harmon, Professor Emeritus

To the United States House Natural Resources Committee
Subcommittee on National Parks, Forests, and Public Lands

Concerning the hearing on Climate Change and Public Lands: Examining Impacts and Considering Adaptation Opportunities

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My name is Dr. Mark E. Harmon and I am currently a professor emeritus at Oregon State University. I wish to offer the subcommittee my personal comments and opinions on the issue you are considering. These are based on my 33 years of professional experience examining these and related issues. Over my career I have received a large number of grants (78 in total), published numerous peer-reviewed journal articles (over 140), been an author of three major reviews (one cited over 3,900 times), reviewed about 175 research proposals for agencies such as NASA, NSF, and USDA, served as a referee on many scientific manuscripts (over 450 for a total of 100 different journals), taught several graduate level courses on the topic of forest ecosystems and forest carbon dynamics and well as made dozens of scientific and outreach presentations on these topics, and served as a scientific expert to Oregon's and federal agencies including the US EPA (biogenic carbon). To give more details I am providing my abbreviated curriculum vitae, but I believe most scientists in this field would consider me a leading expert particularly in the field of forest carbon.

I have a general concern about both the written and transcribed testimony from Dr. Oneil (the minority witness) that I have recently read regarding the examination of climate change impacts on public lands and adaptation opportunities. To sum up the basic logic that appears to have been presented: 1) a warming climate coupled with increased tree density has lead increased disturbance caused by fire, insects, and disease in forests; 2) therefore more trees must be harvested to reduce tree density; 3) these management actions will reduce the amount of disturbance and 4) will result in greater stores of carbon thus reducing one of the key drivers of climate change, atmospheric carbon dioxide. I find this analysis to be overly simplified, lacking context, and incomplete as it leaves out many key concepts that need to be part of any practical and credible solution. In the following sections I elaborate.

Selecting a Management Solution

The choice presented in the testimony seemed to have been that one can either let nature take its course or institute management involving deliberate campaign of widespread tree harvesting. I believe that is a false choice that does not reflect the diversity of forest management objectives present in the US, nor does it reflect the range of forest conditions and responses; nor does it reflect the practical and economic limitations that will undoubtedly shape management choices. One can envision a wide diversity of potentially effective management options that go far beyond what was offered:

> In some remote wilderness/park/reserve areas the best choice might be to allow nature take its course given lack of access, expense, and management objectives (which might include allowing nature to dominate);
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> In other such areas it might make sense to reintroduce disturbances such as fires to achieve objectives;
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> In yet other areas it might make sense to suppress fires aggressively under certain weather conditions, but not others;
>
> In the interfaces between forests and human communities it might make sense to not only reduce tree density, but to remove trees altogether.

This not an exhaustive list, but the point is that the management solution must match the specific management objectives, have a strong chance of achieving the objectives, and be realistic regarding economic and logistical limitations. Using forest harvest such as thinning in all situations would mean roads would have to be built into parks and wilderness areas often at extreme financial and environmental cost, but it would also mean that areas where complete tree removal is needed, such as for fire breaks and defensible spaces, would not be managed appropriately either. In plain terms we need to match specific solutions to specific conditions, not find a general problem to impose the single solution that we desire to implement.

In deciding which management actions to take, the primary objective of management for a particular forest needs to be recognized. Despite studying forest carbon for decades, I do not believe that carbon sequestration is the primary reason why most forests are managed today. While certainly important, carbon is a secondary objective/concern that should be managed to maximize stores (in the forest, in products, and substitutions) within the constraints of the primary management objective. One of my concerns with the testimony I read is that it seems to suggest that management actions will be taken to increase carbon stores and that other benefits such as economic, housing, energy benefits will follow. I would encourage everyone to stop dropping “the carbon bomb” to convince others of the validity of their desired management objective. There is a wide range of valid forest management objectives that have little to do with carbon. A more productive pathway would involve accepting the wide range of forest management objectives that exist and within those consider how carbon can be managed effectively.

Mortality Considered

Increased mortality beyond the historic range of this process is a concern, and I have no doubt some aspects of these changes need to be managed and mitigated through adaptation. However, it is overly simplistic and counterproductive to imply that mortality is always undesirable or that it automatically degrades forest ecosystem function. Mortality has always occurred in forests and that is why there are numerous species of animals, plants, and fungi that have evolved to take advantage of dead trees. Moreover, mortality is how forests thin themselves and coupled with decomposition is how forests recycle the nutrients they need to grow. Preventing mortality in forests or removing dead trees, as in the very intensive management best seen in 1980's northern Europe, has reduced the abundance of many species by removing their habitat and limiting the structural development/diversification of forests. That is why current forest management in many parts of northern Europe is trying to restore dead tree habitat. It should be noted that mortality does not equate with the loss of carbon or any other general function of forest ecosystems. The concept that carbon is completely lost or habitat is completely lost because of mortality is mistaken at best. When trees die in a forest from natural causes, a substantial part of the carbon remains (even in the case of severe fires more than 90% remains) and this carbon is gradually lost through the process of decomposition (which takes decades to centuries). While live tree habitat is lost during mortality, dead tree habitat is gained. What occurs in mortality is that the form of carbon and type of habitat changes. The only known process to immediately remove live and/or dead tree carbon and habitat at a large scale from a forest is timber harvest. We know this because trees, at least the aboveground part, are deliberately removed from the forest in a harvest!

Mortality is a natural process and ranges from the death of scattered individual trees to small patches of trees all the way up to major episodes covering broad areas. These forms of mortality have occurred in forests as long as forests have existed. None of these scales is more natural than another and over a broad area about as many trees die as scattered individuals as in major episodes. In and of itself these forms of mortality are not cause for concern. What is a concern is the degree that these forms of mortality change forests in ways that prevent specific management objectives from being achieved. This means that we cannot assume that the level of mortality tolerated in an intensively managed forest (very little) is the same as expected in a wilderness area where the creation of open habitats might be an important management objective (a great deal).

