Resource Management and Productivity (RMP) Program Charter

Executive Summary

The Charter is a contract between the Station (Director approval) and the Washington Office (Deputy Chief concurrence). It represents the first step to implementing the Pacific Northwest (PNW) Research Station's Strategic Plan. In support of the Station Mission, the RMP Program mission is to "Increase understanding of the biology and productivity of forest ecosystems and develop management tools that enhance production of wood products and other resource values." The scope of this mission encompasses three major R&D Issues for the Program:

- Management to sustain production of forest products and values depends on improved fundamental knowledge of biology, ecology, and genetics of plants in forested and non-forested ecosystems**.**
- A wide range of silviculture and genetic practices is needed to provide the variety of conditions, services, and products that will be demanded from forested lands**.**
- Developing research models, databases, measurement techniques, and analysis tools is needed to evaluate forest management options.

In addition to the Program Charter, each team in the RMP Program will complete a new Problem Analysis, a level of specificity that gives outside clients a better opportunity to interact with the Program. Finally, each major study or project undertaken by the team is required to have an approved Study Plan on file. Therefore, the Station Strategic Plan is implemented in a step-wise fashion with increasing specificity or detail:

Strategic Plan → **RMP Program Charter** → Problem Analyses → Study Plans

The RMP Program Charter, to run from FY03 to FY12, was reflects changes in Program research emphasis, associated personnel changes, and the Station Strategic Plan completed in 2000:

Research – New emphasis areas developed in the past few years are clarified:

- Agenda2020 – RMP is the lead for the PNW Station's regional Agenda2020 public-private partnership between industry (American forest and Paper Assoc) and Forest Service Research. In addition, RMP has significant involvement with the Fall River Study, a National Agenda2020 project of high priority.

- Multi-disciplinary ecological silviculture – In the 1990's the Station became increasingly invested in large operational silvicultural experiments that address many other values (e.g., biological diversity, riparian management) in addition to wood production, with RMP providing the leadership. As a result, several IUFRO conferences were held in 2003, 2004, and 2005 to capture this kind of work.

- Emerging areas – include molecular tools to assess genetic health of a variety of rare native species, native plant restoration research east of the Cascades, recent collaborative work in fire and invasive plant species, and use of airborne laser scanning (known as "lidar") to produce high-resolution maps of forest cover and stand structure for use in forest inventories, growing stock estimates, wildlife habitat mapping, fuel mapping, and crown fire behavior models.

Resource Management and Productivity Research Program

Charles E. Peterson Jr., Program Manager, Portland Forestry Sciences Laboratory

Mission: Increase understanding of the biology and productivity of forest ecosystems and develop management tools that enhance production of wood products and other resource values.

JUNEAU: Silviculture & Ecology of Southeast Alaska, Mike McClellan (TL), Dave D'Amore
In Juneau, the team applies ecological knowledge to develop silvicultural practices that maintain or enhance a wide range of forest values-including timber, soil productivity, fish and wildlife habitat, biological diversity, and visual quality. This work is cooperative and multi-disciplinary, and includes studies of (1) alternatives to clearcutting in old-growth forests; (2) management of young-growth stands for multiple values; (3) growth and development of forests regenerating on wetland soils; (4) effects of thinning and pruning on growth and yield, wood quality, and understory vegetation; and (5) soil moisture effects on forest productivity.

SEATTLE: Silviculture and Forest Models, Steve Reutebuch (TL), Bob McGaughey
This cooperative R&D effort with the University of Washington develops remote sensing and image processing methods for terrain and vegetation measurements. Current efforts are focused on the development of forest structure measurement and monitoring techniques that utilize airborne laser scanning (LIDAR) and interferometric synthetic aperture radar (IFSAR). Applications of these technologies by federal, state, and private land managers include forest canopy fuels mapping, forest inventory, and habitat structure monitoring. The team has produced analysis and visualization software that allows forest managers to more easily understand and utilize these new remote sensing technologies.

OLYMPIA: Silviculture and Forest Models, Steve Reutebuch (TL), Dave Marshall, Connie Harrington, Tim Harrington
This unit focuses on evaluating the biological, cultural, mensurational, and operational aspects of managing coniferous mixed-species stands using a broad range of silvicultural tools and alternatives. This includes producing wood products under alternative silvicultural regimes while managing for additional societal values. Other studies emphasize joint work with universities and NGOs on plant invasive species issues, wildlife scientists on silvicultural practices to create habitat and food sources for wildlife species, with sociologists on public acceptance of alternative systems for wood production, and with wood anatomists on relationships between stand management and timber quality as reflected in stem characteristics and wood properties.

CORVALLIS: Biology and Culture of Forest Plants, Paul Anderson (TL), Nan Vance
Basic and applied ecological research is conducted in collaboration with university scientists and other partners to develop silvicultural systems and native plant restoration and conservation tools needed by federal, state, and private land managers. Research on the biology and culture of forest plants focuses on 3 areas: (1) the roles of riparian reserves and overstory thinning in sustaining ecological processes in headwater forests; (2) plant biology and ecology important to sustaining or enhancing native plant species and communities; (3) silviculture of young forests to meet a broad range of structure, diversity and production objectives.

CORVALLIS: Genetics, Brad St.Clair (TL), Randy Johnson, Rich Cronn
Conduct genetics research focusing on the sustainable management of genetic resources, maintaining or enhancing ecosystem productivity and health, and conserving genetic and species diversity. Research includes genetics for native plant restoration; genecology of forest and range plants and implications for seed movement, gene conservation, breeding strategies, and responses to climate change; identifying genomic approaches developed for model species, and extending these to address germplasm conservation issues for ecologically important plant species exploring integrated approaches to genetics and silviculture that enhance and predict the quantity and quality of wood production while protecting other forest values; and developing information managers will need for both the management and conservation of genetic resources.

(Adapted from FS-4000-1)

RESEARCH DEVELOPMENT AND APPLICATION PROGRAM CHARTER	**1. Station:** Pacific Northwest Research Station

2. RD&A Program Title (Number): Resource Management and Productivity (RMP), PNW-4163

3. RD&A Program Manager (Name and address): Charles E Peterson, Portland Forestry Sciences Laboratory, 620 SW Main St., Suite 400, Portland, Oregon 97205

4. Area of Research Applicability: Terrestrial resources: silviculture, genetics, field operations, soils, plant processes, and site productivity research primarily in southeast Alaska, western Oregon, and western Washington; also throughout western U.S. and international.	**5. Estimated Duration:** 5 years

6. Response to Station Program Priority(s): Develop a fundamental understanding of ecological, social and economic systems and their interaction; to assess the status and trends of ecosystems and natural resources and their uses; develop science-based options that enhance management; to communicate science findings and enhance their application.

7. Mission: Increase understanding of the biology and productivity of forest ecosystems and develop management tools that enhance production of wood products and other resource values.

