ECOSYSTEM FUNCTION AND HEALTH PROGRAM CHARTER

Pacific Southwest Research Station

Review and Approval (Adapted from FSM-4000-1)

ECOSYSTEM FUNCTION AND HEALTH PROGRAM
Pacific Southwest Research Station
Executive Summary

The forests and wildland ecosystems of California, Hawai'i, and the US Affiliated Pacific Islands are exceedingly diverse and provide a wide array of societal goods and services. From clean water, timber and non-timber products, and carbon sequestration to recreational use, aesthetic beauty, and native biodiversity, these ecosystems are national treasures that contribute to the prosperity of current and future generations. However, a growing list of environmental pressures, including climate and land-use change, water scarcity, and an increasing human population, threaten the health and integrity of these ecosystems. Therefore, the program's research will focus on the poorly understood interactions among changes in or brought about by biotic and abiotic factors such as temperature and precipitation, invasive species, air pollution, insects, pathogens, and past and current land management actions. In response to these significant and widespread environmental problems, scientists in the Ecosystem Function and Health Program conduct research that provides an integrated understanding of ecosystem function and health and of the biophysical conditions that threaten ecosystem resilience, including how environmental changes are initiated and progress, what thresholds are associated with these changes, and what the consequences are of crossing identified thresholds.

Research in the program will focus on the following four problem areas:

1. Determine how biophysical factors influence the function and productivity of tropical, subtropical and temperate ecosystems. Past harvesting practices, extensive fire suppression, and forest fragmentation have reduced forest ecosystem resiliency and health across much of California, Hawai`i and the Pacific Islands.
2. Quantify and predict ecosystem responses and adaptation to environmental stressors. The ability of land managers and policymakers to provide sustainable flows of goods and services from forests and watersheds has been significantly diminished, due to unprecedented stresses on forest ecosystems, including wildland fire, outbreaks of native and invasive species, as well as changes in climate and land use.
3. Define and measure the impacts of biotic and abiotic stresses on hydrological and atmospheric systems. Our water and air resources are both at serious risk across the Pacific Southwest region due to multiple environmental impacts and increased societal demands.
4. Develop models and tools, and evaluate management options for restoring, sustaining and enhancing ecosystem function and productivity. Land managers are accountable to the public to show that their actions effectively achieve management goals while maintaining or restoring properly functioning terrestrial, aquatic, and riparian ecosystems.

Research within the Program will enhance knowledge and develop strategies to address interacting disturbance processes, specifically insect and disease outbreaks, resource extraction, and global environmental change over multiple temporal and spatial scales. Our expected outcomes include science and technology to:

- Improve ecosystem function, health, and productivity and provide viable forest and wildland habitats for future generations.
- Develop techniques and indicators for assessing the functionality and health of ecosystems.
- Sustain water resources in the arid, semi-arid and tropical environments of the California, Hawaii and the Pacific Islands.
- Understand the underlying mechanisms of ecosystem adaptation to climate change, land use change, poor air quality and other environmental stressors.
- Improve understanding and provide management options to mitigate impacts of invasive species and those native species that become damaging because of climate change..

R&D PROGRAM NUMBER

TBD

STATION

Pacific Southwest Research Station (PSW)

R&D PROGRAM LOCATIONS

Albany, Arcata, Davis, Fresno, Placerville, Redding, and Riverside, California
Hilo, Hawai`i

R&D PROGRAM TITLE

Ecosystem Function and Health

PROGRAM MANAGER

David Levinson, Ph.D.

AREA OF APPLICABILITY

Program research, development, and science delivery is focused on California, Hawai`i, and the US Affiliated Pacific Islands, with regional, national, and international collaborations contributing fundamental knowledge that is relevant to problems and issues at all geographic scales.

ESTIMATED DURATION

This Program is chartered for 10 years (2011–2021) with a mid-term review and potential charter revision after 5 years (in 2016). Amendments will be made as needed to address emerging issues.

