

Project Summary - The Holt Research Forest (HRF) is a field station located in southern mid-coastal Maine with a 35-year history of multidisciplinary ecological research. It features a red oak-white pine forest ecosystem, an important and relatively understudied forest type, as well as estuarine frontage with salt marshes and mudflats. HRF is currently in transition with a change in both PI leadership and the supporting foundation. This proposed planning project seeks to design a new research, educational, and public outreach program for the HRF over the next decade. This will be accomplished by engaging diverse stakeholders (e.g., students, scientists, family forest landowners, natural resource professionals) through three workshops and a conference; soliciting an external evaluation from experts in the field; networking with peers at similar stations; and synthesizing the findings into a 10-year strategic plan that will guide future endeavors.

Intellectual Merit - Oak-pine forests are an important ecosystem type throughout the eastern United States and are expected to significantly expand with climate change. However, they are relatively understudied compared to other forest types, especially those that dominate regions of commercial forestry. In addition, the HRF is quite unusual in that it is situated in the urban-rural interface, unlike many remote field stations, and thus provides a variety of novel research and outreach opportunities. As important as the physical site, the HRF is characterized by a 33-year database that provides an unusual depth and breadth of information about a particular ecosystem, from spatial and temporal variation in forest structure and composition to salamander population dynamics. While past research has primarily focused on forests, HRF also provides an opportunity to study estuarine ecosystems and the impact of sea level on them and adjacent forests. This proposed planning project will significantly enhance the HRF's capacity to do relevant research on all these issues and more.

Broader Impacts - HRF focuses on research that contributes to healthy managed forest ecosystems. The oak-pine forest type is commercially valuable and the forest products industry is a significant part of the natural resource economy. Ecosystem services, including clean water, biodiversity, and recreation, provided by these forests impact the economic and social conditions of adjacent communities. Currently, HRF provides educational opportunities for limited numbers of graduate students, K-12 students, and adult learners. A key outcome of the planning grant and resulting strategic plan would be expanded opportunities for teaching, training, and learning that engage graduate students, post-docs, undergraduate students, K-12 teachers and youth, and adult learners (especially including natural resource professionals and family forest landowners). Across all of these groups, we would enhance opportunities for underrepresented minorities. A strategic plan would allow for enhanced infrastructure, refined data management and increased access, broader dissemination of research results, and developing a network between HRF and similar field stations. Diverse stakeholders – researchers and students using the long-term data, K-12 youth developing connections with natural and managed forests, natural resource professionals implementing the findings in locations around New England, and more--will benefit from strategic planning efforts to ensure the legacy and growth of this unique field station.

FSML Planning for the Future of the Holt Research Forest

Project Description

Basic description of the existing station

History - Initial funding for the Holt Research Forest was first provided in 1981 and research began in 1983 with the hiring of an onsite researcher and a 3-person student crew. Initially, the Holt Research Forest had two primary goals, (1) maintain the property as a site for long-term forest ecosystem studies and (2) develop a demonstration forest where state-of-the-art multiple use management techniques can be presented to the public. These goals intersect well as the ecosystem studies monitor the long-term effects of the various forest management practices. The concomitant forest management goals were providing a sustainable crop of high-quality timber, habitat for a diversity of wildlife, and maintaining aesthetics, which all align well with the objectives of most non-industrial private forest owners.

Since its inception, Holt Research Forest has been a site for cooperating researchers, training opportunities for graduate and undergraduate students, and public service and outreach to the community. Holt Research Forest is located in southern coastal Maine (Figure 1) and its facilities consist of two buildings on a land base of approximately 125 ha (Figure 2). The vast majority of the property is forested uplands dominated by an oak-pine ecosystem. Some 20 ha are wetlands

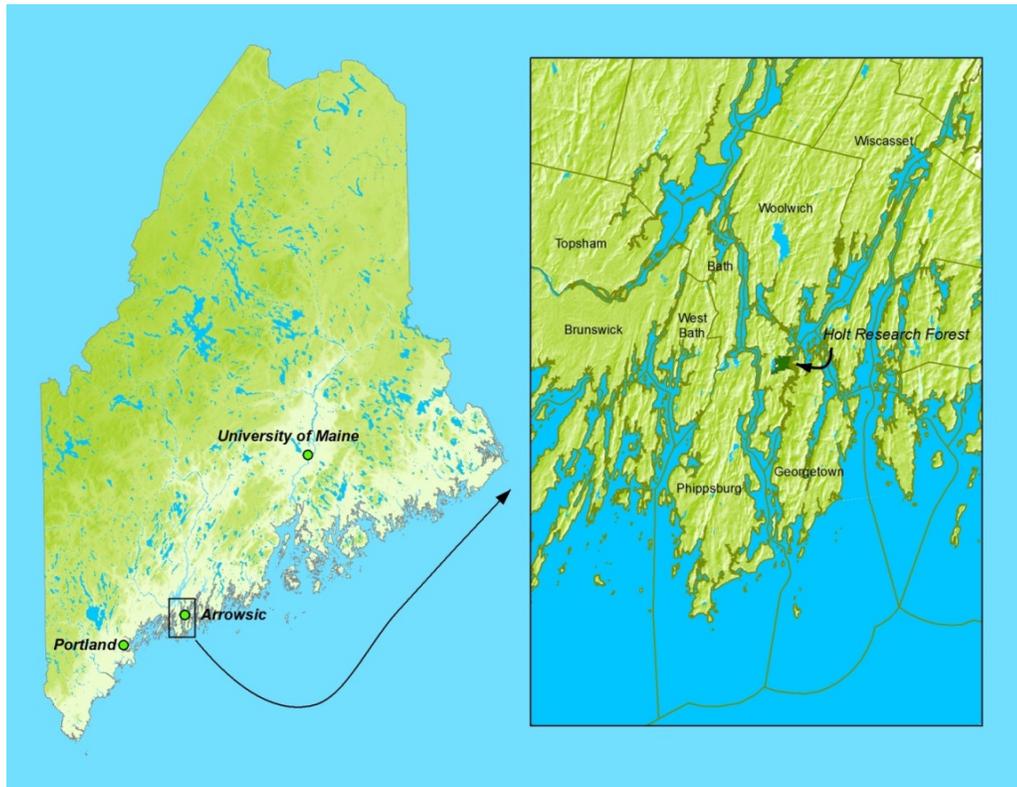


Figure 1. Location of the Holt Research Forest in southern midcoast Maine.

