ECOLOGICAL PROCESS AND FUNCTION PROGRAM CHARTER

Pacific Northwest Research Station

Review and Approval

Signature	Title	Recommendation		Date
		Qualified	Unqualified	
/s/ Edward J. DePuit **Recommended**	**Program Manager**			*August 6, 2009*
Recommended RICH VPOLYAT	WATER, AIR, SOIL **Strategic Program Area Lead #1**	✓		9/17/09
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Robert L Deal **Recommended** ROB DOUBRICK	RESOURCE USE SCI **Staff Director #2**			09/23/2009
/s/ Bov B. Eav **Approved**	**Station Director**			*August 6, 2009*
David A Cleaves **Concurred**	**Deputy Chief for Research**			9/24/09

(Adapted from FSM-4000-1)

Qualification: The Charter does not contain the specificity needed by the Washington Office to provide the national oversight identified in the Forest Service Manual, planning, cross station and agency coordination, and responses to Congressional or Administration queries. Submission of a business plan that identifies staffing, resource needs, and planned accomplishments would likely provide the needed information to redeem national responsibilities.

(Adapted from FSM-4000-1)

CHARTER
ECOLOGICAL PROCESS and FUNCTION PROGRAM
Pacific Northwest Research Station

Executive Summary

Society depends on natural ecosystems for a wide array of services and values that contribute to both human sustenance and quality of life. The nature and sustainability of ecosystem services and values is governed by inherent ecological processes and functions in dynamic interaction with environmental changes and ecological disturbances. Full understanding of fundamental ecological processes and functions is hence basic to developing natural resource policy and management options that strive to restore, maintain, or enhance desired ecological conditions and ecosystem services. In light of this:

The mission of the Ecological Process and Function Program is to advance and communicate knowledge of fundamental ecological processes and their interactions at multiple scales, and to develop applications of such knowledge that enable improved management of ecosystems and resources.

The Ecological Process and Function (EPF) Program will broadly focus its efforts on improving understanding of the influences of biophysical environment and natural and human-caused disturbances on fundamental ecological processes and functions; and on identifying, assessing and determining the causes of changes in ecosystem attributes, processes and functions over time. The program's work will address four Problem areas, each with more specifically focused elements:

Problem 1: How does the biophysical environment influence the function and properties of ecosystems, ecological communities, species, populations and organisms?

Problem 2: What are the potential influences of climate change on ecosystem attributes, patterns, ecological processes, and their interactions?

Problem 3: How do disturbances influence ecological patterns and processes, and how do disturbances and ecological processes interact to determine the overall function, attributes and dynamics of ecosystems?

Problem 4: What are the determinants of ecological status and trends of biota and ecosystems?

Work in these areas will address terrestrial and aquatic ecosystems, primarily in the Pacific Northwestern United States, but, in certain cases, extend beyond this region; both physical and biological components of ecosystems (and their interactions); and multiple levels of ecological organization. Research will be conducted at multiple spatial and temporal scales. The EPF Program's research will be integrated with that in all other PNW Station programs. EPF will be a source of knowledge on fundamental ecological relationships that will augment, inform, and underpin applied work in other PNW programs.

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STATION
Pacific Northwest Research Station

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R&D PROGRAM TITLE
Ecological Process and Function Program

PROGRAM MANAGER
John A. Laurence, Acting Program Manager

AREA OF APPLICABILITY
The primary geographic area addressed and served by the Ecological Process and Function (EPF) Program is the Pacific Northwestern United States (Oregon, Washington, and Alaska). This principal geographic focus notwithstanding, findings from many of the program's studies will be directly or indirectly, wholly or partially transportable and applicable elsewhere, owing to their emphasis on fundamental ecological relationships and processes that can be common to ecosystems regardless of geographic location. The program also will pursue research relevant to certain of its problems that extend beyond the immediate Pacific Northwest/Alaska region. Such extra-regional work will lead to improved understanding of the national and global context within which the Pacific Northwest fits; and of how ecological processes, disturbances and environmental changes at national and global scales influence the Pacific Northwest and vice versa.

ESTIMATED DURATION
The EPF Program is chartered for 10 years (2010–2020) with a mid-term review and potential charter revision after 5 years (in 2015). Amendments will be made to the charter as needed to address emerging issues.

MISSION
To advance and communicate knowledge of fundamental ecological processes and their interactions at multiple scales, and to develop applications of such knowledge that enable improved management of ecosystems and resources.

JUSTIFICATION AND PROBLEM SELECTION

Program Justification

Society depends on forest, rangeland, riparian and aquatic ecosystems for a wide range of values and services that are essential to both sustenance and quality of human existence. The nature and sustainability of ecosystems are governed by a complex, integrated array of fundamental physical and biological processes that interact with external influences (physical environment, environmental change, and natural and anthropogenic disturbances) to control ecological functions, conditions and dynamics. Improved understanding of fundamental ecological processes and functions therefore is of critical, foundational importance to development and application of natural resource policy and management options that are soundly based upon science.

Purpose

The EPF Program's primary role and function in the Pacific Northwest (PNW) Research Station will be to generate and supply knowledge of fundamental ecological relationships that will augment and inform applied work of other PNW programs as they pursue their specific missions and research problems. In this sense, the EPF Program will assume a foundational role in the PNW Research Station.

A secondary, but still important, role and function of the EPF Program will be to directly generate and communicate applications of improved fundamental knowledge that are relevant to PNW clientele needs. Outcomes of EPF fundamental research will be used as the basis for tools and applications relevant to societal and clientele needs, as developed both by EPF, other PNW programs and by other segments of the scientific community.

Focus and Scope

The broad problem areas identified as the primary foci for EPF Program research will be described in depth in the next section of the charter, but may be summarized as:

a) Understanding the influences of
   - Biological and physical environment (including climate), and
   - Natural and human-caused disturbances on fundamental ecological processes and functions; and

b) Determining the causes of current status and long-term trends in ecosystem attributes, ecological processes and functions.

Common themes for work in all Problem areas include not only advancing fundamental understanding but also developing applications of fundamental knowledge that will assist clientele; and characterizing the nature and implications of uncertainty, error and incomplete knowledge in our understanding ecological processes and function.

The scope of EPF work in the above focal areas will encompass fundamental ecological research that addresses:

- Terrestrial (forest and rangeland) and aquatic ecosystems, as well as their riparian interfaces
- Relationships across multiple spatial and temporal scales, and levels of ecological organization.
- Physical and biological components and processes of ecosystems, as well as their interactions in overall ecosystem function.