If maintaining forests is the management objective, then widespread mortality coupled with low tree regeneration success is the key concern, not mortality on its own. Mortality need not lead to a permanent loss of desired forest conditions, especially when a disturbed forest retains and regenerates the elements needed to restore these conditions. In many cases, disturbance-related mortality is a temporary reorganizer of forests and there are natural processes that allow forests to “recover” the conditions that are desired. The recovery process can begin quickly (years) or slowly (decades), but one must bear in mind that the perceived speed of successful recovery is strongly influenced by management objectives: 5 years may be too long for tree regeneration in a short rotation production forest, but 50 years or more may be appropriate in a remote wilderness. If management actions such as seeding and planting are needed to speed forest regeneration, then these actions need to be targeted to specific locations and situations as they may be neither needed (moist soils) nor effective (persistently very dry soils) in all locations. Moreover, if regeneration is assisted, the approach should be to introduce a wide range of genetic stock and species to cover the possible spectrum of future conditions. This acknowledges our uncertainty in predicting future conditions and increases changes of success because it allows natural processes to find the most successful “players” in the future forest.

To understand how to solve a problem one must understand what the problem is. Much was made in the testimony of the observation that mortality has increased four-fold in National Forest timberlands over the 1976-2016 period. While the data support this observation, it is misleading if taken at face value. The implication is that if mortality has increased four-fold, it must be solely due to increases in disturbance. This is misleading because, as noted above, about half of all tree mortality occurs at the individual level (which is not generally considered a disturbance), but also because mortality as it was expressed (that is a volume dying per year) depends on two items: 1) the proportion dying each year and 2) the volume of trees that can potentially die. Mortality can increase if either term increases. As Figure 1 in Dr. Oneil’s written statement makes clear, net growth (the amount forest live volume/biomass/carbon increases) has been positive throughout the 1952-2016 period. This means, despite the occurrence of mortality, that live tree volume has increased over this time period. Based on the values presented in Dr. Oneil’s testimony I estimate that tree volume may have roughly doubled over this period[1]. Thus, one would expect half of the four-fold mortality increase evoking concern to have been caused simply by the fact that today’s forest has substantially more volume than earlier forests. By analogy if one plans to buy a house at 4% annual mortgage interest then do not be surprised if the $100,000 house has one-half the interest payment of the $200,000 house. This not to say that there has not been an increase in the proportion of tree volume dying. Using the mortality rate reported by Dr. Oneil, it does appear that the proportion of tree volume dying has increased by about a factor of two between 1972 and 2016 with much of this increase occurring in the past two decades. However, in addition to knowing what level of reduction is required one must also understand the specific mechanisms behind the changes: one has to ask why the proportion of tree volume dying has increased. The suggestion in the testimony seems to be that it is related to fire and bark beetles; while I suspect this is partially true and there is evidence to support this hypothesis, there are other substantial sources of tree mortality that have increased over this period such as those related to wind and invasive species that are not related to either tree density or drought. Therefore, it is hard to envision how forest thinning, the proposed solution to reducing fires, disease, and insect attacks, would decrease the impact of wind disturbance, or that related to invasive insects such as the woolly adelgids attacking eastern hemlocks and Fraser fir or the emerald ash borer attacking green ash much less diseases such as sudden oak death. In fact, in some cases thinning might exacerbate these forms of mortality.

While an increase in the proportion of trees dying each year is of concern, the idea that the proportion of gross growth (NPP) allocated to mortality is indicative of a problem is misguided. Specifically, concern was expressed that 2/3 of gross growth (equivalent to net primary production or NPP) is currently being "lost" to mortality. The suggestion is that this "large" proportion is unnatural, but that ignores the fact that, absent harvests (which are after all forms of human induced mortality), forests allocate gross growth (NPP) into either net growth or mortality and this allocation changes as forests age. In young forests the majority of gross growth is allocated toward net growth (leading to a rapid increase in volume) and in older forests an increasing share of gross growth (up to 100%) is allocated toward mortality. This change is why forest volume does not increase forever and tends to saturate as forests age. This is a fundamental relationship found in all forests, documented in the forestry literature for more than a century, and is observed even those in management systems in which harvest mortality replaces natural mortality as a source of live tree removal. In fact when a sustainable harvest system is implemented, the expectation is that harvest and mortality comprise 100% of gross growth, hence the volume over a large area remains constant. As a specific example of how the allocation of mortality changes as forest age, we can examine the case when tree maximum lifespan is about 500 years. For this kind of forest, mortality would comprise 63% of the gross growth of an even-aged stand at about 100 years. In a stand that is 200 years of age one would anticipate that mortality would comprise 85% of gross growth and for a stand of 300 years age mortality would comprise 95%. Returning to the National Forest timberlands data we find that between 1952 and 2019 all forms of mortality (harvest included) have increased as a share of gross growth from 53 to 69%. But much of this is related to the fact that these forests have become older, a fact consistent with the observed two-fold increase in volume over this period. The only alternative explanation for increased live mass is that National Forest timberland acreages have increased two-fold, whereas we know these acreages have remained relatively constant.

Where and When is High Tree Density a Problem?

The idea that high tree density (that is number of stems) is the primary cause of recent unnatural mortality levels is overly simplistic. This is because it ignores the natural variation in space and time that one expects of tree density. In closed forest ecosystems, tree density is highest once forest stands have regenerated. As trees grow and start to compete for resources, mortality is expected to increase. Harvest thinning in these forests is a way to mimic and control this expected natural mortality process.

While some forests have higher tree density because of management actions such as fire suppression, others have climates and reproductive strategies that lead to high tree density. Those most influenced by fire suppression in the west include ponderosa pine and mixed conifer types where tree density has greatly increased over the period of fire suppression. One could argue that harvest thinning in these types would be appropriate. However, in many other forest types tree density is naturally high and is unlikely the direct cause of recent widespread mortality. A prime example would be the recent massive beetle-kill in lodgepole pine forests. The cause of these outbreaks was not high tree density. Tree densities in these types are naturally very high because of this species' reproductive strategy and tree densities in these forests have not noticeably increased substantially due to fire suppression. Rather, warmer conditions allowed bark beetle populations to increase and coupled with a long-term drought widespread mortality occurred. Ironically, the lodgepole pine stands least susceptible to beetle-kill were those with small diameter and high tree density, the conditions where drought conditions should have had the highest impact due to high levels of competition. The ecology of these species tells us why: this beetle species cannot reproduce when bark falls below a certain thickness and adult beetles will not attack trees if the beetles cannot reproduce within them, regardless of the tree's drought stress. It is therefore important to apply basic ecological knowledge in developing an effective solution and not impose a one-size fits all solution unrelated to addressing actual mechanisms.