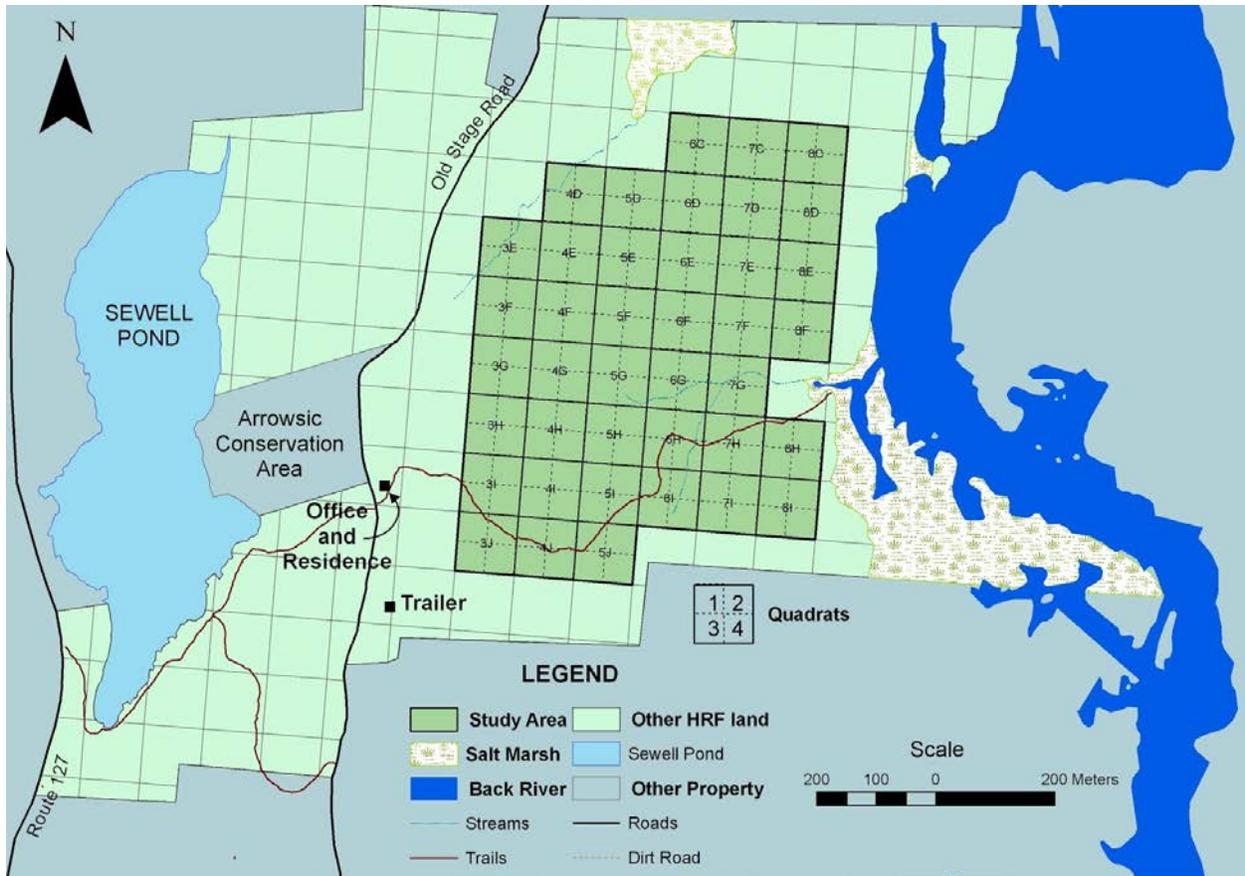


Figure 2. Layout of the Holt Research Forest, including 40 ha study area, 20 ha of salt marsh, and river and pond frontage.

of various types, primarily salt marsh. The property is bordered by the Back River, an estuarine tributary of the Kennebec River, on the east. Sewell Pond, the largest pond on Arrowsic Island, forms the western boundary. The northern and southern boundaries of the property are adjacent to largely forested conservation land held by The Nature Conservancy and Maine Department of Inland Fisheries and Wildlife.

Long-term baseline data has been collected on many aspects of the forest system but has focused on components that are reliable and meaningful to monitor (Table 1). Of primary focus has been the woody and herbaceous vegetation. Complete tree inventories in a 40 ha study area have been repeated three times (>30,000 trees per survey) with additional partial inventories. Individual stems have been mapped on 20 ha of the forest. Complete and partial relevé descriptions of plant communities have also been repeated. Numerous sampling methods have been used to evaluate the tree regeneration including stem-mapping on 1.2 ha. Seedlings and seeds are monitored annually. Past sampling has included phenological observations as well as fruit production and an examination of reproductive effort by understory herbaceous and woody plants. Numerous other additional studies have been conducted on the forest and include destructive sampling for tree volume and biomass, seed fall traps, and dendrochronology. A more thorough listing of the various datasets is given below.

Table 1. Summary of long-term ecological data that has been collected at the Holt Research Forest for the 30+ years.

Dataset	Years Measured	Variables Assessed	Method	Key Reference(s)
Breeding Bird Territory Mapping	1983-2015	Breeding bird density, Location	Territory mapping	Campbell et al 2007, 2010, 2012
Small Mammal Trapping	1983-2015	Small mammal abundance	Mark/recapture	Elias et al. 2004, 2006
Seeds	1983-2015	Seeds/ha	Seed trap collection	Elias et al. 2004, 2006
Salamander	1987-2015	abundance	Cover boards	Monti, et al. 2000
Vegetative cover (subquadrat, 25X25m)	1985, 1988, 1990-91, 1996	Plant species distribution and % cover	Relevé	White et al. 1999
1m ² Vegetation Plots	1996, 2011	Plant species abundance (% cover)	Relevé	Schumann et al. 2003
Timber inventory	1984, 1988, 1996, 2007	Species, DBH, condition	100% tally	White et al. 1999
Canopy gap mapping	1988	Canopy gap size and location		Kimball et al. 1995

Studies of birds have including 33 years of bird censusing via territory mapping, all season strip censusing, and behavioral observations. Mammals have been inventoried by track counts and annual small mammal trapping. Upland salamanders have been extensively sampled and an array of artificial cover boards is used for seasonal population monitoring. The 25 x 25 m resolution study grid has allowed for the development of an extensive spatial database of many components including oak-pine ecosystem types, high intensity soils maps, forest canopy gaps, bird territories, and more. Overall, these projects and others have created a database that provides insights into many aspects of the ecosystem as it dynamically responds to forest management, changes in climate, and various disturbance agents.