MISSION

To lead the development and communication of knowledge and technology required to sustain, enhance and restore the function, health, and productivity of ecological, hydrological, and atmospheric systems, and associated benefits to society.

OUTCOMES

To develop knowledge and technologies required to quantify ecosystem function and health, understand how global change, pollution, and land use impact ecosystems, and to manage or rehabilitate ecosystems for enhanced resilience to change. Our work will provide the science and technology to address the following outcomes:

1) Improve ecosystem function, health, and productivity in order to provide sustainable and viable forest and rangeland habitats for future generations. To achieve this outcome, we must develop the techniques and measurable indicators (outputs) for quantifying the function, productivity, and health of ecosystems.
2) Provide sustainable water and air resources in the arid, semi-arid and tropical environments of the Pacific Southwest region. Understand the underlying mechanisms of ecosystem change, including drivers such as climate change and disturbance agents (e.g. fire, insects, disease, invasive species, land use change, etc.) and their individual and cumulative impacts on watersheds and airsheds.
3) Develop adaptable approaches and effective technologies for sustaining, enhancing or restoring capacity and productivity of tropical, subtropical and temperate ecosystems. The results will provide specific methods and tools that improve the ability of ecosystems to provide goods and services under a changing climate.

JUSTIFICATION AND PROBLEM ANALYSIS

Society depends on forest, rangeland, riparian and aquatic, alpine, sub-alpine, and desert ecosystems for goods and services essential to human well being. The functioning of these ecosystems is controlled by physical and biological processes and the interactions of these processes with climate change, invasive species, land-use, air pollution, resource management actions, and natural disturbances. Improved understanding of ecosystem function and the underlying processes, especially in response to global climate change, is of critical importance to developing and implementing sustainable natural resource management strategies and policy. Research will contribute to fundamental scientific knowledge and to science-based management options, designed to sustain, enhance, or restore ecosystem capacity to provide goods and services under changing conditions. Research will provide products and assessments for use at regional, national and international levels.

The Problem Areas for the Ecosystem Function and Health Program are designed to build on fundamental knowledge of hydrology, micrometeorology, climatology, biogeochemistry, geomorphology, forestry, entomology, chemical ecology, landscape ecology, statistical sciences, silviculture, soil science, and disturbance ecology, among others, to understand and quantify how existing and emerging threats are initiated and progress, the consequences associated with crossing ecological thresholds, and actions that can be taken to sustain, enhance, and restore ecological, hydrological and atmospheric resources. Research will serve to define potential future ranges of physical and biological conditions associated with current and potential changes, as well as provide decision support tools needed by managers and policymakers to address these changes. The PSW Research Station's network of experimental forests, ranges and watersheds will provide a platform to conduct this research, develop technology transfer products, and demonstrate how management can sustain, enhance or restore ecosystem function, health, and

productivity. Program scientists will also rely on partnerships with regional and national universities, state and local resource agencies, international partners, nongovernmental organizations, States, Tribes, and the forest industry.

Transfer of scientific and technical information and the creation and delivery of products and services to the science, policy and natural resource management communities will enable PSW research to be accessible and useful and so enhance the impact of Program research. Dissemination of science findings will include conventional peer-reviewed or refereed publications, presentations at scientific meetings and direct consultation with peer scientists external to the Program. Technology transfer programs to external users will be designed and delivered by science staff in partnership with PSW Communications Group and leadership through publications, websites, videos, workshops and field courses, field visits and decision support tools. Program scientists will engage in partnerships with National Forest Systems, State and Private Forestry, and International Programs, and other federal agencies including Landscape Conservation Cooperatives, as well as state agencies, universities and nongovernmental organizations to develop and implement information and technology transfer programs. To this end, we will work closely with universities and academic institutions in California, Hawai'i and the U.S. Affiliated Pacific Islands. More specifically we will continue and expand collaboration with researchers and faculty within the University of California system, the California State University system, the University of Hawai'i at Manoa and Hilo, as well as other cooperative institutes and higher education campuses within and outside of the Pacific Southwest region.