Effective Management Solutions with a Responsive System

While it tempting to assume that once a management treatment is imposed from "above" that the problem is solved, this is a mistake when applied to forests[2]. This is because forests do not stay the way one leaves them, and they often respond in ways that counter treatment objectives. Perhaps the best example of this is fire suppression and its effects on fuels: suppressing fires initially leads to a decrease in fire impacts, but as fuels increase (because of the lack of fire) the impacts (at least in some forests) eventually increase. A similar response behavior is quite possible for the management actions being proposed. Specifically, reducing tree density or carbon in the form of fuel is a temporary solution because, unless the underlying controls are changed, forests will respond to these actions by increasing tree density and carbon. Hence, the solution will have to be repeated frequently raising long-term logistical, environmental, and economic concerns. This repeated treatment also leads to permanent carbon debts: if high fuel/carbon level is the cause of undesired levels of disturbance, then to solve the problem one must reduce fuel/carbon permanently, hence a carbon permanent debt develops. I should add that the argument that carbon debts cannot occur in forests because forests are renewable resources is completely erroneous: if high fuel/carbon is causing a problem then why would be want this high level to renew?

Even if the goal of reducing tree density is permanently achieved, forests may react in ways that counter the expected goal. Suppose the goal is to greatly reduce the occurrence of crown fires; then tree density would have to be greatly reduced because average tree distance has to be increased beyond that needed to spread these types of fires. This degree of opening in turn would allow smaller forms of vegetation (fine fuels associated with fire spread) to greatly increase and these openings would also greatly increase the rate of fuel drying. So while crown fires might be reduced, fires would continue to be widespread and challenge control efforts. In other words, one would replace one problem with a slightly different one.

To avoid these problems, one cannot think of forests as static systems that do what they are "told". Instead forests are adaptive, responsive systems than need to be persistently "persuaded" to move in the directions consistent with our management objectives.

The Fate of Harvested Trees

In the testimony harvest removal is viewed as not only solving the problem, but having major benefits in terms of goods and economic gain as well as major carbon benefits that would exceed carbon losses incurred in the forest. The carbon benefits would come in two forms: 1) carbon stores related to forest products and 2) substitutions that would reduce the use of fossil carbon. While there is an element of truth to these statements, they are misleading if accepted at face value.

Let us consider the statement that harvested carbon is stored in products. A more accurate statement would be that **some** harvested carbon is stored in products for **some** time. Although these sound similar, they are profoundly different in their effects. Specifically, when carbon is removed from forests through harvest, not all of the carbon ends up as solid products. If the harvested carbon is used for lumber/plywood/OSB production then somewhere between 30-40% is lost to the atmosphere in the manufacturing process. If the harvested carbon is used to make paper, then the amount lost to the atmosphere is around 50% and if used as fuel then it is 100%. Contrast these amounts to the range of live carbon lost to the atmosphere during natural disturbances: somewhere between zero and 10%. Moreover, consider the fact that wood products have varying lifespans in use and after they are disposed, that these timeframes can be quite short, and are roughly comparable to those found for wood decomposing naturally. While is it often assumed that the carbon related to mortality is lost to the atmosphere, that process can take three to fifty decades to complete. Taken together, the initial losses in manufacture and the losses in use and disposal means that removing carbon by harvest have roughly the same carbon storages effects as leaving the wood in the forest to decompose. Granted harvesting produces items that humans can use and generates wealth, but that should not be conflated with carbon effects.

Perhaps the biggest misconception is that using harvested wood will lead to large amounts of fossil carbon not being used through the process of substitution. While this is theoretically possible, there are several considerations that must be acknowledged to determine the degree this actually will happen. For example, in the case of product substitution (that is substituting wood for concrete and steel in construction), the preferences for materials has to be considered. In North America wood is the preferred material for residential homes, with about a 95% preference for wood. That would mean that one could try to replace the 5% of buildings not utilizing wood and gain a substitution benefit, but it is not possible to substitute wood for wood and gain a substitution benefit for the other 95%. The situation for taller buildings would differ as concrete and steel are currently preferred, but this raises a different problem: to build taller buildings using wood one need to engineer laminated materials, a process that involves more energy. It is highly unlikely that concrete and steel manufacturers will increase their fossil carbon use to keep the product-related displacement factor the same. Hence, it is possible that amount of fossil carbon displaced by wood use could decrease substantially in the case of taller buildings. Finally, for both substitutions related to products and energy one must recognize that the fossil carbon not used by the building sector today will likely be used by other sectors in the future. Consider the estimates of the times that fossil fuel carbon is likely to be depleted: 50-250 years depending on the form of fossil carbon. Unless this substitution-related carbon is protected by some actual mechanism, the assumption that unused fossil carbon today will never be used in the future is completely naïve. Taken together it is highly likely that actual substitution benefits will be far lower than most expect and, in some cases, will not fully counter carbon losses related to forest harvest.

A Strategy that Acknowledges Odds of Success and Failure

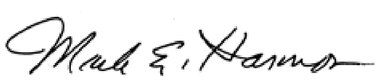
As described in the testimony, the suggested management treatments appear to assure complete success. Conversely, the path of allowing nature to take its course appears to assure complete failure. That may be, but this view seems overly deterministic given the system we are actually dealing with: critical conditions such as drought and temperature that vary greatly from place to place, season to season and year to year; different historical pathways creating varying forest structures that react to climate and other stressors in different ways; and species that not only have different characteristics, but that do not interact in consistent ways[3]. In other words, the system we have to deal with is not deterministic, it is highly stochastic (seemingly random). Like it or not, we are forced to play games of chance in our management.

There are several ways to increase the odds of success when playing games of chance including: 1) know the rules and the possibilities, 2) understand the odds regarding outcomes, 3) use a range of strategies, 4) recognize that while there is a chance of winning, there is also a chance of losing, and 5) decide where and when it is best to not play at all. This general strategy is applied to everything from poker to investments to medicine. I am not sure why we would not apply it to climate change adaptation.

Summary

I believe that it is a mistake to apply a single solution (such as more tree harvest) to a problem with the complexity of forest adaptation to climate change. A more appropriate and productive approach would be the development of a broad strategy that considers the likelihood of climate change-related phenomena modifying forests in ways that do not meet the very wide range of management objectives related to forests. To work, this strategy would have to be applied a local level given the wide variation at multiple scales from landscapes to regions to the nation in terms of management objectives as well as the conditions present in forests. Moreover, it would have to assess the range of negative responses possible, their magnitude, and likelihood so that efforts can be prioritized. Management solutions would have to be tied to the actual mechanisms causing the undesired changes and the possible negative side effects (environmental, economic, ecosystem) and potential countervailing processes would have to be considered to evaluate the chances of success once the solution is implemented. Finally, given the inherently stochastic nature of this problem it would make sense to use a diversity of approaches (even at the local scale) until more information can be gathered as to the most effective and efficient solutions.