Capabilities for enabling scientific research and training - By meeting its research and educational objectives, Holt Research Forest has been a site for numerous cooperating researchers, a variety of training opportunities for graduate and undergraduate students, and several public service and outreach activities to the community. Graduate and undergraduate students have made up a significant portion of the work force carrying out the field work that forms the 30+ year database. To date, more than 20 research scientists have studied here or used

Holt Research Forest data, over 100 students have had career building work experience, and some 1,000 people including natural resource professionals, small woodlot owners, and the interested public have attended workshops and other educational programs here. Holt Research Forest has worked with many partners and has strong relationships to enable future opportunities for both research and education.

Though many forests are open to researchers, instructors, and university students, few can provide information derived from rigorous, multi-disciplinary scientific exploration. Holt Research Forest is the site of long-term research on forest ecosystems and their response to natural disturbance-based management. Researchers, students, and practitioners have and will continue to benefit from ongoing research initiatives, technology transfer activities, and work-study opportunities. In particular, the study design, implementation, and data collection have been undertaken with a small multi-disciplinary team. Almost all of the annual measurements for the last 30 years have been solely conducted or supervised by the on-site scientist with the help of undergraduate summer research assistants. Graduate students have supplemented these efforts with individual research projects, often incorporating analysis of the long-term data. This exemplifies the Holt Research Forest's long legacy, consistency, and efficiency.

A team of scientists conducted a peer review of the project in 1996 and applauded the comprehensive and long-term research emphasis because it included elements of critical importance to maintaining healthy forests and to meeting the needs of woodland owners in Maine and adjacent states. They suggested that maintenance of a productive healthy oak-pine ecosystem should remain the key element of the research vision because of its economic and biological value to the region. One of their conclusions was that the maintenance of research activity is crucial to reap the future benefits of the past investment in data collection.

The current on-site facilities consist of a log house, and a two-story garage/lab. The log house is the current residence for the on-site researcher/manager. The second floor garage/lab is primarily used as office space for the on-site staff but also has a multipurpose work area, kitchen, and bathroom. A small travel trailer on a developed site serves as temporary housing for students and others working on the site.

Uniqueness of the site - Holt Research Forest is located on an estuarine island in mid-coast Maine and has some unusual features. First, Holt Research Forest is an oak-pine forest ecosystem near the northern edge of its current range. This region has unusually high woody plant species richness because it is in the transition zone between temperate forests to the south and boreal forests of the north. In particular, the oak-pine forest ecosystem is expected to expand with climate change (Iverson et al. 2008) as both northern red oak (*Quercus rubra* L.) and eastern white pine (*Pinus strobus* L.) are two species that are well adapted to warmer temperatures and have limited natural enemies. However, the regeneration of certain oak species like northern red oak (*Quercus rubra* L.) remains a widespread issue with many open questions. Despite the importance of this forest ecosystem, relatively few field stations are situated in this type of ecosystem.

Second, Holt Research Forest has relatively diverse topography and soils. Due to its proximity to the coast, it occupies a range of habitats including salt marshes, tidal estuarine rivers, a

freshwater lake, and forested wetlands. These provide habitat to a variety of critical species like the spotted turtle (*Clemmys guttata* L.). However, this habitat is currently threatened by projected changes in sea levels, precipitation, and temperature. This range of environments and soils creates a variety of additional research opportunities that have not been fully captured in the past. For example, pollen sampling in the lake sediment or monitoring salt marsh migration would add to the breadth and diversity of research.

Third, the Holt Research Forest is located in the rural-urban interface, which is becoming increasingly more abundant on the landscape (Colgan et al. 2014). In fact, Holt Research Forest is situated in an area recently identified in the 75th and 90th percentiles for the percentage of private forest and watersheds with high-quality water to experience increased housing densities, respectively (Stein et al. 2012). Consequently, the Holt Research Forest is well positioned to address some of the emerging issues that arise from managing forest at the rural-urban interface (Colgan et al. 2014). For example, some of the most pressing issues that emerge at the rural-urban interface are the increased presence of deer and their influence on tree regeneration, the need to maintain certain aesthetics, and greater risk of invasion by exotic species. This geographic location also presents an important and timely opportunity to engage and inform non-industrial private forestland owners in the region, which currently own 34% of the forestland in Maine and like Holt Research Forest are primarily located in the southern half of the state.

Finally, the Holt Research Forest is nearing its 35th anniversary and currently maintains a multi-disciplinary database of a variety of long-term ecological studies with many having annual observations. The uniqueness of these data has been recognized by many external institutions and has led to numerous collaborations and publications. These data continue to be maintained and collected with additional collaborations emerging. For example, NASA has recently tested its new Goddard's LiDAR, Hyperspectral & Thermal Imager (G-LiHT) portable imaging system (Cook et al. 2013) for the second time at the Holt Research Forest, with the most recent flight being in the early summer of 2015.

Overall, the Holt Research Forest is a unique field site with significant opportunities because of its proximity to a major metropolitan area, ecological features, and an extensive multidisciplinary ecological database.

Justification - The time is ripe for a major planning effort because of the temporal confluence of four streams. First, in 2014 sponsorship of the Holt Research Forest programs (and assets) shifted from a California-based family foundation to the Maine TREE (Timber Research and Environmental Education) Foundation, a statewide organization with a strong education agenda but no experience supporting research. Second, as of 2015, the three faculty members who led the Holt Research Forest for over 30 years have retired or partially retired and the Associate Scientist who has been responsible for all day to day operations anticipates retiring within the next 5 years. Simultaneously, two much younger faculty members (Weiskittel and Leahy) have assumed leadership roles and bring different sets of expertise to the project, which opens many new research and education opportunities for the Holt Research Forest. Third, it has been 19 years since the last external review and 13 years since the last planning effort were undertaken for the Holt Research Forest. Recent internal work has primarily focused on the current data management protocols and prioritization of existing datasets, but a comprehensive and external

evaluation has yet to happen due to limited time and resources. Fourth and perhaps most important, this is an opportune time with respect to ever-growing interest in the nexus of ideas that are central to work at the Holt Research Forest: conservation in the urban-rural interface, local production and consumption of food and wood, climate change, shifting demographics and land ownership patterns, and holistic ecosystem management based on principles of natural disturbance.

Our initial framing of issues that require careful evaluation is quite diverse, but have primarily focused on how to:

- make our 33-year data set more readily accessible to other researchers
- link our fine-scale information to coarse-scale information (i.e., extending our utility as a NASA testing site)
- capitalize on having a social scientist on our core team
- incorporate other disciplinary perspectives (e.g., biogeochemistry, paleoecology, estuarine sciences) into the existing multidisciplinary approach
- increase site use by other universities (notably, the many urban institutions that are about 3 hours away in Boston)
- transition from public outreach to public engagement with current and new stakeholders
- develop the physical facilities required for expanded programs

To undertake a coherent approach to addressing such a heterogeneous panoply of opportunities will require a careful planning effort.