In addition, we will continue and expand work with state and federal agencies, including: the California Department of Forestry and Fire Protection, California Air Resources Board, the Hawai`i Department of Land and Natural Resources, Hawai`i Division of Forestry and Wildlife, California Department of Fish and Game, Department of Hawaiian Homelands, and the US Fish and Wildlife Service, National Park Service, Geological Service, Bureau of Land Management, Bureau of Indian Affairs, and Department of Defense, as well as the diverse watershed partnerships and alliances, tribal governments and Native Hawaiian organizations, local agencies, and non-governmental organizations in the region, as well as internationally.

FOCUS AND SCOPE

The Ecosystem Function and Health Program will focus on four broad Problem Areas that are of key importance to understanding ecological, hydrological and atmospheric systems, and to improved management of these systems to sustain, enhance and restore the capacity of these ecosystems to provide goods and services under a changing climate. Specific expertise exists in diverse areas, including but not limited to: (i) the ecology and management of tropical, sub-tropical and western U.S. forests including effects of management on soils, soil microbiology, and soil invertebrates; (ii) mathematical methods required to analyze, model, or otherwise quantify biological and physical data to enhance our understanding of natural resources management; (iii) air pollution impacts on western forests, including effects of pollutants on plant function, soils and soil processes, and water quality; (iv) the effects of climate change on forest biogeography, demography and adaptation, as well as impacts on ecosystem carbon storage, cycling and loss; (v) management and restoration of forests, including the ecology of mixed conifer and subalpine forest stands, accelerating development of late successional stands

through diverse silvicultural approaches, and silvicultural techniques to enhance economic and ecological value of young tropical and sub-tropical forests; (vi) monitoring and management of invasive and native forest insectsand pathogens; and (vii) impacts of climate change and management on upland ecosystems and hydrological systems. Regional, national and international scientific communities will be served by the diverse research conducted by PSW science staff. Finally, through the PSW's Communications Group, new approaches to discuss ecosystem function and health issues with the public will lead to a greater understanding and acceptance of the next generation of resource management strategies and practices.

PROBLEM SELECTION AND TIMELINE

Problem Area 1

Determine how biophysical factors influence the function and health of tropical, subtropical and temperate ecosystems.

Goods and services provided by ecosystems of California, Hawai`i and the US Affiliated Pacific Islands include abundant clean water, carbon cycling and sequestration, plant and animal productivity, recruitment of native biodiversity, high soil quality, and low sediment outputs. Therefore, without a clear understanding of the basic processes and functions of ecological, hydrologic and atmospheric systems we cannot determine the impacts of stressors nor provide tools to sustain, enhance, and restore ecosystem function, health and productivity. Research will examine the different components, patterns and processes of ecosystems to understand how the biophysical environment influences ecosystem function and supports the delivery of ecosystem goods and services.

Planned Topics for Study:

- Design and test methods for quantifying the direct and indirect drivers of ecosystem function, health, and productivity as they operate independently and collectively across different landscapes to develop criteria for effective management of the region's natural resources. Research efforts will complete a pilot study on selected landscapes of interactions between multiple drivers by FY14. Complete in FY20.
- Develop a better understanding of below-ground processes, including carbon storage and dynamics, microbial and mycorrhizal communities and function, and nutrient dynamics, and provide approaches and quantitative criteria for evaluating belowground functioning to enhance productivity and resilience to global changes. Complete in FY17.
- Evaluate the effectiveness of silvicultural and other management practices, both existing and planned, to restore capacity to support production forestry, recruitment of native biodiversity, and ecosystem services. Complete an analysis by FY15 of silvicultural management and sustainable biomass practices as a means of restoring ecosystems and reducing fire danger. Complete in FY20.
- Explore long-term effects of management legacies on ecosystems and identify factors that control how systems recover. Complete in FY18.