Respectfully submitted,



Mark E. Harmon, PhD, professor emeritus

Footnotes

1 Unfortunately the data used in this figure is not publically available as far as I could determine and a full citation was not provided limiting my ability to find it. I have no doubt that the data presented are relatively accurate, however, without knowing the starting volume it is difficult to precisely estimate the degree volume has increased in a relative sense. The data presented suggest that cubic volume has increased by 212,150 million cubic feet over the 1952-2016 period. However, we know that cubic volume was not zero in 1952. Based on the likely fraction of live tree volume dying in 1952-1976, something in the range of 0.3-0.6% per year, it is likely the volume in 1952 was in the range of 250,000 cubic feet. If provided the 1952 volume from this dataset I could easily make a more precise estimate of the relative increase in live tree volume between 1952 and 2016.

2-A mistake that I might add which has been repeated to the degree that an alternative to top down control management approaches has recently been developed.

3-The case of bark beetles illustrates this point. When bark beetle populations are low, many of these species attack recently killed trees, but not living ones. When bark beetle populations are high many species attack weakened living trees, and when very high they attack even vigorously growing trees. This behavior is related to the ability to mass attack trees which is in turn a function of the beetles' population size.

CURRICULUM VITAE

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EDUCATION

Oregon State University, PhD Botany & Plant Pathology, 1986
University of Tennessee, M.S. Ecology, 1980
Amherst College, B.A. Biology, 1975

RESEARCH AND WORK EXPERIENCE

Professor, Emeritus, Dept. Forest Ecosystems and Society, Oregon State University, 2016
Co-Director Central Chemical Analytical Laboratory, Oregon State University, August 2002-2016
Professor and Richardson Chair in Forest Science, Oregon State University, August 1999-2016.
Oregon State University Lead Scientist for the H. J. Andrews Experimental Forest 1999-2006
Research Associate Professor, Dept. Forest Science, Oregon State University, July 1996-July 1999.
Research Assist. Professor, Dept. Forest Science, Oregon State University, October 1990-June 1996.
Research Assoc., Dept. Forest Science, Oregon State University. July 1988-September 1990.
Research Assist., Dept. Forest Science, Oregon State University, October 1984-June 1988.
Research Assist., Dept. Botany & Plant Pathology, Oregon State University, January 1981-October 1984.
Technician, Uplands Field Research Laboratory, Nat. Park Serv., Gatlinburg, TN. Sept.1976-Oct 1980.
Research Assistant, Tennessee Technological University, Cookeville, TN, June 1976-September 1976.
Technician, Gradient Modeling Inc., West Glacier, MT, June 1975-December 1975.

TEACHING EXPERIENCE

Honors College: Global Change Honors Seminar (1990, 1991);
Special Topics: FS599/699: Introduction to Spatial Modeling (1993); Carbon Sequestration in Forests (2001, 2003); Global Change and Carbon Dynamics (2002); Ecology of Forested Landscapes (2004); GEO599:Concepts in Ecosystem Informatics (2004); FS599 Developing a Competitve Grant Proposal (2007); FES599/699 Conversational Ecology.
Reading and Conference FS505/605: The Global Carbon Cycle (1995); FS605 Forest Carbon Dynamics **(**2011**)**
Regular Courses: FS646:Forest Ecosystems Analysis & Application (2001-2005, 2007, 2009, 2011, 2013, 2015, 2016, 2017), FOR240 Forest Biology (2008, 2009, 2010, 2011**,** 2012). FES536: Forest Carbon Sequestration (2012, 2013, 2014, 2016, 2017)

Guest Lectures: FS-552: Current Research in Forest Science (1990-2000); FS491/591:Sustainable Forestry (1999, 2001, 2002); FS/FW553:Forest Wildlife Habitat Management (2000, 2003); FOR 459:Forest Resource Planning and Decision Making (2002); The Silvicultural Institute (1988-1992); FOR240:Forest Biology (field tour 2003); FS520x: Researchable Questions in Forest Science (2003, *2004);* UO-Bi 307 Forest Biology (field tour 2003); FOR365:Global Environmental Change (2004); FOR 321:Forest Mensuration (2004); FS341: Forest Ecology (2005, 2009); FOR 460 Forest Policy (2007, 2008, 2009, 2010); FOR599 Ecosystem Services for Non-industrial Forests (2009), *OU-Architecture* (2010, 2012, *2014*); *Lewis and Clark Forest Law and Policy* (2010, 2012, 2013, *2014*); *Mycology (2014)*

RESEARCH GRANTS AWARDED

Competitive Grants (50 total, last five years listed, lead PI listed first)

1. Harmon, OPUS: The function of dead wood in forest ecosystems: A synthesis for the next decade, $146,900, NSF-OPUS, 2014-2017

2. Harmon, PI, Bond-Lamberty, and Vargas, Reducing uncertainty in heterotrophic respiration: Linking continental scale experiments, analytical modeling, and shared data sets, $82,506, NSF-Macrosystems Biology, 2012-2015.

3. Spies PI, Cohen, Harmon, Kennedy, and Morzillo, "Tradeoffs among carbon and other ecosystem services associated with different forest management practices", $728,066 NASA-Carbon Dynamics, 2011-2014.

4. Bond, Harmon, Johnson, Jones, and Spies, "Long-Term Ecological Research at the H. J. Andrews Experimental Forest: LTER6", $5,520,000, NSF-Long-term Studies Program, 2008-2013.

Non-competitive Grants (28 total, last five years listed, lead PI listed first)

1. Harmon, Tradeoffs among carbon and other ecosystem services in Oregon. USDA Forest Service FIA Joint Venture Agreement, $88,200, 2014-2016.

2. Harmon, Long-term studies of vegetation dynamics in the Pacific Northwest. USDA Forest Service Joint Venture Agreement, $205,629, 2009-2014.

3. Harmon, " Water quality in small streams at the H. J. Andrews Experimental Forest", $157,155, USDA-PNW Joint Venture Agreement, 2008-2013.

4. Harmon, Estimating Carbon Stores and Fluxes for Oregon's Forests:Phase 2. Oregon Department of Forestry, $49,999, 2013.