8. Justification and RD&A Issue Selection: Management to sustain production of forest products and values depends on improved fundamental knowledge of biology, ecology, and genetics of plants in forested and non-forested ecosystems; a wide range of silviculture and genetic practices is needed to provide the variety of conditions, services, and products that will be demanded from forested lands; and improved models, databases, measurement techniques, and analysis tools are needed to evaluate forest management options**.**

9. Station Teams Involved (location(s); Team Leader): See pages 22-23.

10. Approach to Solution of Selected RD&A Issues: See pages 26-37.

11. Review and Approval:

Signature	Title	Date
Recommended: /s/ Charles E. Peterson, Jr.	**Charles Peterson** **RMP Program Manager**	**5/22/03**
/s/ Jimmy L. Reaves	**Jim Reaves, Director** **Vegetation Management and Protection**	**5/22/03**
Approved: /s/ Thomas M. Quigley	**Thomas M. Quigley** **PNW Station Director**	**5/16/03**
Concurred: /s/ Robert Lewis, Jr.	**Robert Lewis Jr.** **Deputy Chief for Research**	**5/22/03**

Charter for Resource Management and Productivity RD&A Program

Table of Contents

1. **Station:** Pacific Northwest Research Station.

2. **RD&A Program Title (Number):** Resource Management and Productivity (RMP) Program, PNW-4263.

3. **RD&A Program Manager (Name and Address):** Charles E Peterson, Portland Forestry Sciences Laboratory, 620 SW Main St, Suite 400, Portland, OR 97205

4. **Area of Research Applicability:** Terrestrial resources: silviculture, genetics, field operations, soils, plant processes, and site productivity research primarily in southeast Alaska, western Oregon, and western Washington; also throughout western U.S. and international.

5. **Estimated Duration:** 5 years.

6. **Response to Station Program Priority(s):** The RMP Program addresses all four goals in the Pacific Northwest (PNW) Research Station's Strategic Plan. In Goal 1 (develop a fundamental understanding of ecological, social and economic systems and their interactions) the RMP Program contributes information primarily to the understanding of structure, function and processes of terrestrial ecological systems, often assisting in understanding the interaction of ecological factors with social and economic considerations. Our work also contributes to Goal 2 (To assess the status and trends of ecosystems and natural resources and their uses) primarily in research conducted on Survey and Manage species and better information on precision forestry technologies. Our work continues to contribute in a strong manner to Goal 3 (develop science-based options that enhance management), due to the history of applications development and tools the Program has provided land managers. A continuing role played by the Program, especially in the area of visualization and web-based information development, is responding to emerging issues and bridging the gap between information generation and its use (Goal 4: To communicate science findings and enhance their application). In sum the work conducted within the RMP Program contributes to attainment of the PNW Station's Goals and Priorities.

This Program operates within many of the PNW Station's priorities. These include the following: 1.1 Advance the understanding of structure, function, and processes of terrestrial ecological systems; 1.2 Advance the understanding of structure, function, and processes of aquatic and riparian ecological systems; 2.3 Develop monitoring protocols and data analysis techniques; 3.1 Manage riparian and aquatic areas for multiple values; 3.2 Restore ecosystems at risk and reduce the risks people face; 3.4 Produce wood within sustainable frameworks; 3.5 Create operational strategies for conservation of biodiversity; and 4.2 Bridge the gap between information generation and its use. A small component of the RMP Program conducts work in Priority 2.3. The largest research component of our Program is focused on Priorities 1.1 and 3.4. We still maintain a strong balance between science focused on basic understanding and development of tools and information for use by natural resource managers.

These priorities, within four Station Goals, were developed when writing the PNW Station's Strategic Plan. The plan recognizes the increased demand that will be placed on natural resources by rising global population and continued environmental pressure. This demand and resulting increase in monetary and other social values applies to all forest resources--values such as fish and wildlife (including species at risk), water, recreation, and aesthetics, as well as wood and non-wood forest products. Program staff, with significant involvement in partnerships and cooperative ventures, will respond to the Station Goals with a mixture of research, development, and application designed to increase knowledge related to the effect of natural and anthropogenic processes on interactions between land and water at multiple scales.

7. Mission: Increase understanding of the biology and productivity of forest ecosystems and develop management tools that enhance production of wood products and other resource values.

8. Justification and RD&A Issue Selection: Three major Issues with broad scope constitute the foundation of the Program Mission; each encompasses many components that are important to PNW clients and society at large – (1) Management to sustain production of forest products and other values depends on improved fundamental knowledge of biology, ecology, and genetics of plants in forested and non-forested ecosystems; (2) A wide range of silviculture and genetic practices is needed to provide the variety of conditions, services, and products that will be demanded from forested lands; and (3) Improved models, databases, measurement techniques, and analysis tools are needed to evaluate forest management options**.**

These three research issues have been chosen because they address basic science needs and the science-based options needed by managers and decision-makers on which to base land management actions. Not only do the issues represent the importance of biological, physical, and social considerations for forest ecosystems, they also focus science on the synergy or linkages among the disciplines. This creates added value to the component parts. The synergy among the three issues addressed by the Charter reflects integration within the RMP Program; not only in how scientists within the program view the work they conduct, but also in how the Teams within the Program are currently organized. Our research teams are comprised of scientists who conduct their work across the PNW Region and have focused on interdisciplinary approaches to their science questions.

8a. Issues and elements being addressed by the PNW Resource Management and Productivity RD&A Program for the period 2002-2007:

RD&A Issue 1: **Management to sustain production of forest products and values depends on improved fundamental knowledge of biology, ecology, and genetics of plants in forested and non-forested ecosystems.**

> **Element 1.1:** Develop new knowledge of how genetics, site factors, and basic plant processes affect establishment, growth, and structure of forest vegetation.
>
> **Element 1.2:** Increase knowledge of how natural and human disturbances affect plant genetic diversity, composition and structure, soil, and long-term productivity of forests.
>
> **Element 1.3**: Develop biological, ecological, and genetic knowledge of native plants for conservation and restoration of under-represented or vulnerable species, including species that are used for non-timber forest products (NTFP).

RD&A Issue 2: A wide range of silviculture and genetic practices is needed to provide the variety of conditions, services, and products that will be demanded from forested lands.

> **Element 2.1:** Develop options for increasing the quantity and quality of wood production through the integration of genetics and silviculture.
>
> **Element 2.2:** Develop and evaluate silviculture practices that restore, maintain, or enhance multiple forest values, including wood production, fish and wildlife habitat, biological diversity, visual quality, and long-term productivity.
>
> **Element 2.3:** Develop and evaluate options for the management of populations that maintain or enhance genetic diversity in the long-term while providing the basis for genetic improvement in health or productivity of forest systems in the short-term.

RD&A Issue 3: Developing research models, databases, measurement techniques, and analysis tools is needed to evaluate forest management options.

> **Element 3.1:** Develop techniques for measuring and modeling structural and spatial characteristics at the plant, stand- and landscape-level.
>
> **Element 3.2**: Develop strategies and tools that integrate research results into development products that allow better planning, visualization, evaluation, and monitoring of silviculture practices and forest operations.

8b. Justification of Issue Need:

RD&A Issue 1: **Management to sustain production of forest products and values depends on improved fundamental knowledge of biology, ecology, and genetics of plants in forested and non-forested ecosystems.**

Issue -Wide Benefits:

Knowledge of the basic ecology of terrestrial species and processes is fundamental to any persons or organizations making decisions critical to implementing management strategies on forests in the Pacific Northwest and Southeast Alaska. Research will emphasize the discovery of new information, the ecological requirements of plant species, and development of innovative and effective tools to enhance inventory, monitoring, and management activities, to include the restoration of biological complexity, and conservation of at-risk native plant species. Strategies to effectively manage for diverse values are hampered by lack of knowledge needed to develop conceptual frameworks and long-term management tools. Information derived from the research conducted under this issue is apt to be of most benefit to ecologists, wildlife biologists, botanists, geneticists, and silviculturists as well as weed managers, and forest resource managers. Forest ecologists, wildlife biologists, and botanists will be better able to understand the biological constraints operating on the viability of plant populations in relation to other forest organisms. Research will also benefit biological and physical scientists who can use the new knowledge in furthering research and development. New knowledge will be transferred in such a way that land managers, resource specialists, and interested publics will also benefit from the work. This knowledge is needed to pursue RD&A Issue 2.