Approach to Problem Solution:
Without long-term information on the drivers of ecosystem functioning and mechanistic understanding of the factors that regulate ecosystem function, health, and productivity, it is exceedingly difficult to quantify and understand the effects of the environmental changes addressed in Problem Areas 2 and 3. Research in this Problem Area builds on decades of excellent natural resources research at the Pacific Southwest Research Station to determine the drivers of ecosystem function that will be changing with climate change, invasive species, land-use and other factors. This Problem Area will rely on classic methods for measuring the function, dynamics, and nutrient cycling within forests and non-forest ecosystems, often continuing or enhancing measurements on PSW Experimental Forest and Ranges and building on a legacy of long-term research in representative ecosystems. Research will also rely on other techniques such as remote sensing, radiocarbon and isotope-based analyses of soils and vegetation, and eddy covariance techniques for examining ecosystem productivity. Research accomplished in Problem Area 1 will answer core questions of how these systems function, retain nitrogen and carbon, regulate greenhouse gas emissions, and sustain water yields and downstream water quality. Deliverables from this problem area will be scientific publications, models, knowledge transfer, and advisory services that will improve land owners', managers' and the public's ability to understand the functional outcomes of management at multiple spatial and temporal scales.

Problem Area 2

Quantify and predict ecosystem responses and adaptation to environmental stressors.

A variety of environmental stressors impact ecosystem function, health, and productivity and alter an ecosystem's capacity to provide abundant clean water, sequester carbon, and support native biodiversity. Research will address management actions required for anticipating change related to environmental stressors, and will develop adaptable approaches and effective technologies for sustaining, enhancing or restoring capacity of ecosystems to provide goods and services under a changing climate.

Planned Topics for Study:

- Improve understanding of the broader interactive effects of multiple stressors on ecosystems under various climate change scenarios to better prepare managers and policy makers for changes to ecosystem goods and services that will result from the interacting effects of climate, invasive species, and existing and newly emerging native pests. Develop by FY15 guidelines for sustaining wildlife habitat and resilience of forest- and non-forest ecosystems under changing climate conditions. Complete in FY20.
- Quantify how climate change impacts water and carbon cycles, and terrestrial and aquatic productivity and biogeochemistry, as declines in ecosystem function and health will be exacerbated by increased dominance by invasive species, increased susceptibility of native plants to pathogens and insects, and changes in nutrient deposition. Complete in FY19.
- Improve understanding of how upland vegetation interacts with riparian systems, and

how those interactions might be affected by climate change effects such as changes in precipitation, stream-flow and storm intensity. Complete in FY17.

- Evaluate how responses of various biological and physical components of an ecosystem interact to modify the overall system response to environmental stressors. Evaluate resilience of diverse pine forest types to beetle infestations after fuel reduction and forest restoration treatments by FY15. Complete in FY19.
- Develop new techniques required for estimating biomass storage and distribution in different forests. Analysis and assessment of Carbon storage at regional scales by FY15. Complete in FY17.

Approach to Problem Solution:

The increased risk to ecosystems caused by global change and complex disturbance interactions define future management challenges for the region, and will require a combination of experimental approaches, monitoring, and simulation models to understand and manage for these impacts. The adaptive capacity of ecosystems to provide goods and services will be a core feature of this Problem Area, and research will provide understanding and techniques to enhance the capacity of PSW landscapes to meet societal needs for natural resources. Research will develop knowledge on ecosystem capacity to sequester carbon and adapt to the effects of elevated atmospheric greenhouse gases from Problem Area 1. Deliverables from this problem area will be knowledge in the form of scientific publications, and techniques needed to improve ecosystem function, health, and productivity. Research will inform actions to manage impacts of global change on valued resources at multiple spatial and temporal scales.

Problem Area 3

Define and measure the impacts of biotic and abiotic stresses on hydrological and atmospheric systems.

Research in this Problem Area will examine how ecosystems, and specifically their hydrologic and atmospheric components, respond to stressors, including cumulative watershed effects, changing and variable climate conditions, novel or enhanced disturbance processes, deteriorating air quality, and their interactions. Research will also provide detailed and statistically sound information for forecasting effects and responses to global change at forest scales from an individual tree, to the stand, to landscape-scale.