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2. Van Huysen, T., S. S. Perakis, and M. E. Harmon. 2016. Decomposition drives convergence of forest litter nutrient stoichiometry following phosphorus addition. Plant and Soil (DOI 10.1007/s11104-016-2857-6).

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8. Harmon, M. E. and R. Pabst. 2015. Testing hypotheses of forest succession using long-term measurements: 100 years of observations. Journal of Vegetation Science 26:722-732.

9. Moroni, M.T., D.M.Morris, C. Shaw, J.N.Stokland, M.E.Harmon, N.J. Fenton, K.Merganičová, J. Merganič, K. Okabe, and U. Hagemann. 2015. Buried-wood: A common yet poorly documented form of dead wood. Ecosystems 18: 605-628.

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11. Woolley, T. J., M. E. Harmon, and K. B. O'Connell. 2015. Inter-annual variability and spatial coherence of Net Primary Productivity across a western Oregon Cascades landscape. Forest Ecology and Management 335:60-70.

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15. Harmon, M. E., B. Fasth, C. Woodall, J. Sexton. 2013. Carbon concentration of standing and downed woody detritus: Effects of tree taxa, decay class position, and tissue type. Forest Ecology and Management 291:259-267.

16. Krankina, O. N., M. E. Harmon, F. Schnekenburger, and C. A. Sierra. 2012. Carbon balance on federal forest lands of western Oregon and Washington. Forest Ecology and Management 286:171-182.

17. Goetz, S. J., B. Bond-Lamberty, B. Law, J. Hicke, R. A. Houghton, S. McNulty, T. O'Halloran, A. J. H. Meddens, E. M. Mildrexler, E. Kasischke, and M. E. Harmon. 2012. Observations and assessment of forest carbon recovery following disturbance in North America. Journal of Geophysical Research-Biogeosciences 117: G02022, doi:10.1029/2011JG001733.

18. Campbell, J. L., M. E. Harmon, S. R. Mitchell. 2012. Can fuel reduction treatments really increase forest carbon storage in the western US by reducing future fire emissions? Frontiers in Ecology and the Environment10(2): 83-90.

19. Mitchell, S. R., M. E. Harmon, K. B. O'Connell, and F. Schnekenberger. 2012. Carbon debt and carbon sequestration parity in forest bioenergy production. Global Change Biology-Bioenergy 4:818-827.

NONREFEREED PUBLICATIONS (48 total, last five years listed)

1. Harmon, M. E. and J. L. Campbell. 2017. Managing Carbon in the Forest Sector In: Forests to Sustain People and Biodiversity: Lessons from Moist Coniferous Forests of the Pacific Northwest, B. Van Horne and D. H. Olson, Editors, Timber Press.

2. Harmon, M. E. 2016. How I got to here and now. In Rot:The Afterlife of Trees. Corvallis Art Center, Corvallis, OR.

3. Harmon, M. E. and E. B. Rastetter. 2014. A usable simulation model archive: Does it really exist? LTER Network News 27(4):1-3. (http://news.lternet/Article3158.html)

PUBLISHED ABSTRACTS (40 total, last five years listed)

1. Hagemann, U., Moroni, M.T., Stokland, J., Shaw, C., Fenton, N.J., Harmon, M., Merganicover, K., Merganic, J., Morris, D., and Okabe, K. 2014. How relevant is the burial of aboveground deadwood for forest floor C stocks and dynamics? BIOGEOMON 2014 - Proceedings of the 8th International Symposium on Ecosystem behaviour. University of Bayreuth, July 13-17 2014. Bayreuther Forum Ökologie Vol. 119, p. 155

INVITED PRESENTATIONS (52 total, last five years listed)

1. Harmon, M. E., T. A. Spies, and J. Kline. 2015. Carbon, wood products, and wildlife: a framework to explore tradeoffs. Research Across Boundaries, Oregon State University. Department of Forest Ecosystems and Society Spring Seminar Series, May 26, 2015, Corvallis, OR.

2. Harmon, Mark E., John Battles, Audrey Barker Plotkin, Jim Clark, Grizelle González, Michelle Mack, Scott Ollinger, Roger Ruess, and Jonathan Thompson. 2015. Forest NPP: Examining spatial and temporal heterogeneity within the LTER Network. NSF LTER Minisymposium, March 5, 2015, Arlington, VA.

3. Harmon, M. E. 2015. Dead wood three ways: Utility, science, and culture. Brown and Williams Invited Speaker Series. February 26, 2015, University of Louisville, Louiseville, KY.

4. Harmon, M. E. 2015. Reflections on the evolving understanding of dead wood and its ecological function. Brown and Williams Invited Speaker Series. February 27, 2015, University of Louisville, Louiseville, KY.

5. Harmon, M. E. 2012. Is the credibility of the forest sector at risk? Role of Forests and Forest Products in Carbon Mitigation and Energy, Denman Forestry Issues, University of Washington, Seattle, WA, May 15, 2012.

VOLUNTEERED PRESENTATIONS (62 total, last five years listed)

1. Kline, J.D. (presented), T. Spies, M. Harmon, B. McComb, F. Schnekenberger, A. Morzillo, R. Pabst, B. Csuti, and K. Olsen. 2014. Defining timber harvest, carbon storage, and potential habitat possibilities for western Cascades forests. Forest Ecology and Management seminar, School of the Environment, Portland State University, December 3, Portland, OR.

2. Kline, J.D. (presented), T. Spies, M. Harmon, B. McComb, F. Schnekenberger, A. Morzillo, R. Pabst, B. Csuti, and K. Olsen. 2014. Timber, carbon storage, and habitat production possibilities. A Community on Ecosystem Services (ACES) conference, December 8-12, Washington, DC.

3. Domke, G.M., Harmon, M.E., Woodall, C.W., Fasth, B., Walters, B.F., Gray, A.N. The effect of varying estimation procedures on downed dead wood carbon stock estimates using the national forest inventory of the United States. IUFRO World Congress and SAF National Convention. Oct. 5-11, 2014. Salt Lake City, UT.

4. Harmon, Mark E. One hundred years of observing tree growth and mortality on the Willamette Forest. Northwest Science Association Meeting, Portland, OR, March 22, 2013.

5. Harmon, Mark. E. 2013. Uncertainty analysis: An evaluation metric for synthesis science. 98th Meeting of the Ecological Society of America, Minneapolis, MN, August 5, 2013.