Publication in refereed journals will be emphasized under this issue. Although many of the studies are long-term, scientists will be encouraged to publish results as soon as significant information becomes available. Products will include models; e.g., partitioning of genetic variation among and within woody or herbaceous plant populations. Results that would be used by managers, resource specialists, or the public will be disseminated in ways that will be most useful to them. These include Station series papers and presentations at workshops. Other forms of technology transfer will include articles in newsletters, field trips to study sites, and consultations.

What net benefit will the clientele and society receive if this issue is solved?

Society will receive a more scientifically grounded basis for management decisions, and will be the beneficiaries of those strategies that provide for conservation of those values important to the public. Management strategies may be more broadly integrative so that more options for achieving diverse outcomes important to different publics can realized. For example, information on overstory-understory dynamics will be produced for silviculturalists who will be developing systems designed for thinning overstory to achieve multiple benefits of forest health, structural complexity, or reduced fire potential, while providing for a broader range of native plant communities. Management decisions

will use a greater science-based approach that will allow overstory manipulations that will protect and support greater understory diversity. New knowledge of ecological relationships in other key biotypes ranging from riparian areas to fire prone, dry forest uplands and savannas will enable scientists, managers, and the public to work together to improve managing forests for health and diversity and for a broader range of benefits.

What is the likelihood that the R&D effort will provide a solution to the issue?

There is a high probability that the research program will generate new knowledge about the ecology and management of forest systems. Primarily, information is so limited that new data and understanding will significantly advance the base of scientific knowledge. In addition, enough of this work has already been initiated to be encouraging to the scientists, and results will become available much sooner than if all of the research was starting from the early stages of problem analyses and planning. Finally, some of the procedures to be used have proved successful in other geographic areas or ecological situations.

Element 1.1: Develop new knowledge of how genetics, site factors, and basic plant processes affect establishment, growth, and structure of forest vegetation.

Environmental and genetic factors are the primary forces that shape individual plant development, and ultimately, forest structure. Silvicultural manipulations of these factors include changes in vegetation density, soil quality, and genetic composition. If silvicultural treatments are to be cost-effective to forest landowners and society as a whole, a basic understanding is needed of the influence of environmental and genetic factors on plant responses. New knowledge on forest ecosystem processes can be used as a foundation to predict the consequences of management at the stand level. Improved knowledge also can be used to justify decision-making at a broader forest or landscape scale. Neglected areas of research that are topically important today include overstory/understory interactions, plant development as affected by above- and belowground factors, and autecology of lesser-known species.

Need/Value of current and future research:

a. *Understory vegetation responses to overstory density and structure*: Because of public opposition to clear cutting and the need to produce many ecological values and services from forest lands, public land managers currently are practicing a variety of methods for managing forest stands. A problem common to these new methods is the lack of information on the response of existing understory vegetation to disturbance and the establishment and growth of new vegetation. This information is needed for tree seedlings of commercial species to regenerate the future stand and to better understand the development of other woody and non-woody species. Information is needed on regenerating tree seedlings in terms of their spatial distribution, species composition, and early growth, and on the interactions between tree seedlings and other vegetation. If public lands are to produce a sustained flow of wood products and other services, specific regeneration standards must be met. However, response

of species other than commercial tree species is also important in meeting wildlife habitat, biodiversity, and aesthetic objectives. Although many silvicultural systems or modified silvicultural practices are being tested throughout the region, little scientific information exists regarding vegetation response to varying overstory and understory stand conditions.

b. *Root, stem, and crown characteristics of trees as influenced by soil, microclimate, and stand characteristics*: The morphology of a tree provides information about its genetic composition, its history of development in response to environment, and its potential to respond to future environmental conditions. Past silvicultural research has emphasized stand-level responses to broad scale treatments; however, greater site specificity of management and ability to manage multiple-species forests are needed to address public concerns that a given silvicultural treatment or system is justified. In addition, the primary tenets of ecosystem management (diversity, stability, and resilience) require a detailed understanding of how individual trees respond to their environment at the microsite level. Thus, a basic understanding of tree morphology (e.g., number, size, and spatial distribution of growing points) is needed to understand its past and to predict its future responses to environment. Because morphology is under genetic control, it will be important to understanding how genetic variation contributes to important tree and stand characteristics.

c. *Regeneration of neglected woody species*: Management emphasis on biodiversity, wildlife habitat, and late-successional stand characteristics is increasing. Responding to this trend requires knowledge of characteristics of tree and shrub species that were previously considered unimportant. Examples of information needed include: timing and frequency of seed crops, factors influencing seed production, seed collection guidelines, regeneration methodologies, and growth potential under specific soil-site conditions and climatic conditions. Information critical for successful establishment and for understanding relationships between environmental conditions and plant growth are particularly lacking. A specific need is for information on yellow-cedar regeneration in southeast Alaska. Natural regeneration is the common practice in southeast Alaska, but yellow cedar regenerates poorly, even when surrounding stands contain numerous seed trees. This problem is particularly severe in the northern Tongass N.F. In addition, yellow cedar is an unreliable seed producer, and this complicates efforts to regenerate the species by artificial regeneration. Given the knowledge needed to establish a variety of shrub and tree species, forest managers will be able to restore, and if necessary, create specific forest communities for wildlife habitat, aesthetics, and other ecosystem values.

d. *Soil water effects on forest productivity:* Soil water content is an important determinant of forest productivity in southeast Alaska. Information on the degree and timing of soil saturation is essential for stratifying soils in productivity research studies and in classifying lands into management productivity classes. Fundamental information on soil-water effects on carbon/nutrient cycling and transport will help explain observed differences in site productivity and landscape-level linkages between source and sink terrestrial sites and between terrestrial and aquatic systems.

Project-level planning for roads, culverts, and watershed management will be improved with better information on temporal and spatial patterns of soil water storage and transport.

e. *Genecology of native forest species*: Successful reforestation and restoration efforts require the use of plant materials that are adapted to local environmental conditions. A number of historical plantation failures have resulted from using "off site" genetic stock where the seed came from sources that were not adapted to the planting site. Successful deployment of planting stock (both natural and genetically improved) requires an understanding of the extent of adaptive variation in the source materials; such insight provides rational guidelines for how far one can safely move plant material without a resulting decline in productivity. Genecology is the study of geographic genetic variation patterns and structure, and its relationship to the environment. From genecology studies, one can design seed transfer guidelines, develop selection schemes and delineate breeding zones in breeding programs, and interpret patterns of phenotypic and genetic variation to use in planning gene conservation programs. Knowledge of genecology can also be used to predict effects of global change on adaptability and flexibility of natural and planted tree populations.

Element 1.2: Increase knowledge of how natural and human disturbances affect plant genetic diversity, composition and structure, soil, and long-term productivity of forests.