Proposed Planning Efforts - This proposal calls for a multi-pronged planning process leading to a 10-year strategic plan. The planning effort would consist of eight primary steps:

- 1) Create a Steering Committee (see below) to design the planning process; collate, synthesize, and prioritize recommendations; and write the final report. This Steering Committee would consist of individuals that are both internal and external to the current project.
- 2) Host a one-day conference to showcase past and ongoing Holt Research Forest research including talks, posters, and field tours. Proceedings would be produced from this conference to help document past projects. In addition to the presenters (current and former Holt Research Forest researchers), we would focus on inviting new faculty and graduate students from regional institutions and across the UMaine campus.
- 3) Organize three stakeholder professionally facilitated workshops, one each focused on research, education, and public outreach. For the research workshop our stakeholders would include both researchers from UMaine and other regional institutions who would be interested in using our facilities and long-term data bases, and natural resource managers from government agencies, consulting groups, and private conservation groups who would apply the science generated. The education workshop would include K-12 and university teachers, specialized educators such as those who focus on forest-centered education (e.g., Project Learning Tree) or environmental education groups (e.g., Maine Audubon and Hidden Valley Nature Center). For the public outreach workshop, we would invite stakeholders from diverse groups including the

Maine Forest Service, the Small Woodland Owners Association of Maine, and local landowners (both individuals and groups such as the Kennebec Estuary Land Trust, The Nature Conservancy, and the Maine Dept. of Inland Fisheries and Wildlife). We plan to follow other successful models of engaging stakeholders to help guide strategic planning recently demonstrated by the University of Maine's National Science Foundation Sustainable Solutions Initiative project (e.g. Hart and Calhoun 2010).

4) Invite a Committee of Visitors who are familiar with analogous field stations to visit Holt Research Forest as a group for two days to: see our site; review all our programs assessing our strengths and weaknesses; and make formal recommendations for our future development. We anticipate inviting five people with diverse interests in ecology, forestry, and natural resource management. These would include leaders from major institutions such as David Foster, Director of the Harvard Forest, Gene Likens or Bill Schlesinger, former directors of the Carey Institute of Ecosystem Studies, or Lindsay Boring (a 1996 Evaluation Visitor), Director of the Jones Center for Ecological Research. We would also include representatives from smaller field stations, more similar to ours, such as the Bowdoin Scientific Station, Eagle Hill Institute, Hopkins Memorial Forest Field Station, Huyck Preserve and Biological Research Station, especially those with ties to the Organization of Biological Field Stations. We would try to schedule their visit to overlap with the conference described above.

5) Establish connections with other regional field stations with a focus on forests such as Harvard Forest, Hubbard Brook, Hopkins Memorial Forest, Black Rock Forest Consortium, and the Adirondack Ecological Center. Two of the Steering Committee members will travel to these sites to initiate the creation of a network within the framework of the Organization of Biological Field Stations. Additionally these visits will allow us to learn best practices, collect ideas for new opportunities, and seek advice from other professionals who have similar roles.

6) Consult with experts in affordable and flexible data management, likely from the NEON and LTER networks.

7) Synthesize our findings into a summary document to be presented to the upper administration at UMaine, the Maine TREE Foundation, and other interested parties to bolster their support. In addition, this document could perhaps serve as a foundation for seeking additional resources to assure long-term sustainability at a higher level through a targeted capital campaign.

8) Identify and prioritize actions items identified in the summary document. Each action recommended in the final report will be matched with someone charged with ensuring its timely execution. Similarly moving from plan to action will require a timeline, list of required resources needed and likely funding sources, identification of outputs and outcomes, and an evaluation procedure.

Management of Operations - The PI will be responsible for managing the overall project, overseeing the budget, and reporting to NSF. Anticipated expenses for this planning project are primarily for travel and associated expenses. The PI, co-PIs, and three additional experts will constitute a Steering Committee that will be responsible for:

- selecting and inviting a Committee of Visitors,
- organizing planning meetings with local stakeholders,
- consulting with data management experts,
- designating two Steering Committee members to visit other field labs,
- synthesizing findings,
- producing and distributing a report with an action plan,
- identifying key personnel to begin implementation of such actions,
- presenting the report and communicating with the University's upper administration, Maine TREE Foundation, and other interested parties.

Steering Committee - The members of the Steering Committee will consist of 7 individuals comprised of the 4 PI/Co-PIs for this project as well as 3 external experts. These individuals will bring a diversity of knowledge and skills to this planning project. Collectively, their expertise covers forest ecology, wildlife habitat, human dimensions, technical knowledge of data management, environmental education, and stakeholder engagement. The individuals would include:

Aaron Weiskittel, Associate Professor of Forest Biometrics and Modeling, (P.I.), is a forest ecosystem modeler with expertise in projecting impacts of climate change on forests and using large, long-term ecological datasets. He is the Irving Chair of Forest Ecosystem Management and a Cooperating Scientist with Cooperative Forestry Research Unit.

Jessica Leahy, Associate Professor of Human Dimensions of Natural Resources, (co-P.I.) is a forest social scientist specializing in the application of communication and education theories to natural resource stakeholders and is the Family Forest Program Leader within the Center for Research on Sustainable Forests.

Malcolm Hunter, Librarian Professor of Conservation Biology, (co-P.I.) initiated the Holt Research Forest Project in 1981 and was director until 2015. He is internationally known for his work on the interface of forestry and wildlife management with two books and scores of papers on this topic.

Jack Witham, Associate Scientist, (co-P.I.) has been the resident scientist and field station manager at Holt Research Forest since research activities began in 1983. He has some 40 years of experience with field work and data management and extensive ties to the local communities and stakeholders.

Bruce Wiersma, Retired Dean of the College of Natural Sciences, Forestry and Agriculture. Dean Wiersma's research focused on the establishment and development of a global network of monitoring and research sites to help track the long term transport of pollutants and their possible impacts on natural ecosystems. He is author of a widely used textbook, Environmental Monitoring and he continues to be editor of Environmental Monitoring and Assessment and associate editor of other journals such as Environmental Indicators.

Sherry F. Huber, Executive Director of Maine TREE Foundation, is the former Executive Director of the Maine Waste Management Agency. She served in the Maine House of

Representatives for six years and is a Corporator of Maine Health. She chaired the board of Mainewatch Institute and is a former trustee of the College of the Atlantic. She is a director of the Land Trust Alliance and a former director of NatureServe. She is a former President and current member of the Forest Society of Maine and a member of the University of Maine School of Law Board of Visitors and the Leadership Council of the Yale School of Forestry and Environmental Studies. She is an Advisory Trustee of the Maine Audubon Society and a Trustee Emerita of Waynflete School. She is an Honorary Director of the Friends of Casco Bay. Sherry is a graduate of Smith College.