6. Spies T., M. E. Harmon, and W. B Cohen 2013. Trade-offs between carbon stores, wood products and wildlife. NACP Biannual Meeting, Albuqueque, NM.

7. Harmon, M. E. 2012. An integrated perspective of woody carbon in forests: The live to soil continuum. Ecological Society of America 97th Annual Meeting, August 8, 2012, Portland, OR.

Outreach Publications

1. Harmon, M. E. 2006. The “other” life of a tree. pp 9-10 In: Field guide to the wildlife of Mark Dion’s Seattle vivarium. Olympic Sculpture Park, Seattle Sculpture Museum, Seattle, WA. 41 pp.

Outreach Presentations (13 total, examples)

1. Harmon, M. E. 2011. The theoretical and empirical basis for understanding the impact of thinning on carbon stores in forests.Workshop on Density Management Studies in Forests of the Pacific Northwest, Corvallis, OR, September 2011.

2. Harmon, M. E. 2010. Soil and carbon storage. Forest Restoration Learning Network Meeting, Camp Waskowitz Outdoor School, WA June 15, 2010.

3. Harmon, M. E. 2009. Increasing Rates of Tree Mortality in the West: A Sign of Climate Change? Oregon Association of Environmental Professionals, Portland, OR, April 15, 2009.

4. Harmon, M. E. 2009. Forest carbon: What Can We Count On?. Oregon Natural Resouurces Institute Symposium on Climate Change, Corvallis, OR, April 15, 2009.

5. Harmon, M. E. 2008. Management of carbon in forests. Central Cascades Adaptive Management Program. US-BLM Office, Eugene Kinton Grange, OR, July 25, 2008.

6. Harmon, M. E. 2008. Carbon management. Oregon Woodland Cooperative. Kinton Grange, OR, June 21, 2008.

7. Harmon, M. E. 2008. Forest carbon basics. The Nature Conservancy Climate Change Workshop. Portland, OR. April 18, 2008

8. Harmon, M. E. 2008. Atmospheric carbon and climate change. Clearcutting the Climate, Eugene, OR. January 26, 2008.

Outreach Short Courses

Mangement of Carbon Sequestration in Forests, H. J. Andrews Experimental Forest, September 30-October 2, 2008. Main organizer and presenter.

Outreach Committees

Selection jury for art works to be included in the Rot:Afterlife of Trees, Corvallis Art Center.

Congressional Testimony

“Carbon Dynamics of the Forest Sector”, presented to US Senate September 19, 2013

“Forest Carbon Basics” presented to the Subcommittee on National Parks, Forests, and Public Lands of the Committee of Natural Resources for an oversight hearing on “The Role of Federal Lands in Combating Climate Change”, March 3, 2009, Washington, D. C.

HONORS AND AWARDS

2016 Dean's Award for Outstanding Achievement in Research, College of Forestry, Oregon State University
2014 Certificate for Excellence in Reviewing, Forest Ecology and Management
2006 Harvard Forest Bullard Fellow, Harvard University
2003 Dean's Award for Outstanding Achievement in Research, College of Forestry, Oregon State University.
2002 Big Fish Service Award, Department of Forest Science, Oregon State University.
1998 Outstanding Graduate Student Mentor, Department of Forest Science, Oregon State University
1990 Dean's Award for Outstanding Achievement of Andrews Research Team, College of Forestry, Oregon State University.

COMMITTEE/ADVISORY BOARDS

University-level
University Conflict of Interest Committee since 2003
Oregon State University Advisory Board of Vice Provost for Research 1998-2005
Ad Hoc Committee to Develop an Earth Science Curriculum 2007
Ad Hoc Committee to Develop an Earth Science Research Program 2007

College-Level
College of Forestry Pomotion and Tenure Committee 2014-2016
Guistina and Knudson Professors Selection Committee 2009
Judge for the Pack Essay Award 2003, 2005, 2007, 2008, 2009
Undergraduate Curriculum Evaluation Committee 2007- present
Search Committee Ruth H. Spaniol Chair in Renewable Resources 2004
Megatrends Analysis Committee 2007
College of Forestry Forest and Climate Faculty Working Group 2007

Departmental-level
Oregon State University, Department of Forest Ecosystems and Society, member, Tourism and Recreation Assistant Professor Search Committee, 2015
Oregon State University, Department of Forest Ecosystems and Society, Chair FES Natural Resource Option Committee, 2015
Oregon State University, Department of Forest Ecosystems and Society, Chair Governance Committee, 2012-2014
Oregon State University, Department of Forest Ecosystems and Society, undergraduate curriculum committee, 2010-2014
Oregon State University, Department of Forest Ecosystems and Society, graduate curriculum committee, 2010-present
Oregon State University, Department of Forest Ecosystems and Society, Promotion and Tenure Committee for Matt Betts, Chair 2011
Spaniol Chair Search Committee 2011-2012

Oregon State University, Department of Forest Ecosystems and Society, Promotion and Tenure Committee Co-Chair 2008-2010
Oregon State University, Department of Forest Science, Promotion and Tenure Committee Chair 2007-2008
Oregon State University, Department of Forest Science, Mentoring Committee for Matt Betts, Chair 2007-present
Oregon State University, Department of Forest Science, Chair of H. J.Andrews Forest Director Selection Committee 2003.
Post-tenure faculty review (subcommittee chair 1 time)
Tenure and Promotion Subcommittees, Department of Forest Science (subcom chair 3 times)
Department of Forest Science Curriculum Committee since 2000
Oregon State University, Department of Forest Science, Silviculture Position Selection Committee 2000.
Oregon State University, Department of Forest Science, Chair of LTER Permanent Plot Scientist Selection Committee 2003.
Oregon State University, Department of Crop and Soil Science Landscape Pedologist Selection Committee 2000.
Oregon State University, Department of Forest Science, Chair of Student Awards Committee 2000.
Department of Forest Science Research Committee 1990-2000

LTER-related
Chair HJ Andrews Forest Director Search Committee 2002/2003
Andrews LTER Website Editorial Board (head) 2003-2004
US LTER Network Strategic Plan Committee 2002-2005
US LTER Network Advisory Committee for the Network Informatics System 2002-2005
Editor LTER/Cascade Center Monthly Meeting Notes since 2001-2004
Coordinator of LTER/Cascade Center Monthly Meetings 1997-2002
H. J. Andrews LTER Executive Committee 1999-2014
Cascade Center for Ecosystem Management Executive Committee 2000-2003
H. J. Andrews LTER representative to US Long Term Ecological Research Network LTER Network Coordinating Committee since 1997-2002.