The knowledge of disturbance effects and recovery processes in plant-soil systems forms the basis for much of our silvicultural practice. Despite a rich history of disturbance ecology research and application, new knowledge is needed to address emerging natural threats to valued species such as yellow cedar, to assess the affects of human-caused disturbance—including forest management activities—on genetic resources and long-term productivity, and to design silvicultural options that are better adapted to changing societal expectations. Traditionally, managers applied silvicultural treatments to minimize damage to trees, but we have come to recognize that damaging agents may create important resources such as food, cover, or nesting sites for valued non-tree species. This realization has lead to a need for techniques for managing for desired levels of disturbance, rather than the former goal of eradicating all damage. Another important application of disturbance ecology is providing a yardstick for measuring the effects of alternative silvicultural treatments. Resistance to partial cutting and uneven-age management is often based on concerns over damage to residual stands. Naturally occurring rates of damage provide a basis for evaluating rates observed in both traditional and alternative silvicultural systems.

Need/Value of current and future research:

a. *Natural disturbance dynamics and their response to harvesting:* Knowledge of damaging agents, disturbance, and the resultant forest structure and composition is useful for the development and evaluation of silvicultural options. This knowledge may be used to design systems that maintain disturbance-related features found in

native forests, or to design systems that control or minimize disturbance. For example, managers of coastal forests often are concerned with potential increases in damaging agents, such as windthrow and dwarf mistletoe, following heavy thinning of previously dense stands, or when residual trees are left to serve as the overstory in the creation of two-aged stands. On the other hand, there is greater recognition that dead or damaged trees provide habitat for a wide range of organisms and serve various ecological functions, so management for multiple values may attempt to maintain damaging agents at a level that balances wood production with the production of structures beneficial to wildlife and other values.

b. *Impacts of intensive management on long-term productivity of forest sites:* Forest management has become increasingly less oriented on wood production on many public lands in recent years; some public lands have been withdrawn from timber production and future harvests are expected to be very limited on other public lands. The demand for wood products continues to increase as our national population increases. As a society we are faced with the choice of importing a greater amount of wood from parts of the world with fewer environmental safeguards than are present in the U.S. or with increasing intensive management on acres designated for that purpose. Intensive management requires implementing a variety of activities on every acre and, if not properly conducted, some of these activities could impair long-term site productivity. Guidelines are needed to ensure that intensive management activities such as mechanized harvesting, intensive wood utilization, site preparation, planting, and early stand tending maintain or enhance site productivity. Research needs to be conducted on a range of common soil types and differing climatic conditions in western Washington and Oregon to develop these guidelines.

c. *Management and natural disturbance effects on non-native invasive plants and native plant communities:* Non-native plant species are frequently strong colonizers that intensely compete with native plant species of forest, riparian, or grassland plant communities. Increasing dominance by non-native invasive species may result in loss of biodiversity within native plant communities, alteration of ecosystem function, and shifts in plant succession. It is generally accepted that disturbance can play a role in invasion by non-native plant species but there has been little research towards understanding direct and indirect influences of silvicultural treatments such as overstory removal, thinning, mechanical fuels reduction and understory vegetation manipulation using prescribed fire. In addition, very limited information exists on the efficacy of current strategies and techniques for native plant community restoration following natural disturbances such as wildfires. Development of effective long-term control strategies will require new knowledge of basic biology and ecology of many noxious wildland invasive species, their relative abilities to compete with native plant species for site resources, and intended and unintended consequences of silviculture and restoration practices that influence risk of invasion by non-native plant species.

d. *Yellow cedar decline:* Yellow cedar wood is decay resistant, mechanically strong, and aesthetically appealing, and for these reasons it is the most valuable wood produced in southeast Alaska. The value of the yellow cedar component is often the determinant of profitability for timber sales in southeast Alaska. A decline syndrome of unknown cause has been found in native, unmanaged forests and appears to date from the late 1800s. Studies of the decline date from the mid-1980s and have eliminated biological agents as potential causes of the decline. Research is needed

on methods to manage or restore existing yellow cedar areas and on methods for establishing new areas of yellow cedar. Research is also needed to further understand the biology of yellow cedar.

Element 1.3: Develop biological, ecological, and genetic knowledge of native plants for conservation and restoration of under-represented or vulnerable species, including species that are used for non-timber forest products (NTFP).

Diverse forest plants perform critical biological and ecosystem functions such as contributing to nutrient cycling, microclimate moderation, carbon sequestration, provide resilience to disturbance, forage and habitat for wildlife. Many native plants are at risk of becoming listed as T&E and some are already listed. Conservation strategies are hampered by lack of knowledge of what critical information is needed to manage for protecting species and habitats. Little is known about the reproductive ecology, genetic architecture, community dynamics, and management of many herbs, shrubs, and trees of non-timber economic value that may be beneficial to economies seeking alternatives in natural resource-based industries. Conservation of native plants lacks knowledge needed of how native plants are affected by invasive exotic species. This information will help to develop appropriate integrated management strategies to restore native plant population structure and communities that provide diverse values including those of commercial importance.

Need/Value of current and future research:

a. *Conservation biology of listed plant species currently included in Survey & Manage (S&M):* Management guides and recommendations and important policy decisions regarding rare and sensitive species under federal, state, or agency jurisdiction are often overly conservative because they lack credible scientific understanding of the species and its habitat. Studies being conducted under this charter period will provide information needed for revising and updating management recommendations, annual species review and listings, and conservation plans for Survey & Manage. They will also increase knowledge of federally and state listed plant species, which are receiving ongoing restoration efforts.

b. *Sustainable harvest and conservation of NTFP plant species:* Developing guidelines for sustainable harvest, models of sustainable management and policy decisions regarding the conservation and management of harvested species has been limited by lack of information. Specific information generated from studies designed to examine the effects of harvest and the basic ecology of conservation of species that are subject to harvest is needed for managing a suite of plant species in a particular forest type, or for developing policies on those species in most critical need of management.

c. *Biology and ecology of Quercus garryanna:* Oregon white oak communities are successional on most sites in the Pacific Northwest and require disturbance (usually fire) for their existence. Given the lack of periodic burning by indigenous peoples, the success of fire suppression programs, and conversion of many oak areas to management for other species or non-forest uses, less than 5% of the former oak areas are still in oak cover and even fewer of them are in good condition. Research is urgently needed on methods to manage or

restore existing oak areas and on methods for establishment of new oak areas. Research is also needed on oak biology, especially factors influencing acorn production, as many wildlife species are associated with oak forests. This research will provide resource managers tools for improving the condition and function of oak communities.

d. *Molecular genetics of plant species integral to landscape restoration and ecosystem health:* Informed management and conservation of native flora requires knowledge of population demography, as well insight into the extent and limitations to gene flow, and patterns of population differentiation across highly heterogeneous landscapes. Restoration strategies suffer from lack of knowledge of the genetic structure of species and how genetics interacts with population dynamics.

RD&A Issue 2: A wide range of silviculture and genetic practices is needed to provide the variety of conditions, services, and products that will be demanded from forested lands.

Issue -Wide Benefits:

Knowledge critical to science-based management will be derived using both basic and applied research approaches. Research on silviculture and genetic practices will continue to refine our understanding of how management activities can be used to maintain and potentially enhance forest ecosystems while continuing to produce needed wood products and other values such as fish and wildlife habitat, clean water, special forest products, and publicly acceptable landscapes. Those studies that integrate silviculture and genetics research will allow development and testing of management alternatives that capitalize on knowledge that can only be produced by applying research in both sciences simultaneously. Development of new management alternatives and genetic practices will help managers to better allocate limited resources for long-term sustainability of economical, social, and ecological systems of Pacific Northwestern and Alaskan forests.