Planned topics for study:

- Identify new technologies for expanded landscape scale analyses, especially better tools to remotely detect or predict significant environmental and ecological changes, specifically within hydrological or atmospheric systems, to enhance landscape-scale land management capacity. Complete in FY18.
- Quantify how the transport of water, sediment, organic material, and chemical constituents through the watershed influences downstream environments and ecosystem components to develop management practices that can maintain or improve the supply of clean water and reduce flood related hazards. Complete in FY17.

- Quantify relationships among biophysical variables that influence sediment loads and water chemistry to improve management of water quality and the delivery of water-based goods and services. Complete an analysis of long-term variability of sediment loads in alpine and coastal watersheds by FY15. Complete in FY17.
- Monitor and model concentrations of ozone and other toxic pollutants as well as atmospheric nitrogen (N) deposition, to characterize the aerial chemical environment including spatial and temporal distributions of air pollutants, elemental inputs, and nutrient cycling to understand and assess the negative consequences of poor air quality on forest ecosystems. Complete in FY18.
- Characterize air quality and air quality related values from a perspective of human and ecosystem health impacts, leading to development of refined knowledge (such as critical load estimates for N deposition) to inform natural resources management and policy. Initial results from pilot studies across the region completed by FY15. Complete by FY18.

Approach to Problem Solution:

The research within this problem area will focus on mitigating human impacts and environmental stressors on hydrologic and atmospheric systems, and how to adapt these systems to changing climate and land-use conditions. Research will lead to effective resource management approaches and policies for the diverse ecological, hydrological, and atmospheric systems of the region, including information required for the protection of at-risk ecosystems and watersheds; managing systems to increase resilience to exogenous stressors and threats; and the restoration of degraded ecosystems, watersheds and landscapes. Research will focus on developing management options, systems, strategies, and practices for adaptation to global change with a focus on productivity, native biodiversity recruitment and biogeochemical cycles. Deliverables will include analyses of the impacts of biotic and abiotic stressors on forest air and water resources, along with publications and reports describing these results. In addition, the research within this problem area will result in the knowledge required for development of decision support tools for enhancing management effectiveness in the face of changing decisions.

Problem Area 4

Develop models and tools, and evaluate management options for restoring, sustaining, and enhancing ecosystem function and productivity.

Management that spans passive to active actions represents a critical need in the region if ecosystems are to persist, adapt, and function in the face of diverse and growing stressors. Rarely is the option of “no action” viable if managers and society desire to retain functional ecosystems. Without management, many systems will continue to be compromised until the systems are completely transformed and the desirable attributes they support are lost from the system. Therefore, managing ecosystems with the goals of sustaining, enhancing and restoring function, health, and productivity in the face of environmental changes will require the integration of diverse fields of studies. To address this need the focus of research in this Problem Area is on the development of models and tools to aid in providing options to land managers for

restoring and sustaining ecosystem function, and as a result also combines and synthesizes research conducted under Problem Areas 1, 2, and 3.

Planned topics for study:

- Develop new landscape-based approaches to improving coordination and effectiveness of diverse management and restoration efforts to enhance landscape scale capacity of watersheds to meet society's needs for clean water, fiber, carbon management and other goods and services. Near-term milestone is the completion by FY14 of a pilot study to assess carbon storage capacity using new technology. Complete in FY20.
- Develop new resource management approaches needed to accelerate succession for young, secondary forests and non-forest systems to achieve timber production, conservation or restoration goals. Complete in FY16.
- Develop empirical and process-based models of forest growth under various conditions and treatments, including thinning for fire loss risk reduction, to generate biomass, to help managers plan and manage forest health and productivity. Complete in FY16.
- Develop statistical and stochastic methods for quantifying the interacting and interrelated elements of ecological systems, and the uncertainties in association with these systems so that recommendations for management actions are based on robust, clearly understood information. Complete an analysis using data of a limited geographic area focused on a defined set of interactive elements by FY15. Complete in FY20.
- Develop or enhance predictive models of how the physical (elevated temperature, drought) and chemical (aquatic, pedospheric, and atmospheric derived nutrients and pollutants) attributes of environmental change impact carbon, water and nutrient cycles to inform managers and policy makers on potential future management challenges. Complete in FY17.
- Develop landscape-level silvicultural prescriptions and other management techniques, including chemical, semiochemical, and biological control methods, to mitigate the expected effects of climate change on native and invasive forest insect and disease pests. Complete in FY20.