Regional-level
Oregon Greenhouse Gas Commission, Task force on Forest Carbon, 2000, 2015-present
Oregon Roundtable on Sustainable Forest Management 2009
PNWREO (Pacific Northwest Regional Environmental Observatory) Organizing Committee 2004
Local Steering Committee for 4th North American Forest Ecology Workshop 2002-2003
Pacific Northwest Research Station H. J. Andrews Scientist Search Committee 2001.
Reviewer of Forestry Program for Oregon-Goal 5- Maintain and Enhance Forest Contributions to Global Carbon Cycle. Oregon Department of Forestry-2002
Northwest Scientific Association Board of Trustees 2006-2013

National/International-level
Academic Editor, Forests 2014-present
Scientific Advisory Board to US EPA on the Biogenic Carbon Framework 2011-present
National Center for Conservation Science and Policy Advisory Board 2009
COREO (Consortium of Regional Environmental Observatories) PNW representive 2004-2006
Editorial Advisory Board Forest Ecology and Management October 2002-present
National Advisory Committee of Wind River Canopy Crane Facility 1997-2002
Scientific Advisors Board Federal Forest Carbon Coalition 2013-present
Editorial Advisory Board Global Change Biology-Bioenergy 2014-2016
Ecosystems Panel National Science Foundation 2014

SOCIETY MEMBERSHIPS
American Geophysical Union
Ecological Society of America
Northwest Science Association
Sigma Xi
Torrey Botanical Club

NATIONAL/INTERNATIONAL PROFESSIONAL SERVICE

Workshops Attended (19 total, last five years listed)

1. Macrosystem Biology All-Investigators Workshop. June 19-20, 2014, Arlington, VA.

2. Macrosystem Biology All-Investigators Workshop. June, 5-6, 2013, Arlington, VA.

3. Macrosystem Biology All-Investigators Workshop. March 11-14, 2012, Boulder, CO.

Symposia/Workshops Organized

Heterotrophic respiration science of the future Workshop 2, Bonneville Hot Springs, WA, Novemeber 16-19, 2014.

Heterotrophic respiration science of the future Workshop 1, H. J. Andrews Experimental Forest, OR, October 31-Novemeber 3, 2013.

VegDB Planning Workshop II, Seviletta Field Station, Socorro, NM April 30-May 2, 2013.

VegDB Working Group Session, LTER All Scientists Meeting, Estes Park, CO, September 12, 2012.

VegDB Planning Workshop, Harvard Forest, Petersham, MA June 18-21, 2012.

Seeking Conceptual Equity in Forest Carbon Balances: Looking Beyond NPP: Organized Oral Session. Ecological Society of America 97th Annual Meeting, Portland, OR, August 8, 2012 (Robert Scheller co-organizer).

Workshop 4 of the NCEAS Decomposition Working Group. June 26-30, 2006, Sanata Barbara.

Workshop 3 of the NCEAS Decomposition Working Group. March 16-19, 2006, Sanata Barbara.

In it for the long-term: Lessons from the H. J. Andrews Experimental Forest, 78th Annual Northwest Science Meeting, March 26th, 2005, Corvallis, OR (organizer)

NSF-LTER Symposium: Application of LTER Science to Ecosystem Management, February 26th 2004, NSF HQ, Arlington, VA (Organizers: Mark Harmon and Phil Robertson).

The 4th North American Forest Ecology Workshop: Ecosystems in Transition, June 16-20, 2003, Oregon State University, Corvallis, OR (local steering committee)

Developing a NEON Observatory in the Pacific Northwest: Workshop 2. June 12-13, 2001, Portland, OR.

Developing a NEON Observatory in the Pacific Northwest: Workshop 1. February 24-25, 2001, Portland, OR.

First Annual H. J.Andrews LTER Symposium, lead organizer, June 13, 1997. Corvallis, OR.

Plant Mortality: A link between population, community, and ecosystem processes. Ecological Society of America 42nd Annual Meeting, August 7, 1991, San Antonio, TX.

Synthesis of tree mortality studies in the LTER Network. May, 1990, Corvallis, OR.

Grant Reviews (number)
Department of Energy (6)
Earthwatch (2)
EPA (4)
Estonian Science Foundation (1)
NASA (39, LBA-panel, LCLUC 2000 Panel)
Natural Environment Research Council (UK) (1)
Natural Sciences and Engineering Research Council of Canada (9)
National Geographic (1)
National Science Foundation (83), Biocomplexity Panel-2000, **Ecosystems Panel-2014**
University of Maine Agricultural and Forest Experiment Station (1)
University of California Agricultural Natural Resource Competitive Grants (1)
USDA Competitive Grants (38, Ecosystems panel)
USGS Biological Resources (1)

LTER Site Reviews
Hubbard Brook LTER July 2002.

Promotion and Tenure Reviews
Boston University (1)
Michigan Tech University (2)
Northern Arizona University (1)
Purdue University (2)
Smithsonian Institution (1)
University of Jordan (1)
University of Maryland (1)
University of Missouri (1)
University of Minnesota (3)
University of New Hampshire (1)
University of Pennsylvania (1)
University of Vermont (3)
USDA Forest Service (3)
Wayne State University (2)
Western Washington University (1)

External Thesis and Dissertation Reviews
Australian National University
Dissertation Opponent, Umea University, Sweden
Outside reviewer Brown University, University of British Columbia, University of Joensuu, Finland
Outside reviewer for 2007 PhD thesis medal, Swiss Federal Institute of Technology, Zürich, Switzerland.