Public and private sector resource managers, primarily in the Pacific Northwest and Alaska, will derive the most direct benefits from the research and development conducted

under this issue. However, a significant amount of the results will also apply either directly or indirectly throughout the western United States and elsewhere in the world where conditions and situations are similar to the areas under study. Other scientists will also benefit from the work by gaining further understanding of vegetation dynamics that result from silvicultural or genetic practices.

RD&A products that incorporate science knowledge into decision-making tools for resource managers will be emphasized under this issue. Products to accomplish this include dissemination of early, interim results in newsletters or at workshops. The latter will include oral presentations, display posters, and papers in published proceedings. Some of the field installations will make good demonstration areas. This application will be encouraged by volunteering the sites as tour stops for appropriate conferences, association tours, and extension programs. Final results will, for the most part, be published in Station series papers or other appropriate, easily accessible documents. Scientists will of course also submit new information or technology for publication in refereed scientific journals when it is appropriate.

What net benefit will the clientele and society receive if this issue is solved?

This knowledge is being used to improve the scientific basis for management plans and policies for natural resources throughout the Pacific Northwest region, including Alaska and British Columbia. Research on a wide variety of silvicultural and genetic practices will increase the number and types of management options for providing conventional, as well as prospective, products and services from forests. Testing of management practices on a wide variety of sites also will enable better matching of silvicultural prescriptions and genetic materials to individual sites. Perhaps most importantly, by following the outcomes of silvicultural treatments and genetic practices, it will be possible to identify some of the factors critical to long-term management of productivity and health of forest ecosystems. New knowledge and new applications of technology generated by this research will be incorporated into models and strategic databases for use by resource managers and other research scientists. Management can then be applied with a greater scientific basis, and managers will have a better understanding of the likely consequences of management activities. In the final analysis, current and future citizens will benefit through improved economics of forest products and the existence of more sustainable, productive ecosystems.

What is the likelihood that the R&D effort will provide a solution to the issue?

It is likely that highly useful products and significant progress will result from the research and development performed under this issue. The integration of silviculture and genetics research in Element 2.1 has an element of risk to it, because such integration has

not seriously been attempted before--but the potential to provide useful information is extremely high. In cases where the objective is to develop silvicultural or operational practices for providing resource values other than timber production, past success and knowledge generation in timber production research suggest that it is highly probable that practices can be developed to provide a higher level of desired non-timber values. In still other cases, changes in silviculture and forest operations are taking place so rapidly (e.g. changes in riparian management due to new forest practices regulations, implementation of treatments to accelerate development of late-successional characteristics under the NWFP, and new mechanical fuels reduction operations) that little analysis is occurring before new systems are being implemented; thus, research and development will reduce risk of applying new "untested" systems. In the areas of management of genetic materials, little previous work has addressed maintenance of genetic diversity and implications of genetic variability on long-term sustainability. Therefore, research in these areas will provide fundamental knowledge at a rapid rate. New information and knowledge will also improve the likelihood of finding compatibility among a variety of outputs available on federal and other lands. This new information will enable increased cost effectiveness in achieving broad forest management goals while reducing trade-offs with other resource uses and values.

Element 2.1: Develop options for increasing the quantity and quality of wood production including the integration of genetics and silviculture.

Because of population growth and public land withdrawals, the remaining highly productive timberlands of the Pacific Northwest have become increasingly important for meeting society's wood products needs, both in terms of quantity and quality. The RMP is a leader in the region in developing the long-term databases needed for research in this area. Many of the ongoing databases of the RMP are strategic in their coverage of species and treatments. Past research in the region has provided numerous ways to enhance wood production in young managed stands within the region. However, in most cases, these enhancements have come from research within specific disciplines, including silviculture, genetics, harvest and processing technology. Further gains and the development of techniques to manage for a growing complexity of demands will be enhanced through the integration of the various disciplines involved in forest resource management. This emphasis on integrated research will lead to syntheses that more effectively utilize existing knowledge and products and new management practices that enhance the quantity and quality of wood products and other important non-wood values produced by forests in the Pacific Northwest and Alaska.

Need/Value of current and future research:

a. *Remeasurement and analysis of key young-growth studies*: Extensive stands of young-growth have been established following clearcutting from about 1950 to the present. The primary emphasis in these areas has been wood production. Effective management options that are available to meet a wide range of objectives require accurate stand-growth models, knowledge of factors affecting growth, and quantitative evaluation of the effects of intermediate treatments such as thinning and pruning. Collection of quality data to understand and describe tree growth and stand

development requires long-term observations. While past research provides much information on the major species in the region, changing markets and management strategies have shifted the focus to utilizing smaller sized trees and a greater interest in management of previously neglected species. Past research has also emphasized the production of volume, but to capture the full benefits of today's markets, value production much also be considered. There is little knowledge in the region of how basic management practices can be used to enhance production of many species and species mixes and the resulting impacts on wood quality. This work will be done in southeast Alaska and the Pacific Northwest.

b. *Management of genetically improved seedlings and trees*: Much of the silvicultural practices used in the Pacific Northwest and Alaska have been developed using planting stock of unknown or unimproved origin. In contrast, current reforestation efforts are utilizing planting stock from tree improvement programs. Silvicultural systems may need alterations to fully capitalize on the investment in improved planting stock from current tree breeding programs. This will require a better understanding of how enhanced planting stock should be deployed (e.g. in species mixes, family mixes, individual families, or individual clones), how planting stock that is optimal for plantation conditions (full-sun) will perform in the partial shade conditions created by management practices that retain a portion of the overstory into the next generation, and whether silvicultural prescriptions require modification in order to address altered growth trajectories of genetically-improved planting stock.

c. *Silvicultural treatment effects on wood characteristics*: With the wide range of forest landowners in the Pacific Northwest and Society's desire for forest lands to supply a wider range of values and services is resulting in managers developing and using many new management practices. Changes in management strategies by various landowners include shorter and longer rotation lengths, more species being emphasized under management, use of specific seed sources or level of genetic improvement and different silvicultural systems that result in multiple age classes and greater spatial variability. These changes cannot only impact yields, but can also alter the characteristics of the trees being harvested and the resulting wood quality. Wood quality is an important factor to be considered because it determines the suitability of the wood for specific end uses and ultimately value.

Element 2.2: Develop and evaluate silviculture practices that restore, maintain, or enhance multiple forest values, including wood production, fish and wildlife habitat, biological diversity, visual quality, and long-term productivity.

Past silvicultural research and practice typically emphasized wood production but, more recently, demand has developed for silvicultural options research that provide the information necessary to understand the tradeoffs and synergies among forest values, particularly on public lands. Research described under element 2.1 focuses on practices for increasing the quantity and quality of wood produced. In contrast, the research under this element (2.2) emphasizes the development and testing of silvicultural practices for wood production compatible and co-equal with other resources. Resources of concern

typically include wildlife and fish habitat, visual quality, compositional and structural diversity, old-growth legacy elements, productivity, and resistance to damaging agents. Research on restoration efforts might be directed at individual species or at a desired forest "condition." While neglected species are important, restoration might include species that are abundant but for which we know little about their biology or response to management. Similarly, a species which has received a lot of attention may still be in need of restoration. Restoration efforts might be focused on a forest "condition," such as an understory comprised of many important species, which would likely entail putting the forest stand on a trajectory towards a future desired condition. Depending on the location, development stage, and management history of stands, the focus may be on the retention, creation, or maintenance of these features. Critical information needs exist for the management of riparian buffers and reserves and for alternatives to clearcutting. Studies of the production of multiple values often require research approaches that differ from past practices. The studies are often interdisciplinary, integrated, and large-scale—frequently at operational, stand, or even landscape scales.