Kevin T. McCarthy, Board President of Maine TREE Foundation, is currently Manager of Certification for Sappi Fine Paper North America with responsibilities in the areas of fiber certification and chain of custody for FSC, SFI, PEFC and other certification systems. In addition, he is responsible for the design and development of business systems for the wood procurement group. Prior to joining Sappi, Kevin had a 30 year career with International Paper where he managed technical forestry services and land transactions for operations in the northeast and north central United States. He is a licensed professional forester, wood scaler and internal auditor with advanced degrees in forestry. He is a member of the Society of American Foresters, the Institute of Internal Auditors and SWOAM and serves as President of Forest Industries Telecommunications, Inc. Kevin serves on numerous industry committees and is an active member of Ducks Unlimited, the Wild Turkey Federation and the Ruffed Grouse Society.

Timeline

If this proposal is funded, the Steering Committee will work in summer of 2016 to select and invite the Committee of Visitors and begin other aspects of the project planning. The networking with other field stations and stakeholder meetings will begin in fall of 2016. We anticipate the one-day conference, Committee of Visitors review, and the remaining stakeholders meetings to occur in the summer of 2017. To manage our workload, the majority of interactions with the data management experts as well as the synthesis and report writing will occur in winter of 2018.

Table 2. Gant chart of proposed activities by year and quarter.

Activity	2016		2017				2018
	Q3	Q4	Q1	Q2	Q3	Q4	Q1
Formation and meeting of Steering Committee							
Establish connections with other nearby regional field station							
Facilitated workshop with undergraduate and graduate students							
Conference showcasing past and current							

Activity	2016		2017				2018
	Q3	Q4	Q1	Q2	Q3	Q4	Q1
research							
Site visit by Committee of Visitors							
Facilitated workshop with research stakeholders							
Facilitated workshop with public outreach stakeholders							
Consult with experts on data management							
Prepare and present final report to interested parties							

Research and Training Use of the Facility during the most recent five-year period.

Scientist and Student Day Use- HRF is open and available for use by visiting scientists and students. Table 3 shows use during the most recent 5 year period. Approximately 40% of visiting investigator days were overnight visits. To date, over 110 undergraduates have worked here with a majority of them going on for graduate degrees.

Educational Activities & Meetings

Visiting Colleges – University of Maine, ME; Unity College, ME; University of Southern Maine, ME; Bates College, ME; in conjunction with forestry/ecology courses/labs.

Offsite outreach activities – Jack Witham has given talks or participated in workshops by Small Woodlot Association of Maine, Foresters for the Birds, Project Learning Tree, Kennebec Estuary Land Trust, Bath Community Forestry Committee, Friends of Merrymeeting Bay, Maine Land Trust Network, Maine Forest Service and a symposium Many Rivers, One Estuary at Bowdoin College.

Table 3. User days at the Holt Research Forest by affiliation to the University of Maine.

By Program (total number of people)	All visitors	UMaine	Non UMaine
K-12 Teachers	14	0	14
Visiting Colleges (classes)	100	0	100
Visiting Investigators	130	95	35
Workshops/Meetings	121	12	109
Totals	349	95	254

Summary of the most significant research and training accomplishments

Education and Training – All university faculty members are involved in mentoring undergraduates, graduate students and postdoctoral fellows. The Holt Research Forest's educational programs have focused on natural resource professionals and forest land owners (private non-industrial). Graduate and undergraduate students gain valuable training and work experience during summer field seasons at Holt Research Forest. As mentioned above, a total of 110 undergraduate and 12 graduate students have been involved with research there.

Research – Examples of the diversity of research carried out at the Holt Research Forest are presented below, together with 10 publications.

Aaron Weiskittel is the current PI at the Holt Research Forest. Since joining the University of Maine in 2008 has been using data collected at the Holt Research Forest. This has ranged from assessing variation in the relationship between tree diameter and height to the influence of spatially-explicit competition indices on tree dynamics. Recently, Dr. Weiskittel has supported three primary research projects on the HRF. The first is assessing regional variation in tree biomass and allocation, which has involved destructively sampling and dissecting several trees of various species at the Holt Research Forest. The second project is evaluating the long-term influence of tree form and vigor on observed growth and mortality. This has involved re-measuring many of the long-term research plots. Finally, Dr. Weiskittel has been engaged with the ongoing remote sensing research at the Holt Research Forest. This has involved using the LiDAR to map aboveground biomass at a 10x10 m resolution and the combination of high-resolution digital imagery and hyperspectral to map individual tree crowns and their health. This research has leveraged the large stem-mapped data available at the Holt Research Forest and will continue in the future.

Malcolm Hunter is the founding previous PI at the Holt Research Forest, recruiting and leading the team that designed the research and management program. His graduate students at the Holt Forest have studied both basic ecology and the impact of forest management. Topics have included bird community response to canopy gaps and other forest edges, tree seed predation by small mammals, methodologies for surveying salamanders, fruiting behavior of herbaceous plants, and effects of lichens on the distribution of mites. A substantial portion of his overall research (at the Holt Forest and elsewhere) has focused on the interface of forestry and biodiversity and he has written two books, and many review articles, essays, and original research papers on this topic.

Dr. Joanne M. Sharpe, an independent researcher also associated with Luquillo LTER site, has completed the fifteenth year of an ongoing long-term monitoring of ferns at the HRF. Over 750 individuals of the marginal wood fern, *Dryopteris marginalis*, and the glandular wood fern, *Dryopteris intermedia*, have been tagged. These long-lived species have very low mortality rates and have been examined annually to assess leaf growth, spore development, and herbivore/fern interactions. One goal is to make comparisons of growth, longevity, and fertility to similar tropical fern species. In 2016, the methodologies of Pérez-Harguindeguy et al. (2013) will be used for HRF ferns to assess plant functional traits.

Since 1989, HRF has been cooperating with Maine Medical Center Research Institute's Vector-borne Disease Laboratory to research the many biological and non-biological influences that contribute to the emergence and establishment of deer ticks in Maine. This effort led by Robert Smith, MD and Peter Rand, MD, has examined tick burdens on small mammals trapped at HRF. Collected ticks are identified to species, sex, and life stage and tested for prevalence of the Lyme agent, *Borelia burgdorferi*. Consistent with regional trends in Maine, a major development at HRF has been the appearance of the vector of Lyme disease, the blacklegged tick (*Ixodes scapularis*) and Lyme disease itself. Results to date show replacement of other tick species by blacklegged tick and an increasing prevalence of *B. burgdorferi*. In future years, we hope to study the prevalence of *B. burgdorferi* infection in mice and blacklegged tick and tick burdens as they relate to the cyclic white-footed mouse populations here at HRF.