Work will involve integrated contributions from EPF scientists in several fields of ecological science (including plant ecology, ecophysiology, wildlife biology/ecology, hydrology, geomorphology, landscape ecology and disturbance ecology), as well as collaborations with scientists in other fields (e.g., social sciences, atmospheric sciences, entomology, plant pathology, aquatic ecology, fisheries sciences) in other PNW programs or external to the station.

The PNW Research Station's network of experimental forests will prove invaluable to the EPF Program's research, especially because addressing certain of the program's research priorities will require long-term ecological research. The EPF Program will both use and assume direct oversight of the Wind River, H.J. Andrews, Starkey, Cascade Head, South Umpqua and Bonanza Creek Experimental Forests, [1] and may also use several other PNW experimental forests and research natural areas..

Needs and Benefits

As a basis for planning and implementing resource management, resource managers and policymakers need comprehensive, science-based understanding of how ecosystems function, and how they respond to changes and natural and human interventions. Despite past scientific progress, our knowledge of fundamental ecological processes and functions is far from adequate to meet the needs of the management community. Substantial gaps in understanding exist on how species, ecosystem attributes and fundamental ecological processes respond to:

- Specific changes in the biological or physical environment, with climate change a conspicuous current example
- Natural and human-caused disturbances, with wildland fire and active resource management conspicuous current examples
- Interactions among environmental changes and disturbances at varying spatial (especially broad) and temporal (especially long-term) scales

Research under EPF's four Problems will contribute substantial new knowledge of fundamental ecological relationships and responses relevant to each of the above areas. Such knowledge will be of immediate, direct benefit to resource managers and policymakers when understanding of fundamental ecological responses is necessary for

[1] Strategic Business Plans have been prepared for these experimental forests and may be referenced for detail on purpose/goals, resources, research plans and research opportunities.

making management or policy decisions. It also will benefit the scientific community (including other PNW programs) by advancing both ecological theory and basic scientific understanding of how and why ecosystems function as they do. Lastly, increased knowledge of fundamental ecological processes and functions from EPF research will comprise a basis for development of tools and applications for resource management that are better grounded on scientific understanding and hence more potentially effective in meeting ecological and societal goals.

Information/Technology Transfer

Transfer of scientific, technical and general information and other outputs from EPF research will be critically important to enable the above-noted general benefits of program work to be realized, i.e., to enhance recognition, understanding, application and impact of program research. Dissemination of science findings to the external scientific community will be accomplished via conventional peer-reviewed or refereed publications, presentations at scientific meetings and direct consultation with peer scientists external to the program. Technology transfer programs to clientele (i.e., external users) will be designed and delivered by EPF scientists and professional staff, sometimes in partnership with the PNW Station's Communications and Applications Group, Focused Science Delivery (FSD) Program, Western Wildland Environmental Threat Assessment Center (WWETAC) and/or other PNW programs/teams. External partnerships (e.g., National Forest System, State and Private Forestry, other state/federal agencies, universities/cooperative extension, nongovernmental organizations) also can and will be used in development and implementation of tech-transfer programs.

Relationships to National Strategies and Goals

The EPF Program's work is directly relevant to several important national issues and priorities, including forest health as addressed by the Healthy Forest Restoration Act (HFRA), the Endangered Species Act, global climate change, the National Fire Plan, and four of the six specific goals of the U.S. Forest Service's (USFS) draft *2008-2012 Strategic Plan*:

Goal 1: Restore, Sustain and Enhance the Nation's Forests and Grasslands (including fire, wildlife, invasive species, landscape ecology, global change and range research)

Goal 2: Provide, Sustain and Enhance Benefits to the American People (including ecosystem services research)

Goal 4: Maintain a Full Range of Basic Management Capabilities of the Forest Service (including decision-support research and development/transfer of synthesized information, tools and technologies)

Goal 7: (overarching goal) **Improve the Scientific Basis for Sustainable Natural Resources Management** (including high-quality research responsive to current and anticipatory of future priorities, and facilitation of increased use of research-derived information, tools and applications)

In addressing the above goals, the EPF Program will fully support the national mission of USFS Research and Development (FSR&D) as stated in its *Draft Strategic Plan 2008-2012* (Version 3.0, August 2006), 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";* with the associated vision of being *"recognized as a world leader in providing innovative science for sustaining global forest resources for future generations."* The program's work includes research in all seven FSR&D national Strategic Program Areas (SPAs):

1. Water, Air and Soil (EPF Problems 1, 2 and 3)
2. Resource Management and Use (EPF Problems 1, 2, 3 and 4)
3. Fish and Wildlife (EPF Problems 1, 3 and 4)
4. Wildland Fire (EPF Problems 2 and 3)
5. Invasive Species (EPF Problems 3 and 4)
6. Recreation (EPF Problem 3)
7. Inventory and Monitoring (EPF Problem 4)

Relationships to Station Strategies and Other Programs

The program's work is directly related and integral to the research directions established in the PNW Research Station's 2008 Strategic Business Plan (SBP), which included definitions of five foundational themes for station research over the next 10 years. By intent, definition and name, the EPF Program directly corresponds to the *Ecological Process and Function* SBP foundational theme.

The EPF Program also contributes to and interrelates with each of the stations's other foundational themes/programs: Resource Monitoring and Assessment (RMA), Threat Characterization and Management (TCM), Land and Watershed Management (LWM) and Goods, Services and Values (GSV)[2], as well as with the science synthesis and delivery efforts of the FSD Program and with the ecological risk assessment efforts of the WWETAC. *The primary niche of EPF among this array of PNW Programs is as a source of increased understanding of basic, functional, cause-and-effect relationships that govern the attributes, processes and dynamics of ecosystems.*

Program-to-program relationships are summarized in the appendix, and more specific detail on inter-relationships with other programs will be provided in EPF Problem and Problem Element descriptions later in this charter. It will be evident that, in many cases, EPF and other PNW programs will focus research on different aspects of similar problems, but in complementary rather than redundant fashion. This said, the following are key distinctions between EPF and other PNW programs:

RMA: The RMA Program will have lead responsibility for determining and assessing ecological status and trends, as well as for developing methodologies for resource monitoring, analysis and assessment. The EPF

[2] Descriptions of Problems for other PNW programs are provided in other program charters.