Need/Value of current and future research:

a. *Operational silviculture for sustaining wood production and other values*: In response to new information and changing societal values, clearcutting is being reduced or eliminated on many ownerships in the Pacific Northwest and Alaska. Much is known about the ecological effects, economics, and social effects of clearcutting, but there is little documented experience with other silvicultural systems over much of the area, particularly options that allow timber harvest while maintaining visually acceptable landscapes, fish and wildlife habitat, and soil productivity. Continued uncertainty over the costs, technical challenges, public acceptance, and biological effects associated with other silvicultural and harvest options has hindered their adoption. A range of sound management options--and knowledge of costs and benefits associated with each--are needed to resolve conflicts over forest land uses and enhance sustainable management of forested ecosystems. Research on this topic is concentrated in two distinct geographic areas: old-growth forests in Southeast Alaska and mature and young-growth production forests (primarily state and private lands) in western Oregon and Washington.

b. *Silvicultural practices for riparian buffers and headwater forests*: Approximately 60% of the forest landscape is designated as Interim Riparian Reserves on federal forest lands in western Oregon and Washington to meet aquatic conservation objectives. From 20 to 40% of the westside landscape on state and private forest lands fall in riparian zones that require special management considerations under new state forest practices regulations. Many of these riparian areas contain dense young Douglas fir/western Hemlock forests previously managed primarily for timber production. Land managers need information concerning the effects of different management options (including thinning and planting) on:

- Establishment of diverse understory and over story species in riparian zones, including establishment of conifers in hardwood-dominated riparian zones
- In-stream environments, including water quality and temperature, shade, stream bed conditions, large woody debris, and aquatic vertebrate and invertebrate populations
- Riparian terrestrial environment, including temperature, light regimes, and understory development
- Riparian vegetation structure and diversity
- Levels of sustainable timber production from riparian areas.

Managers also need information concerning how different management regimes applied on federal, state, and private lands within the same watershed affect the overall functioning, health, and sustainability of riparian ecosystems at the landscape scale.

c. *Silvicultural practices for production of multiple values in young-growth forests*: In addition to the large operational-scale research experiments in which the Program is currently engaged, there is a continuing need for smaller-scale studies to determine the effects of silviculture practices on an expanded range of forest values. Silviculture practices for intensive timber management were designed to capture site resources for wood production from a limited number of tree species. Western forestlands contain hundreds of thousands of acres of relatively young, even-aged conifer stands managed with these practices. Although such stands provides non-timber values at some level, new or modified silviculture practices are needed to meet increasing demands for non-timber values. New technology is needed to remove or use smaller diameter trees, and to provide new management practices for lands to enhance production, maintenance, or restoration of non-timber values. Specific silvicultural practices are needed that:

- Change the vegetation species mix to produce stands that enhance or restore landscape-level biodiversity and rare ecosystems while producing landscapes that are less susceptible to fire, insects, and disease, or produce other desirable resource values
- Accelerate the development of late successional characteristics needed by old-growth associated species
- Enhance the diversity and abundance of understory plants and associated values
- Reduce density in overstocked, small-diameter stands to encourage development of more resilient stand structures, particularly in areas of high fire or windthrow risk

Element 2.3: Develop and evaluate options for the management of populations that maintain or enhance genetic diversity in the long-term while providing the basis for genetic improvement in health or productivity in the short-term.

Sustainability is the predominant issue facing forest management today. One key to providing for uncertain future environments is the conservation of genetic diversity. The importance of genetic diversity for sustainable forest management has been explicitly recognized in several international agreements. For example, three criteria for the conservation and sustainable forest management stated in the Santiago Agreement of interest to forest genetics research are: (1) conservation of biological diversity including ecosystem, species and genetic diversity, (2) maintenance of productive capacity of forest ecosystems, and (3) maintenance of forest ecosystem health and vitality (Anonymous 1995; www.mpci.org/home_e.html). The success or failure of plants to thrive in their range and adapt to new challenges is a direct reflection of the amount and kind of genetic diversity included in their common gene pool and the amount of selection pressure applied to these populations. In recent decades the impact of forest management on the natural processes of selection has increased as a result of altering the environment at a faster rate through introduced pests (diseases, insects and invasive species), altered growing conditions (intensive management), and possible climatic changes (global climate change). The genetic composition and structure of species and populations have also been altered by moving planting stock throughout the region via our reforestation and restoration efforts and by changing gene frequencies through artificial selection in breeding programs. Research focuses on understanding the natural state of genetic variation and the possible consequences of the altering the gene pools and environments.

<u>Need/Value of current and future research:</u>

a. *Conservation of genetic resources*: Public land policy decisions are frequently influenced and constrained by the management needs of rare species or populations within species. These species and populations often exist in sufficiently small numbers that the risk of extinction is significant. Understanding the amount and structure of the genetic variation helps us to understand the future potential of a species or population. Research focuses on identifying populations that are at risk due to small population sizes, geographic isolation or management oversight, and then to assist in developing appropriate conservation measures.

b. *Breeding for disease and insect resistance*: Increased pressures from plant and insect pathogens represent a significant threat to the health of native forests on both a regional and global scale. The introduction of exotic pathogens has reduced the ability of some species and populations to survive in the short term (eg. Dutch elm disease and chestnut blight) or restricted its ability to adapt to future conditions by reducing population sizes and thus the amount of genetic variation (eg., *Cronartium ribicola* on the 5-needle pines and *Phytophthora* species attacking Port Orford Cedar and tan oak). Changing management practices can also increased disease incidence as evidenced by the Swiss needle cast epidemic presently affecting coastal Douglas-fir on the Oregon coast; which is, in part, due to the increased proportion of Douglas-fir in the spruce-hemlock zone. Research examines natural resistance that may be

present in populations and develops methods to rapidly increase resistance in native populations to allow them to adapt to the new pest pressures. Results from such research will allow us to manage these species to a point where they can remain a viable component of the ecosystem.

c. *Breeding and deployment strategies for reforestation and restoration*: Populations must have sufficient genetic variation in order to adapt to changing environments; the level of required variation varying with the species of interest. Artificial regeneration programs used in reforestation and restoration impose selection on the germplasm source (either through intentional selection for improved traits, or unintentional selection from the regeneration process) and ultimately results in some reduction of genetic variation. Selecting to improve economic traits may also alter other traits that may be important to future adaptation. Seed collection for restoration purposes typically does not try to "improve" traits, but the small populations characteristic of such efforts are prone to reductions in genetic variation as a consequence of selection or random drift. Research examines the potential impact of current breeding and deployment (e.g., seed orchard) practices and investigates how we may be able to simultaneously improve both genetic gain and diversity. Future work will examine the impact of current restoration practices on the genetic structure of the resulting ecosystems.