Approach to Problem Solution:

Research results from this Problem Area will guide how vegetation management can be used to mitigate human impacts across the range of ecosystems across the Pacific Southwest region, and how it can be used to adapt these systems to changing conditions so that goods and services are not interrupted or lost. This Problem Area will rely on both traditional and emerging techniques in the fields of: ecosystem ecology to understand plot level mechanisms; ecophysiology with a focus on plant traits and suitability for restoration or enhancing resilience of ecosystems; landscape ecology to understand how management can be strategically applied to large areas of mixed ownerships to maximize provisioning of ecosystem services; remote sensing to quantify attributes of diverse ecosystems across large areas, document changes over time, and measure potential large-scale responses to disbursed treatments; and modeling with a focus on watershed functioning and biogeochemical cycling. This information is relevant to natural resource

scientists, managers, land owners, policy makers and the public at large, as this information shapes how management of these systems will be designed, prioritized and implemented.

Deliverables will be scientific publications, models, knowledge, and tools that will improve landowners', managers' and the public's ability to understand how management can be used to adapt ecosystems to global change, and maintain valued resources, along with decision support tools that can be used to manage or restore ecosystems at multiple spatial and temporal scales, and inform policy.

ENVIRONMENTAL CONSIDERATIONS

No adverse environmental effects are expected as a result of research proposed in this charter, however, the potential will be revisited in the development of problem analyses and study plans. Where necessary, research efforts will comply with outcomes of National Environmental Policy Act analyses.

STAFFING PLAN AND COST ESTIMATES

This Program Charter was developed based on existing personnel. The EFH Program is staffed with a Program Manager and Program Assistant and16 permanent Research Grade Evaluation Guide scientists representing expertise in forest and landscape ecology, forest genetics, alpine ecology, plant pathology, entomology, silviculture, geomorphology, meteorology, invasive species ecology, and physical and ecological effects of fire. An additional 15 permanent employees provide professional and technical support, while administrative support will be provided by the PSW Business Operations Team. The EFH Program will work closely with PSW's Communications Group to deliver creative and innovative services and products, including press releases, brochures, and online web utilities.

The program's members will be organized into three research teams aligned with the *Air, Water and Soil*, the *Resource Management and Use*, the *Invasive Species*, and the *Inventory and Monitoring* Strategic Program Areas (SPAs). To support the proposed research within this Charter, the base budget from appropriated funds will need to be approximately $5 million per year, exclusive of station administrative costs. We do not expect the work to occur on the entire suite of elements at any one time, and we anticipate using creative methods to expand and contract our workforce as necessary. To achieve this flexibility, the Program budget will be supplemented with support from internal regional and national initiatives, and through competitively secured extramural funding. Aspects of this research outlined above, such as economic analysis, will rely on expertise in other programs within the Station, other Forest Service research stations, or other research institutions. We anticipate Program funding to be distributed as follows:

Problem 1: 30%
Problem 2: 20%
Problem 3: 20%
Problem 4: 30%

APPENDIX*:* RELATIONSHIP TO STRATEGIES, OTHER PROGRAMS, OTHER STATIONS, AND REGION 5

Because of the strong cross-disciplinary nature of ecosystem function and health issues, the EFH Program has strong ties to the three other PSW Programs, as described below. The EFH Program also supports PSW's Climate Change and Water Strategic Plans. Further, EFH research, technology and development are ideally suited to support the Western Wildland Environmental Threat Assessment Center (WWETAC), which seeks "*to generate and integrate knowledge and information to provide credible prediction, early detection, and quantitative assessment of environmental threats in the Western United States."* Thus, the EFH Program, through its research in three Problem Areas, and linkages to other PSW Programs, will provide new or improved understanding of how our ecological, hydrological and atmospheric systems function, understanding the stressors and threats to those systems, and develop science to help managers respond to those threats.