Program's primary role in this area will be to determine causal relationships influencing the status and dynamics of species, populations and ecosystems

TCM: The EPF Program will generate fundamental knowledge on disturbance and environmental change effects on organisms and ecosystems. This knowledge will inform the more applied threat characterization and management research of the TCM Program, including social dimensions, with the exception that fundamental (as well as applied) work on insects, diseases, invasive species and physical fire sciences will primarily reside in the TCM program. Conversely, EPF will have primary station responsibility for fundamental and applied research on terrestrial and avian wildlife, with only limited focus on threats to and threat responses of wildlife in the TCM Program.

LWM: The EPF Program also will generate fundamental knowledge on biophysical and disturbance influences on ecosystems that will inform the more applied, management-oriented research that is a distinguishing focus of the LWM program. While both the EPF and LWM programs will pursue research on aquatic ecosystems, most aquatic research will reside in the LWM Program (including major emphasis on applications and interactions between aquatic and terrestrial ecosystems).

GSV: The EPF Program will not directly pursue the socioeconomic research that is the primary focus of the GSV Program, but rather will provide GSV scientists knowledge of fundamental ecological relationships that is relevant to societal issues, values and needs.

When appropriate and feasible, EPF scientists will directly collaborate with scientists in other programs in integrated projects that focus on subjects of mutual relevance and interest. In all cases, the outcomes of fundamental EPF research will be communicated to and used by other PNW programs to complement and inform their applied work on similar or related problems, and vice versa.

PROGRAM PROBLEMS

The research and development activities of the EPF Program will focus on four broad Problem areas considered of key importance to understanding ecological processes and functions, and to meeting societal and clientele needs for such improved understanding in management of ecosystems. Work within each Problem area will be further focused on an array of Elements that represent more specific (albeit still broad) areas of scientific inquiry. The EPF Program's four problems are closely and logically interrelated. Problem 1 focuses on elucidating the influence of various aspects of the biophysical environment on ecosystem processes, function and attributes, while Problem 2 focuses more specifically on effects of climate as a significant element of the biophysical environment. Outcomes of work on these two Problems consequently are of foundational

importance to work in Problem 3, which focuses on effects of disturbances in interaction with the biophysical environment. Outcomes of Problems 1, 2 and 3 will help to inform work under Problem 4, which addresses ecological dynamics as driven by the biophysical environment and disturbances.

Problem 1. How does the biophysical environment influence the function and properties of ecosystems, ecological communities, species, populations and organisms?

Ecosystems and their biotic (organisms, species, populations and communities) and abiotic (physiographic, hydrologic and edaphic) components and processes are driven by attributes and dynamics of the biophysical environment. The biophysical environment represents the aggregation and integration of endogenous biologic and physical conditions and processes within ecosystems, coupled with exogenous influences such as weather, climate and other externally-imposed conditions. Understanding the influence of the biophysical environment on ecosystem components and processes is fundamental to understanding how and why ecosystems function as they do, and is of foundational importance to developing effective resource management approaches and policies. The EPF Program will pursue such understanding through research in the five primary elemental areas listed and described below.

Problem 1 Elements

1.1 What are the environmental drivers determining species, community and ecosystem patterns and dynamics; and how are the rates, patterns and trajectories of these ecological responses influenced by environmental change?

This element will focus first on identifying the array of environmental drivers that influence ecosystem function, both directly and indirectly, and singly or in interaction with other drivers. Such drivers may include physical (e.g., hydrologic, geomorphic and atmospheric) conditions or processes and biotic processes (e.g., competition, succession and other modes of species interactions), as well as processes involving biotic and abiotic interactions such as soil development and carbon and nutrient cycling. This element will further focus on how the nature and dynamics of interacting biophysical conditions and processes influence changes in species, communities and ecosystems at varying spatial and temporal scales.

1.2 How do the functions and behavior of organisms change during their ontogeny and along environmental gradients, and how do these attributes and their dynamics contribute to emergent ecosystem properties?

This element will focus on understanding basic biology, autecology and ecophysiology of organisms, and their functional and behavioral responses to gradients in biophysical conditions at different developmental stages. Work will also focus on the influence of organism-level functions, behavior and responses to environmental change on species, community and ecosystem-level relationships, processes and attributes.

1.3 What are the characteristics of landscapes that provide functional connectivity for or barriers to ecological processes, and to the distribution and persistence of populations?

This element will focus on landscape-scale attributes and processes of ecosystems, and will strive to identify biotic (e.g., vegetation pattern and distribution) and physical (e.g., physiography, stream networks) attributes that foster or impede interconnectivity, movements, distribution and persistence of species and populations; or influence large-scale ecological processes (including disturbances). Work under this element may complement and be integrated with that in the PNW Station's TCM Program.

1.4 How do the processes of carbon, water and nutrient cycling operate and interact along environmental gradients in terrestrial and aquatic ecosystems; and what are the implications for ecosystem function?

This element will focus on processes that are of foundational importance to the function of, and services provided by, terrestrial and aquatic ecosystems, especially on how carbon, water and nutrient cycling are influenced by changes in the biophysical environment, including natural or anthropogenic disturbances. This element therefore complements and may be integrated with work under EPF Problem 3, as well as the PNW Station's TCM and LWM Programs; and the implications of findings for ecosystem services may be integrated with work in the GSV Program.

Problem Importance

Needs and Issues Addressed: Outcomes of Problem 1 research will meet scientific, managerial and societal needs for improved basic understanding on how the biotic and abiotic environment influences properties, processes, functions and values of ecosystems. This understanding, and derivative applications, will improve capabilities to address a number of important scientific and resource management/policy needs and issues, including:

- Improved understanding of interactions among components of the biophysical environment and their effects on the attributes and functions of biota and ecosystems, and how such influences are expressed in changes in biota and ecosystems over time
- Assessment of current and planning for future desired attributes of ecosystems under altered environmental conditions
- Assessment of current and planning for future supplies of ecosystem services (e.g., water, carbon, products) under altered environmental conditions
- Management of ecosystems across varying spatial scales, especially management at landscape and regional scales
- Management of ecosystems that effectively considers and integrates effects of multiple, interacting biotic and abiotic drivers of ecological conditions, processes and functions

People Served and Benefits: Outcomes of research under this problem will be utilized and benefit the work of the scientific community outside the EPF Program, including that in several other PNW Programs. The fundamental knowledge developed under this problem will be either immediately or ultimately utilized by all external clientele (resource managers, planners, regulators, policymakers and stakeholders) who are dependent upon sound basic scientific information on environment-ecosystem interactions. The development of specific applications of increased fundamental knowledge (tools, models, management practices) by EPF and other scientists will yield benefits of improved scientific basis, credibility, reliability and effectiveness of management, planning or policy decisions and actions.