RD&A Issue 3: Developing research models, databases, measurement techniques, and analysis tools is needed to evaluate forest management options.

Issue -Wide Benefits:

Ecosystem-based planning requires placing management activities in a broad spatial and temporal context. This enables decisions that are informed not only by site conditions but also by landscape considerations. Knowledge of ecological processes that transcend small spatial scales and short time periods is needed so management will result in conditions that are robust to natural variability and other important sources of uncertainty. The development of improved measurement techniques, models, analysis and visualization tools, and database designs will benefit scientists and others by producing tools they can use to better characterize, analyze, summarize, and display data from their projects. Analysis and visualization tools will utilize the more detailed and spatially explicit measures of terrain and vegetation characteristics common to long-term study installations. Scientists will use visualization tools to more broadly understand and communicate information from their studies.

What net benefit will the clientele and society receive if this issue is solved?

Characterization of site conditions via direct measurement or remote sensing will allow resource managers to plan and implement management activities that meet economic,

regulatory, and social goals. Measurement techniques must transcend small spatial scales and short time periods if forest management is to result in conditions that are robust and address natural variability and other important sources of uncertainty at the landscape scale. Measurements must be site-specific but methods must be applicable over large areas to capture the variability inherent in forest ecosystems. In addition, for such information to be useful, it must be organized and summarized in a logical way, accessible to a wide range of users, and easily updated and expanded. End-users of the measurement methods will benefit from descriptions of forest conditions that are more precise and include estimates of variability across large areas.

New methods for organizing, storing, and integrating information and analysis results will benefit forest managers, researchers, and policy-makers by making resource data more accessible and portable. New process models, visual simulation tools, and analysis frameworks will provide an environment where detailed resource descriptions can be used to design, evaluate, and present management alternatives. End-users of the methods and tools will be able to judge the merit and relative importance of specific information because details on data sources and analytical approaches will be included.

What is the likelihood that the R&D effort will provide a solution to the issue?

Program scientists have a long history of developing, testing, and implementing successful techniques and software products to assist with resource measurement, analysis of vegetation and site data, and presentation of this information using visual simulation techniques. Success in the development of basic technologies to acquire large quantities of precise measurements quickly and cheaply is enabling the development of measurement systems that result in detailed, accurate measurements of site and vegetation conditions.

While improved quantitative methods may not solve every management problem, it is very likely they will provide effective tools for characterizing site conditions and conducting sensitivity analyses that define critical features of many management problems. Analysis and modeling tools will assist in the interpretation of site conditions and prediction of the effects of management activities and natural disturbances on site conditions. Visual simulation tools will help managers communicate site conditions and present analysis results.

Element 3.1: Develop techniques for measuring and modeling structural and spatial characteristics at the plant, stand- and landscape-level.

Complexity in natural resource management continues to increase as pressure for multiple outputs from limited lands increases. To meet multiple demands, while complying with forest practices regulations and environmental laws, managers need detailed, site-specific knowledge regarding forest vegetation (both composition and structure) and terrain conditions. Likewise, improved vegetation models that predict responses to management alternatives are needed. New measurement techniques that allow efficient collection of detailed site and resource condition data are needed—both for use in development of improved vegetation models through research and monitoring

activities; and to provide site-specific data for use in formulation and implementation of management activities.

Need/Value of current and future research:

a. *Stand and tree development models*: Large amounts of data from past and on-going silvicultural experiments continue to be collected, but much of these data have not been integrated into a form that is readily interpretable and usable by scientists and managers who need quantitative estimates of the effect of alternative management regimes on stand development and on both timber and non-timber values. Existing models such as DFSIM are limited to a few species and stand conditions (even-age management) and do not provide needed information on response to unconventional silvicultural regimes and treatments; on stand attributes (crown structure, understory characteristics) important to wildlife and biodiversity values; on wood quality attributes important to timber values; or on effects of genetic improvement.

b. *Vegetation structure and terrain measurements*: Most of the resource values and characteristics associated with forest lands are a function of the underlying terrain conditions and vegetation structure that exists on the terrain. To effectively manage forest lands under existing forest practices regulations and management guidelines, managers need detailed data on site-specific terrain conditions and existing vegetation structure. Such data are needed to:

    - Identify and protect sensitive areas (riparian zones, erosion risks, rare elements, TES habitat)
    - Monitor stand development
    - Estimate biomass distribution over the landscape with respect to forest fire risks, wildlife habitat structure, and timber values
    - Provide data for ecosystem component models (e.g. tree growth models, habitat models, erosion models, landscape visualization models, fire behavior models)

    By adapting emerging remote sensing technologies, land managers will have access to more accurate, timely, and higher-resolution information needed to plan and monitor forest operations and subsequent stand and landscape responses.

Element 3.2: Develop strategies and tools that integrate research results into development products that allow better planning, visualization, evaluation, and monitoring of silviculture practices and forest operations.

Designing and implementing silviculture practices and forest operations to provide a mix of resource outputs requires tools that integrate measured site attributes (such as those obtained using methods developed under Element 3.1), analysis results, and model predictions. Managers need to formulate alternative treatments, evaluate the effects of these treatments, and communicate both the treatments and the expected outcomes to concerned stakeholders. However, it is not enough to simply present alternatives for review and comment. Stakeholders demand more information describing existing and future resource conditions including visual simulations of conditions and descriptions of

the process and data used to formulate and evaluate alternatives. Current information distribution technologies including electronic distribution of documents, world-wide-web publishing, and online database and analysis tools can provide opportunities to communicate such information to a wide audience as it becomes available. By exposing the decision making process, stakeholders will be encouraged to engage in more productive and informed dialogue concerning management alternatives and the desired future condition for managed lands. Research focuses on developing analysis, modeling, and summarization tools, developing visual simulation systems and exploring their application to enhance understanding of existing and future conditions, and developing methods to better communicate research results.

Need/Value of current and future research:

a. *Stand and landscape visualization tools*: Land managers must assemble and summarize large amounts of data describing resource conditions and constraints and then use the information to assist with the selection and application of management practices. Managers attempt to address multiple values that, in many cases, require coordinating management activities over large areas (landscapes) since it may not be possible to provide all values at all times from smaller scales (stands). Public stakeholders and regulatory agencies scrutinize management activities on public lands, and increasingly on private lands. Managers need systems that integrate research results and output from ecosystem component (e.g. tree growth, wildlife habitat, sediment and water production, etc.) models, forest inventory information, geographic information, computerized growth models, decision support systems, and other applications to facilitate landscape, ecosystem, and watershed management. They can use such systems to plan management activities, present information detailing stand and landscape conditions through time, and educate stakeholders. Perhaps the most powerful use of such systems is to summarize and present information describing landscape conditions to help break deadlocks in debates over the selection and implementation of management practices. The ability to organize, summarize, and present information in a variety of ways, including visual simulation, helps stakeholders and regulators understand what will happen to stands and landscapes under certain treatments, now and through time. The result is dialogue that is more productive and the potential for greater consensus between managers, stakeholders, and regulators. Technical audiences benefit as well from integrated information tools, including visual images depicting stand and landscape conditions. Discussions regarding current and potential riparian condition, habitat quality, and other more subjective forest characteristics are much more productive when all parties fully understand the condition of the resource and changes that might occur as a result of management practices, disturbance, and growth.

b. *Communication of research results via advanced technologies*: The landscape has changed dramatically over the last 10 years with regards to how the public finds and utilizes research information. Today, many people first search on-line websites and databases, rather than libraries or published abstract indices. To capitalize on this shift in information dissemination, research results and information about on-going

studies will be made more quickly and widely available by developing websites and on-line documents and bibliographies. Likewise, results from research will be integrated into computer models that will be distributed digitally over the Internet. This will give managers and the public much wider and easier access to results, input to on-going projects, and use of existing databases and models.