Selected Bibliography – 10 representative publications

Campbell, S. P., J. W. Witham, and M. L. Hunter, Jr. 2010. Stochasticity as an alternative to deterministic explanations for patterns of habitat use in birds. *Ecological Monographs* 80: 287-302.

Campbell, S. P., J. W. Witham, and M. L. Hunter, Jr. 2012. Long-term changes in spatial distribution of birds responding to a group-selection timber harvest. *Wildlife Society Bulletin* 36: 313–327.

Colgan, C., M. L. Hunter, B. McGill, and A. Weiskittel. 2014. Managing the middle ground: Forests in the transition zone between cities and remote areas. *Landscape Ecology* 29: 1133-1143.

Haynes, K. J., A. M. Liebhold, T. M. Fearer, G. Wang, G. W. Norman, and D. M. Johnson. 2009. Spatial synchrony propagates through a forest food web via consumer–resource interactions. *Ecology* 90: 2974–2983.

Lambert, A. M. and R. A. Casagrande. 2006. No evidence of fungal endophytes in native and exotic *Phragmites australis*. *Northeastern Naturalist* 13: 561–568.

Li, X., K. J. Boyle, T. P. Holmes, and G. P. LaRouche. 2014. The effect of on-site forest experience on stated preferences for low-impact timber harvesting programs. *Journal of Forest Economics*, 20: 348-362.

Lucas, R. W. and B. B. Casper. 2008. Ectomycorrhizal community and ecosystem functioning following simulated atmospheric N deposition. *Soil Biology and Biochemistry* 40: 1662-1669.

Moore, E. H. and J. W. Witham. 1996. From forest to farm and back again: land use history as a dimension of ecological research in coastal Maine. *Environmental History* 1: 50-69.

Plucinski, K. E. and M. L. Hunter, Jr. 2001. Spatial and temporal patterns of seed predation on three tree species in an oak-pine forest. *Ecography* 24: 309–317.

Wang, G., J. O. Wolff, S. H. Vessey, N. A. Slade, J. W. Witham, J. F. Merritt, M. L. Hunter, Jr. and S. P. Elias. 2009. Comparative population dynamics of *Peromyscus leucopus* in North America: influences of climate, food, and density dependence. *Population Ecology* 51:133–142.

Broader Impacts - The Holt Research Forest currently provides access to long-term ecological data and other research opportunities to researchers. There is also a public outreach component to the Holt Research Forest with a variety of educational workshops and engagement of interested stakeholders. The planning process is anticipated to identify and create additional opportunities for research, education and public outreach. We have identified several broader impacts, which are elaborated on below.

The long-term data and research that relies on those data provide value to society by contributing important findings that will only become more important given forest conditions that are expected under climate change scenarios. The Holt Research Forest focuses on research that contributes to healthy managed forest ecosystems. The oak-pine forest type is commercially valuable and the forest products industry is a significant part of the region's forest economy. The ecosystem services, including clean water, biodiversity, and recreation, provided by these forests also impact the economic and social conditions of adjacent communities.

Currently, the Holt Research Forest provides educational opportunities for limited numbers of undergraduate and graduate students, K-12 students, and adult learners. A key outcome of the planning grant and the resulting 10-year strategic plan would be the creation of expanded opportunities for teaching, training and learning to graduate students, post-doc and junior faculty, undergraduate students, K-12 teachers and youth, and adult learners (including natural resource professionals and the general public). Our Steering Committee includes individuals able to facilitate opportunities, including educators at the University of Maine as well as the state coordinator of Project Learning Tree, a K-12 forest-based environmental education program.

The strategic plan would include activities to build opportunities for underrepresented minorities. This will include exploring options for participating in existing relevant programs at the University of Maine such as the forest-based NSF Research Experiences for Undergraduate project, the Department of Education STEM-focused English-language learners project (Project REACH), and various high school girls STEM camps (4-H, College of Engineering, etc.). We will reach out to other partners. For instance, the adjacent landowner, The Nature Conservancy, has a program for underrepresented groups (LEAF) that brings urban youth to Maine for natural resources-based work. Maine has a small but quickly growing minority population. For example, over 95 languages are spoken by English-language learners in Maine's K-12 schools. Largely attributed to immigration from Somalia and Sudan, Maine's black population grew 128% between the 1990 and 2010 Census (Hoey, 2011). The Somali language is spoken by 37% of K-12 English-language learners, followed by Spanish, Arabic, and French (Quebecois).

Our planning process will build critical connections between Holt Research Forest and other field station leaders. Informal networks allow for information transfer, support, and resource sharing between field stations. We will also explore formally creating a network of forest ecosystem field stations of comparable size in our region. The benefits of the informal and

formal connections will extend beyond the Holt Research Forest, and benefit other field stations with common interests and issues.

We strongly believe a strategic plan would lead to enhanced infrastructure, refined data management implementation, and broader dissemination of research data and results. The Holt Research Forest stakeholders, from researchers and students using the long-term data, to K-12 youth developing connections with natural and managed forests, to natural resource professionals implementing the findings in locations around New England, will benefit from our strategic planning efforts, ensuring the continued longevity of this unique field station.

Results from Prior NSF Support - The Holt Research Forest has no prior FSML awards.

Fee Schedule - No fees are currently charged. As part of this proposed planning grant, a full analysis of a potential fee structure will be conducted.