Likelihood of Success in Problem Work

Work under this problem will build upon a significant base of related prior research by PNW scientists in several previous programs; will be staffed by PNW scientists in several important contributive disciplines (wildlife, vegetation, landscape, systems and disturbance ecologies; plant ecophysiology; hydrology; geomorphology; and atmospheric sciences); will draw upon a well-established network of external research collaborators and clientele partners; and will be supported by appropriate PNW laboratory and field research infrastructure (including and specifically field facilities at the Wind River Canopy Crane, H.J. Andrews and other experimental forests). The likelihood of success in making major advances in understanding and applying understanding of biophysical effects on biota and ecosystems over the coming decade is therefore considered high.

Approach to Problem Solution

Greater depth and detail on methods and procedures utilized to pursue research under this problem will be provided in an upcoming problem analysis and, ultimately, in specific study plans under that problem analysis. Work will primarily involve fundamental research on ecological effects of biophysical environment. The primary emphasis will be on original research to develop new knowledge and insights, but when appropriate and needed synthetic studies will collect, integrate and interpret existing information on specific subjects. Original research will be pursued using a number of broad approaches, as suitable to specific problem elements and studies. These will include laboratory and field experimental studies (Elements 1.1, 1.2 and 1.4); field observational and retrospective studies (all Elements); and both empirical and process-based simulation modeling (all Elements). The scope of studies will vary depending on element and research questions addressed, and will range from studies at the organism to species/population to community and ecosystem levels of biological organization; from site to landscape to regional to global spatial scales; and from diurnal to seasonal to annual to decadal and inter-decadal temporal scales. Research under specific elements of this problem inter-relates substantially with that in three of PNW's other four programs: TCM, LWM, and GSV (see element descriptions and appendix).

Problem 2. What are the potential influences of climate change on ecosystem attributes, patterns, ecological processes, and their interactions?

Climate and associated atmospheric processes have overriding influence on ecological processes, on the nature and distribution of biota and ecosystems, and on natural disturbance regimes. The reality of climate change has profound implications for the future of biota, ecosystems and the social systems dependent on ecosystems. Great uncertainty exists on the nature and rates of climate change, and this uncertainty extends to the potential impacts of future climate regimes on ecosystems. EPF Problem 2 focuses specifically on improved understanding of climate change as a physical driver of future ecosystem attributes, ecological processes and functions. Such understanding, including full recognition of uncertainties, will be critically important to the development of policies and management activities to promote both mitigation of and adaptation to potential climate change effects. The EPF Program will pursue such understanding through research in the four primary elemental areas listed and described below.

Problem 2 Elements

2.1 How have the distribution, attributes and functions of biota and ecosystems responded to past climate change; and how might biota and ecosystems respond to future climate scenarios?

Work under this element will be multifaceted. Retrospective studies will elucidate responses of ecosystems and disturbance regimes to past variations in climate, which may provide clues to future changes under altered climates. It will be important to evaluate legacy effects of past climate on current distribution, composition and function of ecosystems; and to determine the ramifications of such legacy effects to future ecosystem dynamics. While lessons from the past may provide clues to the future, it is recognized that major changes in climate may result in distributions, attributes and functions of biota and ecosystems that could be radically different than those of the past and present. In light of this, process-based modeling and other approaches will be used to project ranges of possible future rates, patterns and trajectories of ecological change under potential future climate regimes, including how species or systems may evolve, move or otherwise adjust over time. Research will focus on biotic and abiotic response variables of both terrestrial and aquatic ecosystems, and will also investigate how certain ecosystem services (water, carbon, biological productivity, etc.) may be affected by different future climate regimes. Knowledge of and attention to key atmospheric processes, including their potential future dynamics and variability, will be critically important inputs to such modeling. Advances in fundamental understanding under this element will inform, complement and be integrated with climate change assessment and applications work pursued by PNW's TCM Program and WWETAC.

2.2 How will changing climate influence and interact with disturbance regimes and agents?

Weather and climate exert major influence on the occurrence, nature, extent and impact of disturbance regimes and agents. For example, strong correlations with weather/climate have been demonstrated for wildland fire and other physical disturbances (e.g., floods, landslides, windthrow), and have been postulated for a number of other disturbance agents or processes (e.g., pathogenic insects and diseases, herbivory, invasive species). This element will focus on increasing fundamental understanding of interactions of climatic factors with various ecological disturbances. From that understanding, projections will be developed for potential changes in disturbance regimes under changing climate, as well as the effects of such changes on future biota and ecosystems. Work under this element will directly integrate with research in PNW's TCM Program, with EPF's research distinguished by providing fundamental climate response knowledge that will inform research under TCM problem elements 1.2, 1.4, 2.1, 2.2, 3.1 and 3.2. Outcomes of EPF research under this element will also integrate with predictive and assessment work of WWETAC, as well as informing and complementing climate change management research in the LWM Program's element 2.3.

2.3 What are the ecological bases and constraints for development of mitigation and adaptation strategies that address climate change?

Policy and management responses to climate change may focus both on efforts to mitigate undesirable impacts of such change on biota, ecosystems and ecosystem services; and on facilitated and accelerated adaptation of biota and ecosystems to altered climatic conditions. Building upon the improved knowledge on potential climate change impacts generated under Elements 2.1 and 2.2, research under this element will focus on identifying and understanding the fundamental ecological processes and relationships upon which potentially successful mitigation or adaptation strategies must be based. Research will also identify various ecological constraints (e.g., adaptational breadth and plasticity, genetic/evolutionary potentials and migration potentials of species; edaphic and physiographic controlling factors; etc.) that will impose limits on mitigation and adaptation strategies and what they can reasonably be expected to accomplish. The increased fundamental knowledge generated under this element will provide the ecological bases for climate change management strategies, and thus will directly contribute to and integrate with applied research in the PNW TCM Program (TCM Elements 4.1 and 4.2) and LWM Program (LWM Element 2.3). Findings also may inform socioeconomic (including policy-related) research in the GSV Program.