Book Proposal Reviews
Island Press (2)
Springer-Verlag

Reviews of Government Programs
EPA Biogenic Carbon Accounting Proceedure (2010)
United Kingdom Accounting Procedure for Biofuels (2014)

Manuscript Reviews (number)

AAAS (1)
Academic Press Books (1)
Agric. & Forest Meterology (1)
American Midland Naturalist (2)
Applied Soil Ecology (3)
Annals of Forest Science (2)
Atmospheric Environment (1)
Baltic Forestry (2)
B.C. Ministry of Forestry (4)
Biogeochemistry (6)
Biogeosciences (1)
Biomass & Bioenergy (1)
Bioresources (1)
BioScience (1)
Biotropica (5)
Bulletin of Marine Science (1)
Canadian Journal of Botany (3)
Canadian J Fisheries & Aquatic Sci (1)
Canadian Journal of Forest Research (50)
Carbon Management (2)
Cary Conference Papers (1)
Climatic Change (8)
Conservation Ecology (2)
Ecography (2)
Ecological Modelling (4)
Ecology (19)
Ecological Applications (19)
EcoScience (2)
Ecosphere (1)
Ecosystems (13)
Environmental Protection Agency (4)
Environmental Research Letters (2)
Environmental Review (1)
Environmental Management (4)
Forest Ethics (1)
Forest Ecology and Management (88)
Forestry (1)
Forests (3)
Frontiers in Ecology and Environment (2)
Functional Ecology (3)
Global Biogeochemical Cycles (3)
Global Change Biology (25)
Global Change Biology-Bioenergy (4)
Hydrobiologica (1)
International J Environ & Pollution (1)
International Journal of Wildland Fire (2)
International Soc Computational Biol (2)
Journal of Applied Ecology (4)
Journal of Biogeography (1)
Journal of Ecology (6)
Journal of Ecology & Nat. Environ (1)
Journal of Environmental Quality (1)
Journal of Forest Research (2)
Journal of Forestry (2)
Journal of Geophy Res-Biogeosciences (2)
Journal of Sustainable Forestry (1)
Journal of the Torrey Botanical Society (6)
Journal of Tropical Ecology (2)
Journal of Vegetation Science (10)
Landscape Ecology (1)
Mitigaton &Adapt. Strat. For Global Δ (8)
Mycologia (1)
Natural Resources Defense Council (1)
Nature-Climatic Change (2)
Nature commincations (1)
New Forests (1)
New Phytologist (2)
Northwest Science (4)
Oecologia (3)
Oikos (3)
PeerJ (1)
PLoS One (4)
Plant Ecology (4)
Plant Physiology (1)
Plant and Soil (17)
Public Library of Science (1)
Restoration Ecology (1)
Science of the Total Environment (3)
Scientifc Reports (2)
Scandinavian J. of Forest Research (4)
Silva Fennica (5)
Soil Science (2)
Soil Science Society of America Journal (2)
Southern Journal of Applied Forestry (1)
Springer-Verlag-Ecological Studies (1)
Springer Landscape Studies (1)
Tellus (6)
Tree Physiology (3)

Tree Planters Notes (2)
Turkish J. Agriculture and Forestry (1)
U.S. Forest Service (24)
Vegetatio (2)
Water, Air and Soil Pollution (1)
Wetlands (3)
World Resources Institute (1)

ADVISING
Graduate Students (year degree completed):

Major/Co-major Professor

Masters
Balduman, Lisa (1995)
Butts, Sally (1997)
Englemann, Deanna (2014)
Hortz, Jill (widthdrew)
Janisch, Jack (2001)
Melson, Susanna (2004)
Priestley, A. (withdrew)
Ranseen, Susanne (2013)
Sierra, Carlos (2006)
Vandegrift, Eleanor (2002)
Van Horne, Justin
Wooley, Travis (2005)
Wright, Pam (1998)
Yatskov, Misha (2000)

PhD
Chen, Hua (1999)
Hicks, Bill (2000)
Jobse, Judith (2008)
Michell, Steve (2009)
Pruyn, Michele (2001)
Sierra, Carlos (2009)
Smithwick, Erica Hoffa (2001)
Van Husen, Tiffany (2009)
Yang, Zhiquian (2004)
Yatskov, Misha

Committee Member

Masters
Comstock, Amy
Doughty, Russell (2014)
Dunn, Chris (2011)
Dreher, David (2004)
Hieder, Chris (2000)
Hicks, Amanda (2014)
Lobser, Sarah (2004)
Matkins, Joselin (2008)
Ngo, Nam (2006)
Powers, Jennifer (1995)
Remillard, Suzanne (1999)
Smith, Troy (2001)
Tuiniga, Amy (1995)
Yount, Louise (1997)

PhD
Bible, K.-University of Washington (2001)
Cifuentes-Jara, Migel (2008)
Dunn, Chris
Hayes, Daniel (2006)
Kennedy (Hess), Rebecca (2005)
Hughes, Flint (1997)
Kayler, Zac (2008)
Novita, Nisa
Ryan, Leslie

Sachs, Don (1996)
Schroeder, Todd (2006)
Spears, Julie (2002)
Swanson, Mark-Univ of Washington (2008)
Waldien, David (2005)

Graduate Representative

Masters

Allen, Scott (2012)
Brown, Abby
Collier, Mike (2008)
Copeland, Elizabeth (2009)
Ferrand, Alex (2004)
Foster, Lee (2016)
Frueh, Terry (2011)
Floyd, William (2005)
Gonzales, Rosalinda
Hammond, John (2014)
Hanson, Mette (1993)
McClintock, Matthew (2014)
Neidetcher, Sandy (2012)
Rasmussen, Janet (2009)
Roth, Travis (2012 exam, no pass)
Sapp, Methea (2004)
Saulez, Montague (2003)
Somes, Christopher (2009)
Spaan, Robert
Thompson, Sarah (2006)
Zucker, Steve (1993)

PhD

Abbott, April (2015)
Bhattacharya, Shreya (2014)
Glenn, Betsey
Highland, Steve (2011)
Hammond, John (2014)
Marshall, Sarah (2011)
McCullar, Jennifer (2005)
Mitchell Logan (2013)
Scheri, Richard (2008)
Scott, Alan
Senawong, Thanaset (2004)
Tian-wei Chou, Joyce (1995)
Westphal, Michael (2007)

Post doctoral Advisor

Michele Pruyn 2003-2006
Kari Bisbee O'Connell 2000-2003
Chen Hua 1999-2002
William Hicks-2000 to 2002
Olga Krankina 1993-2001
Nicholas Kruys 2001

Sabbatical/Visiting Scholar Host

Murat Sargenci, Dülzce University, Turkey 2012
Peter Homann, Western Washington State University 2008
Joon Sun Kim-Sunchon University, South Korea, 2004
F. Javier Alvarez Sanchez-UNAM 2001
Charles Halpern-University of Washington 2001
Jianwei Tang, Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences 2000

Graduate Advisors:

Buckner, E., University of Tennessee
Clebsch, E., University of Tennessee
Cromack, K., Jr., Oregon State University
Franklin, J. F., Oregon State University
Hansen, E., Oregon State University
Hayes, R., University of Tennessee
Waring, R. H., Oregon State University
Wilson, M. V., Oregon State University