References Cited

- Campbell, S. P., J. W. Witham, and M. L. Hunter, Jr. 2007. A long-term study on the effects of a selection timber harvest on a forest bird community in Maine. *Conservation Biology* 21: 1218–1229.
- Campbell, S. P., J. W. Witham, and M. L. Hunter, Jr. 2010. Stochasticity as an alternative to deterministic explanations for patterns of habitat use in birds. *Ecological Monographs* 80: 287–302.
- Campbell, S. P., J. W. Witham, and M. L. Hunter, Jr. 2012. Long-term changes in spatial distribution of birds responding to a group-selection timber harvest. *Wildlife Society Bulletin* 36: 313–327.
- Colgan, C., B. McGill, M. L. Hunter, and A. Weiskittel. 2014. Managing the middle ground: Forests in the transition zone between cities and remote areas. *Landscape Ecology* 29: 1133–1143.
- Cook, B. D., L. W. Corp, R. F. Nelson, E. M. Middleton, D. C. Morton, J. T. McCorkel, J. G. Masek, K. J. Ranson, V. Ly, and P. M. Montesano. 2013. NASA Goddard's Lidar, Hyperspectral and Thermal (G-LiHT) airborne imager. *Remote Sensing* 5: 4045–4066, doi:10.3390/rs5084045.
- Elias, S. P., J. W. Witham, and M. L. Hunter, Jr. 2006. A cyclic red-backed vole (*Clethrionomys gapperi*) and seedfall over 22 years in Maine. *Journal of Mammalogy* 87: 440–445.
- Elias, S. P., J. W. Witham, and M. L. Hunter. 2004. *Peromyscus leucopus* abundance and acorn mast: population fluctuations over 20 years. *Journal of Mammalogy* 85: 743–747.
- Hart, D. D., and A. J. K. Calhoun. 2010. Rethinking the role of ecological research in the sustainable management of freshwater ecosystems. *Freshwater Biology* 55: 258–269.
- Iverson, L. R., A. M. Prasad, S. N. Matthews, and M. Peters. 2008. Estimating potential habitat for 134 eastern US tree species under six climate scenarios. *Forest Ecology and Management* 254: 390–406.
- Kimball, A. J., J. W. Witham, J. L. Rudnický, A. S. White, M. L. Hunter, Jr. 1995. Harvest created and natural canopy gaps in an oak_pine forest in Maine. *Bull. Torrey Bot. Club* 122: 115–123.
- Monti, L. M., M. L. Hunter, Jr. and J. W. Witham. 2000. An evaluation of the artificial cover object (ACO) method for monitoring populations of the Redback Salamander (*Plethodon cinereus*). *Journal of Herpetology*. 34: 624–629.
- Pérez-Harguindeguy, N., S. Díaz, E. Garnier, S. Lavorel, H. Poorter, P. Jaureguiberry,

M. S. Bret-Harte, W. K. Cornwell, J. M. Craine, D. E. Gurvich, C. Urcelay, E. J. Veneklaas, P. B. Reich, L. Poorter, I. J. Wright, P. Ray, L. Enrico, J. G. Pausas, A. C. de Vos, N. Buchmann, G. Funes, F. Quétier, J. G. Hodgson, K. Thompson, H. D. Morgan, H. ter Steege, M. G. A. van der Heijden, L. Sack, B. Blonder, P. Poschlod, M. V. Vaieretti, G. Conti, A. C. Staver, S. Aquino and J. H. C. Cornelissen. 2013. New handbook for standardised measurement of plant functional traits worldwide. *Australian Journal of Botany* 63: 167-234.

Schumann, M. E., A. S. White, and J. W. Witham. 2003. The effects of harvest-created gaps on plant species diversity, composition, and abundance in a Maine oak-pine forest. *Forest Ecology and Management* 176 : 543-561.

Stein, S., M. Carr, R. E. McRoberts, and L. G. Mahal. 2012. Forests on the Edge: The influence of increased housing density on forest systems and services. In: David N. D.N. Laband, B.G. Lockaby, and W. Zipperer (Eds.). *Urban–rural interfaces: Linking people and nature*, American Society of Agronomy, Soil Science Society of America, Madison, WI. p. 49-70.

White, A. S., J. W. Witham, M. L. Hunter, Jr., and A. J. Kimball. 1999. Relationship between plant species richness and biomass in a coastal Maine *Quercus-Pinus* forest. *Journal of Vegetation Science* 10: 755-762.

Facilities, Equipment and Other Resources:

Administration

-UMaine, MAFES, Maine TREE Foundation

Staff

-Jack Witham, undergraduate, and grad students

Facilities/Infrastructure (research areas, buildings)

The on-site facilities consist of a log house, and a two-story garage/lab. The log house is the residence for the on-site researcher/manager. The second floor garage/lab is primarily used as office space for the on-site staff but also has a multipurpose work area, kitchen, and bathroom. A small travel trailer on a developed site serves as temporary housing for students and others working on the site.

Equipment

Several computers, printers, copier, and a variety of field equipment.

Access & Transportation

-Paved public road

-Proximity to major metropolitan areas (Portland, Lewiston and Auburn, Boston, greater northeast population)

-Trail system

-Adjacent neighbors (The Nature Conservancy, Maine Dept. of Inland Fisheries and Wildlife)

Cyberinfrastructure

-Computer resources at Holt Research Forest

-Computer resources in Nutting Hall, UMaine

-Advanced Computing Group, Neville Hall, UMaine

-DataVerse, KNB, Morpho

Other Resources

Budget and Justification

SALARY: \$0

No salary is requested and therefore no fringe benefits are requested.

TRAVEL: \$7,500

Domestic In-State Travel is requested for the Steering Committee to travel for meetings together, and for in-state researchers and stakeholders to travel to the Holt Research Forest for meetings and to participate in the review by the Committee of Visitors. Total domestic in-state travel = \$2,500 (Year 1 \$500; Year 2 \$2,000).

Domestic Out-of-State Travel is requested for Holt Research Forest staff and members of the Steering Committee to travel to other forest ecosystem field stations, meet with potential future users of the Holt Research Forest, and participate in professional meetings that present and advance the strategic planning efforts. Total domestic out-of-state travel = \$5,000 (Year 1 \$2,000; Year 2 \$3,000).

Item	Year 1	Year 2	Total
In-State Travel			
Car rental (\$50/day)	-	\$250 (5 days)	\$250
Mileage (\$0.44/mile)	\$500 (4 round-trips from Orono to Arrowsic, Maine and additional trips)	\$860 (5 round-trips from Orono to Arrowsic, Maine and additional trips)	\$860
Per Diem (\$46/day)	\$0	\$230 (5 days)	\$230
Conference registration (\$100/meeting)	\$0	\$200 (2 meetings)	\$200
Hotel (\$115/night)	\$0	\$460 (4 nights)	\$460
Subtotal	\$500	\$2000	\$2500
Out-of-State Travel			
Car rental (\$50/day)	\$250 (5 rentals)	\$250 (5 rentals)	\$500
Per diem (\$46/day)	\$460 (10 days)	\$460 (10 days)	\$920
Hotel (\$115/night)	\$920 (8 nights)	\$920 (8 nights)	\$1840
Airfare (\$500/ticket)	\$0	\$1000 (2 tickets)	\$1000
Mileage (\$0.44/mile)	\$370 (840 miles)	\$220 (500 miles)	\$590
Conference registration	\$0	\$150	\$150
Subtotal	\$2000	\$3000	\$5000
Total	\$2500	\$5000	\$7500

PARTICIPANT COSTS: \$7,000

Travel (out of state) is requested to provide travel support for the Committee of Visitors (6), potential future users of the Holt Research Forester, past researchers and regional stakeholders. Total participant cost travel (out of state) = \$5,000 (Year 1 \$1,000; Year 2 \$4,000).