Problem Importance

Needs and Issues Addressed: The focus of EPF Problem 2 on climate change directly addresses perhaps the most significant environmental issue facing the region, Nation and world in the 21st century. The potential impacts of climate change on ecosystems, and the societies dependent upon resources from such ecosystems, have become recognized as a major concern nationally and internationally. How, where, when and at what rate climate may change remain subjects of intense public and scientific interest, scrutiny and uncertainty. Of even greater uncertainty are the nature and significance of climate change impacts on biota, ecosystems, ecosystem services and climate-linked disturbance processes; and how much these impacts may be ameliorated through policies and

management. The EPF Program will strive to reduce such uncertainties by both increasing fundamental understanding of the potential influence of altered climate regimes on biota and ecosystems, and by generating relevant and useful knowledge-based applications. Research findings will address a number of important scientific and resource management/policy issues and needs, including:

- Improved understanding of and ability to forecast the range of potential effects of climate change on the attributes, patterns, processes, functions and services of ecosystems
- Expanded scientific basis for the development of potentially effective policy and management options to mitigate, cope with or adapt to potential climate change impacts
- Assessment of and planning for linkages between changing climate and altered future disturbance regimes, including analyses of risks, threats and uncertainties
- Assessment of and planning for potential future desired attributes and values of ecosystems under altered climate, including analyses of risks, threats and uncertainties

People Served and Benefits: Research outcomes of Problem 2 will be used by the scientific community outside the EPF Program, including contributions and integration of fundamental EPF work with applied climate change research in several other PNW programs (most significantly TCM, but also LWM and GSV Programs) and WWETAC. The primary benefits will include improved fundamental understanding of the range of potential ecological responses to climate change. Major external beneficiaries of knowledge and applications developed under this problem will include public and private land planners and managers charged with assessing potential climate change effects on natural resources; developing plans for addressing such effects; and proactively applying practices that may ultimately mitigate or promote adaptation to climate change effects. Natural resource and environmental policy-makers and regulatory agencies in local, state and federal government are also expected to utilize Problem 2 findings for making decisions relevant to climate change that are soundly and credibly based on available science.

Likelihood of Success in Problem Work

The PNW Research Station's climate change research under previous programs has been visionary (initiated nearly two decades ago, long before recognition of the realities of climate change became widespread), productive and influential at national to international levels, yielding a solid base upon which to further expand knowledge. The station possesses strength and breadth of scientific staffing in several disciplines of key importance to understanding climate change and its impacts (vegetation, landscape and disturbance ecologies; biogeography and bioclimatology; systems ecology and modeling; hydrology; atmospheric sciences), and through previous work has established excellent networks with collaborating climate change researchers and partnering user groups external to the station. Resolution of all aspects of this problem is highly unlikely over the 10 years of this charter, particularly given the difficulties, uncertainties and limitations of future predictive ability. In light of the above-noted station strengths,

however, the likelihood of substantially advancing knowledge on ecological effects of climate change is still considered high.

Approach to Problem Solution

Greater depth and detail on methods and procedures used to pursue research under this problem will be provided in an upcoming problem analysis and, ultimately, in specific study plans under that problem analysis. All elements under Problem 2 will primarily involve fundamental research to determine ecological effects of climate change, but with an important secondary dimension (especially in Element 2.3) of developing knowledge applications and decision-support tools to directly assist land managers and policymakers. Certain studies will represent continuation of previous lines-of-work (e.g., process-based predictive modeling with appropriate spatial upscaling and downscaling; interactions of climate with disturbances and vegetation), whereas other needed work will be initiated in new areas previously little studied by PNW scientists (e.g., climate interactions with hydrologic processes and wildlife; development of science-based adaptation and mitigation strategies; atmospheric processes contributing to climate change). Problem 2 will emphasize original research to develop new knowledge and insights, but when appropriate and needed synthetic studies will be pursued to collect, integrate and interpret existing information on specific subjects. Original research will be pursued using a number of broad approaches, as suitable to individual problem elements and specific studies under those elements. These will include long-term field experimental studies (Element 2.1); long-term management experiments/studies (Element 2.3); long-term field observational and retrospective studies (all Elements); and empirical or process-based simulation interrelates modeling (Elements 2.1, 2.2 and 2.4). Studies will be conducted from landscape to regional to global spatial scales; and from annual to decadal and interdecadal (and longer) temporal scales.

Research under this problem substantially with that in three of PNW's other four programs: TCM, LWM, and GSV (see element descriptions and Appendix A). The pursuit and outcomes of longer term field experimental or observational studies under Elements 2.1 and 2.4 also may be integrated with long-term monitoring and assessment efforts of PNW's RMA Program.

Problem 3. How do disturbances influence ecological patterns and processes, and how do disturbances and ecological processes interact to determine the overall function, attributes and dynamics of ecosystems?

The attributes, patterns and functions of biota and ecosystems are governed not only by internal biophysical processes and the external environment, but also by an array of natural and anthropogenic disturbances. Some disturbances, such as wildfire, native herbivory and periodic epidemics of native pathogenic insects or diseases, are natural processes in most ecosystems, but can be greatly modified in extent, frequency and impact by human activities (including land management) and environmental change. Other disturbances, such as species invasions and livestock grazing, result from human

intervention in ecosystems. Human activities themselves (land management, recreation, land conversion, resource extraction) comprise a third class of disturbances that certainly can have profound impacts on ecosystems. Disturbances rarely act alone. Rather, they are imposed in combination, sequence and interaction with other disturbances and any changes in the external physical environment. The nature and significance of disturbance effects can vary along both spatial and temporal scales.

The increased understanding of disturbance influences on fundamental ecological processes and functions gained through EPF research under this problem will be of foundational importance to related, more applied work of several other PNW programs (most notably TCM but also LWM and GSV) in development of effective pre- and post-disturbance management strategies; strategies for sustenance of ecosystem services in disturbance-prone environments; and implications for natural resource policies that address ecological disturbances. The EPF Program will pursue such understanding through research in the four primary elemental areas listed and described below.

Problem Elements

3.1 How do natural disturbances and the biophysical environment interact to influence terrestrial and aquatic species and ecosystems, and what are the effects of these interactions on postdisturbance restoration or recovery?