Ecosystem Function and Health Program research also supports the national mission of USFS R&D as described within the USDA Forest Service Research and Development Strategic Plan 2008-2012 to *Develop and deliver knowledge and innovative technology to improve the health and use of the nation's forests and rangelands – both public and private,* while being *recognized as a world leader in providing innovative science for sustaining global forest resources for future generations,* as well as four of the Agency's seven strategic plan goals as defined in the *USDA Forest Service Strategic Plan 2007-2012*:

- **Goal 1: Restore, Sustain and Enhance the Nation's Forests and Grasslands.** Research will address invasive species, landscape ecology, global change and range research.
- **Goal 2: Provide, Sustain and Enhance Benefits to the American People.** Research will address provisioning of ecosystem services.
- **Goal 5: Maintain Basic Management Capabilities of the Forest Service.** Research will support creation of decision-support tools and development of technology transfer products, including synthesized information, tools and electronic media. Through the design of next generation management techniques and synthesis of knowledge, Program scientists will provide information critical to enhancing the function and health of western and Pacific ecosystems.
- **Goal 7: Provide Science-based Applications and Tools for Sustainable Natural Resources Management.** Research will be of high-quality and responsive to current and future anticipated priorities, and will lead to facilitation of increased use of research-derived information, tools, and applications.

Alignment with other PSW Programs:

The EFH program overlaps with the three other PSW Research Programs. It is fully expected that researchers in all four programs will seek out collaborations to address particular research questions that cross PSW programs. Opportunities for integration across Programs include:

Fire and Fuels Program

- Interactive effects of management and increasing fire risk due to climate change, including air quality impacts, is a critical area of overlap. Collaborative research will be required to understand how a legacy of non-sustainable management and climate change impact ecosystem function and health through altered fuel loading, distribution or condition, or altered fire regimes.
- Conserving or restoring healthy watersheds. Wildfires impact watershed functioning – including floods and debris flows and indirect effects following conversion of native forest into invasive grass dominated systems. Further, managing watersheds involves incorporating multiple resource objectives within an integrated management framework. Collaborative research will examine interactions between vegetation, water and disturbance, especially in light of climate change and intensified fire regimes.
- Forest carbon storage and emissions. Forests accumulate carbon as they grow and stored carbon in stable forests can offset 10-15% of anthropogenic emissions. In fire-dependent forests, however, episodic fire can cause short-term change in carbon storage. Our research will focus on identifying optimal forest management strategies that create fire-resilient stands and promote long-term carbon storage.
- Invasive species can alter ecosystems by changing resource supply or the acquisition of resources, as well as by altering disturbance regimes. Some invasive species may exacerbate or even create fire regimes through the production and accumulation of novel fuels, the distribution of fire fuels, and altered microclimate through loss of forest cover. These impacts alter ecosystem productivity, nutrient cycling, water quality, and overall watershed functioning. The effects of these biological and physical changes can accumulate across landscapes to alter regional hydrology, wind and weather patterns, air quality, and the supply of ecosystem services.