Subsistence would be used to provide lunch and coffee breaks for the various hosted events like the one-day conference, visit by Committee of Visitors, etc. The number of individuals expected at these various events is 15 to 40. Total subsistence \$2,000 (Year 1 \$500; Year 2 \$1,500).

Item	Year 1	Year 2	Total
Car rental (\$50/day)	\$200 (4 days)	\$200 (4 days)	\$400
Mileage (\$0.44/mile)	\$110	\$190	\$300
Per Diem (\$46/day)	\$230 (5 days)	\$460 (10 days)	\$690
Airfare (\$500/ticket)	\$0	\$2000 (4 tickets)	\$2000
Hotel (\$115/night)	\$460 (4 nights)	\$1150 (10 nights)	\$1610
Catering	\$500	\$1500	\$2000
Subtotal	\$1500	\$5500	\$7000

OTHER DIRECT COSTS: \$5,100

Materials and supplies will include printed materials such as documents, plans, color printed maps, etc. that will be provided to the Committee of Visitors, stakeholders and others. There will also be a printed proceedings from the one-day conference. Supplies will include those necessary for need assessment meetings such flip charts, markers, digital tape recorder, etc. Total materials and supplies = \$2,600 (Year 1 \$1100; Year 2 \$1,500).

Consultant services including the hiring of a consultant to facilitate, record and synthesize meetings with stakeholders as well as other aspects of the strategic planning effort. Total professional services = \$2,500 (Year 1 \$1000; Year 2 \$1,500).

TOTAL DIRECT COSTS: \$19,600 (Year 1 \$6,100; Year 2 \$13,500)

INDIRECT COSTS: 42.8% of Modified Direct Costs \$5,393 (Year 1 \$1,969; Year 2 \$3,424).

TOTAL REQUEST: \$24,993 (Year 1 \$8,069; Year 2 \$16,924)

Data Management Plan:

Over the last 12 months, the Holt Research Forest staff have developed a data management plan and have begun to implement the initial stages of that plan. The strategic plan, and related materials, datasets, and records developed through this planning grant will be archived and stored following our data management plan. This way the strategic plan efforts can be easily referred to in the future.

The data generated by the Holt Research Forest comes largely from the field, encompassing a wide range of measurement and assessment techniques. These data are collected using instruments and methods described in the original and subsequent Holt Research Forest proposals. The data available include those generated from hand measurements, electronic data loggers, and other commonly accepted data acquisition software. Data, soil and other samples are typically retained for at least three years beyond the award period, as required by NSF guidelines. Due to the unique nature of the many individual projects at the Holt Research Forest, development of a uniform system of data acquisition and storage was challenging. Using resources from the Advanced Computing Group at the University of Maine, we have developed a system for optimizing formatting and storage of data for current and future users. All data are stored in EXCEL or ACCESS based files with appropriate project numbers, plots, dates, variable definitions, and other metadata to aid in future use. Data are managed and stored at the University of Maine's Dataverse. Data in this planning grant will be archived here.

Members of the Steering Committee with access to data will receive instruction in Responsible Conduct of Research (RCR). When requested, data will be made available within a reasonable period of time for sharing to qualified parties by the Holt Research Forest, so long as such a request does not compromise intellectual property interests, interfere with publication, betray confidentiality, or precede data curation. Shared data will include standards and notations needed to interpret the data, following commonly accepted practices in the field. Data will be available for access and sharing as soon as is reasonably possible.

In the event that discoveries or inventions are made in direct connection with our planning grant, then these data will be granted upon request once appropriate invention disclosures and/or provisional patent filings are made. Key data relevant to the discovery will be preserved until all issues of intellectual property are resolved. The data acquired and preserved in the context of this proposal will be further governed by the University's policies pertaining to intellectual property, record retention, and data management. Other than the 10-year strategic plan, we do not anticipate any publications to originate as a direct result of the planning grant. However, should that occur, any published data can be used and/or distributed in any way following the initial publication of the data. There will be no requirements regarding authorship or acknowledgements, other than as may be arranged at the choice of the authors and individuals who may be re-using the data.

Postdoctoral Researcher Mentoring Plan:

This planning grant does not include any direct funding for post-doctoral researchers. However, with an adopted 10-year strategic plan, we intended to expand opportunities for post-doctoral researchers at the Holt Research Forest. When we do, our goal is to provide post-doctoral researchers with the appropriate level of personalized encouragement, supervision, and support so they can exceed their and our expectations. The mentoring program for each post-doc varies based on their educational background, experience, personality, and personal motivations.

We will follow set processes to mentor each post-doc that becomes involved with the Holt Research Forest. Orientation will include in-depth conversations between the PIs and the Postdoctoral Researcher in the first week of his/her arrival. Mutual expectations will be discussed and agreed upon in advance. Orientation topics will include (a) the amount of independence the Postdoctoral Researcher requires, (b) interaction with coworkers, (c) productivity including the importance of scientific publications, (d) work habits and safety, and (e) documentation of research methodologies and experimental details so that the work can be continued by other researchers in the future. Career counseling will be directed at providing the Postdoctoral Researcher with the skills, knowledge, and experience needed to excel in his/her chosen career path. In addition to guidance provided by the PIs, the Postdoctoral Researcher will be encouraged to discuss career options with other successful researchers. Experience with preparation of grant proposals will be gained by direct involvement of the Postdoctoral Researcher in proposals prepared by the Holt Research Forest.

The Postdoctoral Researcher will have an opportunity to learn best practices in proposal preparation including identification of key research questions, definition of objectives, description of approach and rationale, and construction of a work plan, timeline, and budget. Publications and presentations will be expected to result from the work at the Holt Research Forest. These will be prepared under the direction of the PIs. The Postdoctoral Researcher will receive guidance and training in the preparation of manuscripts for scientific journals and presentations at conferences as well. Teaching and mentoring skills will be developed in the context of regular meetings within research groups, during which graduate students and postdoctoral researchers describe their work to colleagues within the group and assist each other with solutions to challenging research problems, often resulting in cross fertilization of ideas. Instruction in professional practices will be provided on a regular basis in the context of the research work and will include fundamentals of the scientific method, field safety, and other standards of professional practice. In addition, the Postdoctoral Researcher will be encouraged to affiliate with one or more professional societies in his/her chosen field. Finally, technology transfer activities will include regular contact with stakeholders of the Holt Research Forest. The Postdoctoral Researcher will be given an opportunity to become familiar with providing tours to natural resource professionals, the general public, and K-12 teachers and students. Success of the Mentoring Plan will be assessed by monitoring the personal progress of the Postdoctoral Researcher, achievement of his/her career goals, and finishing the postdoctoral research experience.