This element will focus on improved understanding of how key natural or biotically-induced ecological disturbances (including wildfire, pathogenic insects and diseases, herbivory by native and introduced grazers, invasive plants and animals) influence species and the attributes, patterns, processes and functions of terrestrial and aquatic ecosystems. Research conducted under this element will interrelate directly with EPF Problems 1 and 2. Research will determine both direct and indirect disturbance effects on vegetation, wildlife, hydrology and associated ecological processes, as expressed at multiple spatial scales and across short to longer-term temporal scales. The influences of both single and multiple, interacting disturbances will be ascertained. The ramifications of disturbance effects for various ecosystem services will be explored, as will the implications and strategies for pre- and post-disturbance management (including bases for post-disturbance recovery or restoration management). Increased fundamental understanding of cause-and-effect relationships gained under this EPF element will complement and inform applied or social science-oriented work under several problems and elements of the PNW TCM Program (i.e., TCM Elements 1.1, 1.2, 1.4, 2.1, 2.2, 3.1, 3.2, 4.1, 4.2 and 5.3); WWETAC and, secondarily, the LWM (LWM Elements 1.2 and 2.3) and GSV Programs.

3.2 How do current and past anthropogenic disturbances influence terrestrial and aquatic species and ecosystems, and post-disturbance restoration or recovery?

This element will address many of the same aspects of disturbance ecology and management as Element 3.1, but in contrast to the above element will focus entirely on anthropogenic disturbances, i.e., those directly imposed by human interventions in ecosystems. The primary questions will relate to effects of various intentional forms of

human intervention that are of regional significance (e.g., management strategies and practices, land use changes, recreation, silvicultural practices and resource extraction) on species and ecosystem attributes and processes, all in interaction with the biophysical environment, and at multiple spatial and temporal scales. Findings will have implications for the future development of both management and policy. Where ecological or social impacts of current or antecedent anthropogenic disturbances are deemed negative, outcomes of fundamental research under this element also will help to inform management strategies designed to restore desired conditions. Increased understanding of basic, cause-and-effect relationships gained under this EPF element will directly complement and inform disturbance management work under PNW's TCM (TCM Elements 1.4, 2.2, 4.1, 4.2 and 5.3) and LWM Programs (LWM Elements 2.1 and 2.3).

Problem Importance

Needs and Issues Addressed: Ecosystems in the Pacific Northwest, Alaska and elsewhere in the Western United States have been and will continue to be impacted by an array of natural disturbances, some of which (wildland fire, insects) have had profound impacts on ecosystem functions and services, and in terms of economic and human costs to society. Similarly significant impacts have occurred and will continue to be expressed as a result of certain human-caused disturbances, such as land-use change, resource extraction and land management practices. Outcomes of Problem 3 research will provide much-needed fundamental knowledge on the nature and consequences of disturbance effects, as well as applications of such knowledge to improve prediction, prevention and mitigation of unwanted disturbances or their adverse impacts. Problem 3 outcomes will address a number of important scientific and resource management/policy needs and issues, including:

- Increased scientific understanding of the breadth and depth of ecological impacts of major natural and anthropogenic disturbances, especially at larger (e.g., landscape) spatial scales, and of the interrelated impacts of multiple disturbances interacting with the biophysical environment
- Improved fundamental knowledge upon which to base improvements in predictive, preventive and restorative disturbance management practices, strategies and policies
- Improved scientific foundation upon which to base ecologically realistic, attainable and sustainable resource management goals, policies and priorities in disturbance-prone, changeable environments

People Served and Benefits: Knowledge applications developed from this problem will benefit public and private land planners and managers involved in assessing risks of and planning for disturbances, and managing resources and ecosystems in disturbance-prone environments. Benefits of Problem 3 outcomes will include increased effectiveness of disturbance predictions, improved scientific basis for impact assessments, preventative management practices, and postdisturbance recovery or restoration management. Natural resource and environmental policymakers and regulatory agencies in local, state and federal government are also expected to utilize Problem 3 findings for making scientifically informed decisions regarding avoidance or amelioration of unwanted

impacts of natural or anthropogenic disturbances. EPF Problem 3 findings will benefit basic and applied scientists in several other PNW programs pursuing related work; WWETAC; and the scientific community external to PNW (academia, other research agencies) involved in disturbance ecology and management research. As with other EPF problems, the primary scientific benefits of EPF Problem 3 work will be derived from improved understanding of fundamental relationships in disturbance ecology, especially the influences of interacting disturbances on biota and ecosystem attributes, patterns, processes and functions at varying scales.

Likelihood of Success in Problem Work

Problem 3 work will build upon substantial past progress in disturbance ecology and management research in PNW, which comprised a prominent area of emphasis in two previous PNW programs. Opportunities for collaborative, integrative work between EPF and the station's other four foundational programs and WWETAC are excellent. The station possesses strength and breadth of scientific staffing in several disciplines of key importance to understanding ecological disturbances and their impacts (vegetation, wildlife, aquatic, landscape, systems and disturbance [including fire] ecologies; physical fire sciences; hydrology; geomorphology), and through preceding work has established excellent networks with collaborating disturbance ecology researchers and partnering user groups external to the station. In light of the above factors, the likelihood of success in advancing knowledge and its positive impact through application is considered high.

Approach to Problem Solution

Greater depth and detail on methods and procedures used to pursue research under this problem will be provided in an upcoming problem analysis and, ultimately, in specific study plans under that problem analysis. Problem 3 will primarily involve basic research elucidating fundamental disturbance ecology relationships and disturbance influences on biota and ecosystems, with a secondary applied research component striving to develop practices, strategies, decision-support systems and tools that support effective management practices and policies. As with other EPF problems, the primary emphasis will be on original research to develop new knowledge and insights, but when appropriate synthetic studies will be pursued to collect, integrate and interpret existing information on specific subjects. Original research will feature a number of broad approaches, as suitable to individual problem elements and specific studies under those elements. These will include (for both elements) laboratory and field experimental studies; short or long-term management experiments/studies; field observational and retrospective studies; and both empirical and process-based simulation modeling. The scope of studies will vary depending on element and research questions addressed, and will range from studies at the organism to species/population to community and ecosystem levels of biological organization; from site to landscape to regional to global spatial scales; and from seasonal to annual to decadal and interdecadal temporal scales.

Research under this problem interrelates most substantially with that in PNW's TCM Program, as well as with the predictive and assessment efforts of the WWETAC, but also will relate to certain work in the LWM Program (see element descriptions and appendix*).*

Problem 4. What are the determinants of ecological status and trends of biota and ecosystems?

Ecological conditions are dynamic rather than static, changing over time in response to both internal and external drivers. Accurate understanding of the current status of species, populations, ecological communities and ecosystems is important for meaningful and comprehensive analysis of extant ecological patterns, processes and functions. Of equal or greater importance is knowledge of longer term trends in ecosystem attributes as gained through long-term ecological research. Long-term trends can indicate how ecological processes, functions and derivative ecosystem services are changing in response to imposed natural or anthropogenic disturbances and changes in biophysical environment. Understanding of current ecological status and the trends/drivers that have led to it is important both because it provides needed context for developing current management and policy options, and because past trends may provide clues to future ecosystem dynamics under varying future management, disturbance and environmental regimes. The EPF Program will pursue advances in understanding in the above areas through research in the three primary elemental areas described below.