Conservation of Biological Diversity Program

- Restoration and adaptation. Biodiversity is a critical component of forests at the gene, species, and ecosystem levels, and ecosystem function can serve as a framework for understanding the role of species within communities, ecosystems and landscapes. Through targeted studies and experiments of the role of native species in ecosystems and watersheds, research will provide insights into the mechanisms by which native species regulate the functioning and health of native ecosystems. Management options needed to maintain forest ecosystems will also be needed to protect and preserve biodiversity in our terrestrial, aquatic, and riparian habitats. Research will be aimed at restoring communities and species, promoting habitat connectivity, and introducing ecologically important and genetically appropriate species to the landscape.
- Research will also examine how alterations to hydrologic cycles can affect species including fish, herpetofauna, and mangroves that rely on functioning watersheds to provide clean water for completion of critical life cycles.
- Invasive species impacts on forest function. Invasive plants, animals, and microorganisms have the ability to eliminate native plants or animals from an ecosystem, with possible impacts on ecosystem function. These foreign invaders sometimes alter ecosystem processes (disturbance regimes, nutrient cycling, productivity), and management options are needed to minimize these changes. Research will seek to understand the effects of native and non-native invasive species on forest function, and how restoration of ecosystems through removal of invaders impacts overall forest function and native biodiversity. Collaborative

research is especially needed to investigate how invaders alter productivity, nutrient cycling, and disturbance regimes, in order to provide the tools for restoring both composition and functioning of invaded ecosystems.

Urban Ecosystems and Social Dynamics Program

- The loss of ecosystem services is a detriment to human communities, and yet some human activities can contribute directly and indirectly to the loss of those same services. Collaborative studies will examine the interconnectedness of landscapes and people as they relate to management decisions, ecosystem services, healthy forests, people, and communities. Collaborative research also focuses on the loss of ecosystem services – especially biodiversity, carbon sequestration and provisioning of clean water – to understand what the degradation of ecosystem, watershed, and landscape health means for communities and economies, what barriers prevent positive change, what supporting perspectives or institutional structures exist and can be enhanced, and how social and ecosystem health are link across space and time.
- Collaborative work between this program and the Urban Connections and Social Dynamics program will be required to understand how natural and social systems are coupled, especially how goods and services will be impacted by reductions in ecosystem capacity to provision these goods and services, and how support for conservation, management, and restoration is affected especially in response to changes within wild land/community interfaces. Overarching questions include: 1) how do changed perceptions lead to changes in ecosystems; 2) can changes be enhanced by management activities; 3) how will changes in native ecosystems, under different human activity and management alternatives, lead to changes in ecosystem services; and 4) how will people respond to altered ecosystem state, function, and health under different future scenarios?

Alignment with other Research Station Programs:

The EFH program also aligns with Research Programs of other research stations, and efforts by EFH science staff will be made to engage colleagues across USDA Forest Service R&D to add value to collective efforts across Stations. These include:

Pacific Northwest Research Station Programs: Resource Monitoring and Assessment; Threat Characterization and Management; Land and Watershed Management; Goods, Services and Values; and Ecological Process and Function.

The International Institute of Tropical Forestry: International Programs; Tropical Forest Monitoring, Management and Rehabilitation Research; and Ecosystems Research.

Rocky Mountain Research Station Programs: Air, Water and Aquatic Environments Science; Wildlife and Terrestrial Ecosystems; and Forest and Woodland Ecosystem Science.

Southern Research Station Programs: Threats to Forest Health; Forest Inventory and Monitoring Science; Forest Ecosystem Restoration and Management; and Forest Watershed Science.

Northern Research Station Science Themes: Forest Disturbance Processes; Sustaining Forests; Providing Clean Air and Water; and Natural Resources Inventory, Monitoring and Assessment.

Links to Region 5 of the National Forest System:

Research conducted in all three problem areas of the EFH Program aligns directly with two of five USFS Pacific Southwest Region Strategic Priorities:
1. Climate Change: Helping the National Forests adapt to changes in climate by restoring the resilience of forest, range, and aquatic ecosystems; managing forests to increase the carbon dioxide they capture and store; using forest products to reduce and replace fossil fuel energy; maintaining a climate change research program; and reducing the agency's environmental footprint through sustainable operations.
2. Ecological Restoration: The need for ecological restoration in our national forests is widely recognized due to myriad threats to our landscapes including catastrophic wildfire, invasive species, climate change, and increasing human population pressures. The Forest Service recognizes the need for a more focused approach that clearly identifies ecological restoration as the primary goal for land management actions.