Problem Element:

4.1 Improve understanding of the nature of and processes governing species, ecological community and ecosystem dynamics at multiple spatial and temporal scales, i.e., how and why do populations, communities and ecosystems change?

Through short- and long-term ecological research, this element will focus on elucidating temporal changes in various attributes and aspects of species and ecological systems, including trends in species population demographics, movements and distribution; successional changes in plant and animal community composition, structure and species turnover; changes in spatial patterns of communities and ecosystems; and changes in ecological processes over time. Research will distinguish and discern the implications of short-term, acute ecological changes vs. those of a longer-term, chronic nature. Research will also identify changes that are reversible vs. those that are not likely to be reversed owing to crossing of ecological thresholds. Research will shed light on both the rates and directions (patterns and trajectories) of ecological changes at multiple spatial and temporal scales. Lastly, this element will link knowledge of ecological dynamics to that of biophysical environmental and disturbance influences gained under EPF Problems 1 through 3, to identify the drivers of observed trends and cause-and-effect relationships. Research under this element will significantly relate to, complement and be integrated with the long-term monitoring and assessment work of the PNW RMA Program, as well as ecological threshold work in the TCM Program, with EPF's primary contributions in the realm of improved understanding of fundamental ecological relationships underlying ecosystem dynamics.

4.2 Increase knowledge of the ecology and habitat requirements of species of importance or concern, and develop applications that will contribute to their productivity, viability and/or recovery over time.

Certain plant and animal species are of particular importance to ecosystems (i.e., keystone species), owing to their degree of influence on ecological processes or conditions, or their value as indicators of the status of those processes or conditions. Other species may be of particular concern owing to declines in populations or viability (i.e., rare, threatened and endangered species), with consequent risks to biodiversity and loss of genetic potential. This element will focus on improving understanding of the status, trends, fundamental biology and ecology of such species, including ecological requirements and interrelationships with other species and habitat factors. Outcomes of this work will contribute to applications (management strategies, options and techniques) designed to enhance the likelihood of maintaining or restoring viable populations over time. Research under this element will inform, and in some cases be integrated with, resource management research in PNW's LWM Program and, secondarily, TCM Program.

4.3 How do scale and varied approaches to observation and interpretation influence the detection and assessment of ecological change?

The detection and perceived significance of ecological changes can be influenced both by the scale at which research is conducted and by how research findings are interpreted. For example, detection of inconsequential ecological changes at landscape scales in some instances may mask some very significant changes at finer, site/stand scales and, conversely, detection of major landscape-scale changes may not necessarily imply changes of the same magnitude at the site/stand level. Similar inconsistencies may occur with detection and interpretation of ecological changes along temporal scales. Improper or inconsistent detection and interpretation of changes caused by scaling issues can be aggravated by difficulties in upscaling or downscaling observed or predicted patterns or trends along spatial or temporal gradients. This element will focus on determining the influences of scale of inference, and observational and analytical approaches on how ecological changes are detected and evaluated; and will develop theoretical and applied approaches that will enable ecological changes to be detected, interpreted and assessed in a more meaningful, consistent and comprehensive manner. Knowledge gained under this element may inform and complement work in PNW's RMA Program, as well as prove useful to that in most other programs.

Problem Importance

Needs and Issues Addressed: Accurate and meaningful knowledge of the causes of status and trends of biota and ecosystems is important because it is the basis for current natural resource management and policy directions, decisions and actions. Such knowledge will be provided not only by EPF under this Problem but by other units of the PNW Station (most notably the RMA Program). It is extremely important to know not only what current conditions and past trends are, but also to understand how and why they have developed and what their implications are for the future. EPF Program

research under this Problem will provide answers to such questions by providing increased understanding of the fundamental ecological processes, relationships and causal factors that influence species and ecosystem dynamics. Outcomes of EPF Problem 4 research will improve capabilities to address an array of important scientific and resource management/policy needs and issues, including:

- Improved understanding of the nature, processes and drivers of multiscale species and ecosystem dynamics that contribute to current ecosystem conditions and functions
- Improved scientific basis and ability for projecting future changes and trends in biota and ecosystem conditions and functions
- Increased scientific understanding of the status, trends and ecology of species of key ecological, societal or management importance or concern, and how such species may be maintained or promoted through management

People Served and Benefits: Within the scientific community, EPF Problem 4 research will benefit work of several other PNW Station units, most notably direct relationships to the RMA Program, long-term studies of the LWM Program, and ecological assessment work of WWETAC. Work under this problem will also serve sectors of the scientific community external to PNW (academia, other research agencies) involved in long-term ecological research. As with preceding EPF problems, the primary scientific benefits of Problem 3 work will relate to improved understanding of fundamental ecological relationships and processes that contribute to species and ecosystem dynamics at varying scales. This problem will also contribute advances in methodologies for determining, analyzing and interpreting ecological change. Major external beneficiaries of knowledge and applications developed under this problem will include public and private land planners, managers and policymakers involved in assessing current resource conditions and trends; making decisions and applying actions based upon such assessments; and planning how to address future changes in dynamic ecosystems and environments. Benefits of Problem 3 outcomes to these practitioners will include improved scientific basis and consequent effectiveness of resource inventories and assessments; policy and management decisions and approaches that better address both short and longer-term consequences of actions taken; and future resource management plans that incorporate potential changes in resources and ecosystems.

Likelihood of Success in Problem Work

The PNW Station has an extended, productive history of long-term ecological research on species and ecosystem dynamics in response to disturbances, environmental change and management interventions that provides a solid scientific base for future work in determining and interpreting ecological status and change. Previous and continuing long-term studies at PNW's experimental forests, research natural areas and other long-term research sites (e.g., Long Term Ecological Research sites, Forest Inventory and Analysis plots) will also comprise valuable resources for research under this problem. The Station possesses strength and breadth of scientific staffing in disciplines of key importance to determining, understanding and assessing ecological status and trends (vegetation, wildlife, aquatic, landscape, systems and disturbance ecologies; mensuration and

biometrics; hydrology; geomorphology), and through previous work has established excellent networks with researchers and resource managers external to the station who collaborate and partner in ecological assessments and long-term ecological research. Determining, understanding and evaluating ecological status and trends comprise areas of work, albeit with somewhat differing emphases, within several other PNW units (especially RMA, but also WWETAC, LWM and TCM), and opportunities for collaborative, integrative work between EPF and these programs are considered excellent. In light of the above factors, the likelihood of success in advancing knowledge in this problem area, and its positive impact through application, is considered high.

Approach to Problem Solution

Greater depth and detail on methods and procedures used to pursue research under this problem will be provided in an upcoming problem analysis and, ultimately, in specific study plans under that problem analysis. The focus of most Problem 4 work will be on basic research to characterize ecological status and trends; to increase understanding of fundamental processes of species and ecosystem dynamics; and to increase knowledge on the influence of disturbances and other biophysical and anthropogenic drivers of ecological changes. Important applications of increased fundamental knowledge will nonetheless be developed in certain areas, most notably under Element 4.2. As with other EPF problems, the primary emphasis will be on original research to develop new knowledge and insights, but when appropriate and needed synthetic studies will be pursued to collect, integrate and interpret existing information on specific subjects. Original research will feature a number of broad approaches, as suitable to individual problem elements. These will include laboratory and field experimental studies (Elements 4.1 and 4.2); short- and long-term management experiments/studies (Elements 4.1 and 4.2); field observational and retrospective studies (Elements 4.1 and 4.2); empirical and process-based simulation modeling (Elements 4.1 and 4.2); and conceptual and applied methodological studies (Element 4.3). Research under Problem 4 will use, whenever appropriate, PNW's network of experimental forests, research natural areas and other long-term research sites for pursuit of studies on species and ecosystem dynamics over extended temporal scales. The scope of studies will vary depending on element and research questions addressed, and will range from studies at the species/population to community and ecosystem levels of biological organization; from site to landscape to regional to global spatial scales; and from annual to decadal and interdecadal (and longer) temporal scales.

Research under specific elements of this problem interrelates most substantially with that in PNW's RMA Program, although substantial linkages also exist with the ecological threat and threshold work of the TCM Program; assessment and predictive work of WWETAC; and with long-term management studies in the LWM Program (see element descriptions and appendix).

Common Elements/Themes

The following two elements (i.e., themes) are of crosscutting importance to all EPF work, and will be common to and pursued under all four EPF Problems:

Common Element 1: Developing new and improving existing methods, models, tools and approaches to assist resource managers, policymakers and stakeholders in applying knowledge of ecological relationships, attributes, processes, patterns and functions.

It is essential that advances in fundamental scientific knowledge generated by research under all EPF problems be available to and usable by natural resource specialists and land managers. This requires development of knowledge-based applications that are relevant to both current and future natural resource issues and needs. Such applications will include management or decision-support tools, models and improved management practices or strategies, and will be developed both by EPF scientists, and by scientists external to EPF in other PNW programs or external to the station who may base applications on knowledge of fundamental ecological relationships generated by EPF scientists.

Common Element 2: Characterizing, addressing and communicating information on sources of error and magnitude of uncertainty concerning ecological relationships, attributes, processes, patterns and functions; and assessing the implications of error, uncertainty and incomplete knowledge for science, management and policy.

It is essential that we fully understand the level of potential error in research findings under all problems, and recognize the limits such error places on interpretation and application of findings. It is also important that we clearly communicate the implications of potential error, incomplete knowledge and resulting uncertainty to both the scientific community and users when science findings and applications are transferred. It is crucial that the ramifications of uncertainty are fully understood and incorporated by clientele in the development of science-based management approaches and 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, National Environmental Policy Act analysis will be conducted.

STAFFING PLAN AND COST ESTIMATES

The EPF Program will be staffed by 18 permanent, full-time research grade scientists, including 6 ecologists, 6 wildlife biologists, 1 biologist, 1 range scientist, 1 forester, 1 hydrologist, 1 geologist and 1 economist, plus an array of approximately 29 permanent, term, post-doctoral or temporary science and administrative support personnel. EPF

personnel will be assembled into four to five standing research teams that are composed to optimally pursue program problems through intra- and inter-team work. It is anticipated that initial gross appropriated funding for the EPF program will be approximately $6.5 million per annum, which will be augmented by temporary external funding procured from sources and for purposes appropriate to EPF mission and problems. Approximate allocation of funding and personnel resources to the four EPF Problems is as follows:

Problem 1: 35%
Problem 2: 20%
Problem 3: 25%
Problem 4: 20%

Additional detail on EPF standing team structure, composition, research focus and budget will be provided through a revision to this charter after the program becomes operational in fiscal year 2010.

APPENDIX: RELATIONSHIP TO OTHER PROGRAMS AT THE PNW RESEARCH STATION

Ecological Process & Function Program Problems and Problem Elements	Other PNW Foundational Programs and Program Problem Numbers														
	Resource Monitoring & Assessment			Threat Characterization & Management					Land & Watershed Management			Goods, Services & Valu			
	1	2	3	1	2	3	4	5	1	2	3	1	2	3	4
Problem 1: Influence of Biophysical Environment…															
1.1 Environmental drivers and change…			y	y	y	y	y	y	**X**	y		y			
1.2 Environmental influences on organisms…				y					y						
1.3 Landscapes characteristics & influences…					**X**		**X**	y	y	y					
1.4 Influences on carbon, nutrient & water cycles…			y						y						
Problem 2: Influence of Climate Change…															
2.1 Ecological responses to climate change…			**X**	**X**		y	y	**X**	y			y			
2.2 Climate change interactions with disturbances…			y	**X**	**X**	y	y	y		y		y			
2.3 Ecological basis for mitigation and adaptation…						y	**X**	**X**		**X**	y				
Problem 3: Influence of Disturbances…															
3.1 Natural disturbance & biophysical environment interactions…			**X**	**X**	**X**	**X**	**X**	**X**	y	y		y			
3.2 Anthropogenic disturbance influences…			**X**	y			y			**X**		y			**X**
Problem 4: Determinants of Ecological Status and Trends…															
4.1 Characterizing/understanding multi-scale species & ecosystem dynamics…	**X**		**X**		y	y	y	**X**	y		y	y			
4.2 Ecology & management of key species…						y			y	X					
4.3 Effects of scale and evaluative approaches on perceptions of ecological change…	y	y	y	**X**		y					X		**X**		

X = High level of interrelationship and/or potential for integrated work y = Moderate level of interrelationship.