9. Station Teams Involved: The PNW Station is structured to take advantage of cooperation and integration of employees working in groups and/or individually to address questions and issues, to research problems and produce knowledge and products that will answer the needs of society. The RMP Program supports and encourages collaborations among Program scientists and staff.

This collaborative research structure is an important aspect of PNW Station Research and the Research, Development, and Application environment. The Station wants to promote integration of skills to answer the broad based questions society is asking about interrelationships and processes. It is no longer reasonable to assume a single-focus approach to natural resources research.

Biology and Culture of Forest Plants, Corvallis, Oregon (Paul Anderson, Team Leader)

Forest Genetics, Corvallis, Oregon (Brad St.Clair, Team Leader)

Silviculture and Ecology of Southeast Alaska, Juneau, Alaska (Mike McClellan, Team Leader)

Silviculture and Forest Models, Olympia and Seattle, Washington (Steve Reutebuch, Team Leader)

9a. Scientific Workforce: In 2002, the research work within RMP and its external partners totaled $5 million, roughly 40 people (37 % on term appointments) at five locations. The workforce available for accomplishing the planned work described in the charter is based on current staff and known changes. Person-years for scientists and professionals (functioning as junior scientists), excluding volunteer or emeritus scientists or those in abolished positions are shown in Table 1. The slight fluctuations you see across the years are anticipated changes in temporary (terms and post-docs) workforce corresponding to new or completed research. There are no changes anticipated in permanent person-years. The person-year values are the sum across all teams working on the Charter issues, and because team leaders were asked by the Program Manager to allocate their team workforce to issues and elements in increments no less than ¼ (0.25) of a person-year, the table entries are carried to the nearest 0.25. What is clear from Table 1 clearly shows that the majority of the Program's work is balanced between Issues 1 and 2, with a small but significant effort under Issue 3, and this proportional effort is expected to continue over the next four years. As indicated in Table 2, the primary work conducted under Issue 3 is in the Reutebuch Team.

Table 1. Workforce Person-years

Issue		FY03	FY04	FY05	FY06	FY07
1	Scientific	6.75	6.50	6.75	6.50	6.50
	Professional	4.50	4.25	3.75	4.00	4.00
	Issue Total	**11.25**	**10.75**	**10.50**	**10.50**	**10.50**
2	Scientific	6.75	7.00	7.75	7.25	7.00
	Professional	6.00	6.25	5.75	5.50	5.50
	Issue Total	**12.75**	**13.25**	**13.50**	**12.75**	**12.50**
3	Scientific	2.50	2.50	2.00	2.00	2.00
	Professional	0.00	0.00	0.00	0.00	0.00
	Issue Total	**2.50**	**2.50**	**2.00**	**2.00**	**2.00**
	Scientific	16.00	16.00	16.50	15.75	15.50
	Professional	10.50	10.50	9.50	9.50	9.50
	Total	26.50	26.50	26.00	25.25	25.00

Table 2. Charter Issues involvement by Team in FY03

Team	Issue 1	Issue 2	Issue 3
Anderson	X	X	--
StClair	X	X	--
McClellan	X	X	--
Reutebuch	X	X	X

9b. Cooperators/Partners List: Cooperators and partners are an integral part of gaining skills. As budgets are reduced and energies refocused on the key issues and problems, the PNW will aggressively promote partnerships to gain the most with the fewer resources. Cooperators and partners are essential. There is a wide range of possible opportunities to structure these working relationships. The Station will continue to search for effective and efficient ways to accomplish the Program Goals.

PNW Programs: Some level of formal cooperation exists with each of the other Station Programs.

Other Forest Service Research Stations: Northeast Research Station, Pacific Southwest (specifically, the Laboratories in Albany, Davis, Redding, and California), Rocky Mountain Research Station, (Moscow FSL, Missoula Fire Lab, Shrub Sciences Laboratory) and the Forest Products Laboratory in Madison, Wisconsin, Southern Research Station (Auburn FSL).

National Forest System: Cooperative relationships exist with the Regional Offices of the Pacific Northwest (Region 6) and Alaska (Region 10) and virtually all of the National Forests in the two regions. Cooperators also include the Washington Office Engineering staff (Missoula Technology and Development Center and Remote Sensing Applications Center), Forest Management Service Center (Fort Collins), and several National Forests in Regions 1, 2, 4, and 5.

The nature of the cooperation varies from direct, on-the-ground involvement in field studies to assistance and scientific leadership in planning for adaptive, ecosystem-based management or mutual involvement in region-wide cooperatives.

State and Private Forestry: Washington Office, Region 6, and Region 10

International Forestry: Operations Branch in Washington Office

Other Federal organizations:

Agricultural Research Service, Department of Agriculture
Animal & Plant Health Inspection Service, Department of Agriculture
Bureau of Land Management, State Office, various Districts & Resource Areas
Department of Defense, Fort Lewis
Department of Energy
Finley National Wildlife Refuge
Fish and Wildlife Service, Department of the Interior
Interagency Regional Ecosystem Office and Research and Monitoring Committee
National Marine Fisheries Service, NOAA
Natural Resources Conservation Service
US Army Corps of Engineers

Colleges and Universities:

Clover Park Technical College
Cornell University
Evergreen State College
Iowa State University
Oregon State University
Pacific Lutheran University

Portland State University
Saint Louis University
Southern Oregon University
State University of New York (SUNY)
University of Alaska, Fairbanks
University of California, Berkeley and Davis
University of Idaho
University of Montana
University of Tennessee
University of Victoria, BC, Canada
University of Washington
Washington State University

State and County Agencies:

Alaska, Department of Environmental Conservation
Alaska, Department of Natural Resources
Benton County Parks
Montana, Department of Forestry
Oregon Department of Fish and Wildlife
Oregon, Department of Forestry
Thurston County Parks and Recreation
Washington, Department of Natural Resources
Washington, Department of Fish and Wildlife

Industry:

Boise Corporation
Cascade Timber Consulting (Oregon)
Green Crow
Pacific Northwest Natives
Plum Creek
Pope Resources
Port Blakeley Tree Farm
Rayonier
Roseburg Forest Products Company
Sealaska Corporation (Alaska)
Shoulder to Shoulder Farm
Sierra Pacific Corporation
Simpson Timber
Starker Forests
Weyerhaeuser Company

Cooperatives, Institutes, and Centers:

Agenda 2020
Alaska Science and Technology Foundation
Coastal Oregon Productivity Enhancement Program
Cooperative for Forest-Systems Engineering
Hardwood Silviculture Cooperative
Headwaters Research Cooperative (Industry, ODF and BLM funded)
administered through NCASI
Institute for Culture and Ecology
Joint Fire Sciences Program
Levels of Growing Stock Cooperative
Medicinal Plant Working Group
Northwest Tree Improvement Cooperative
Nursery Technology Cooperative
Pacific Northwest Tree Improvement Research Cooperative
Precision Forestry Cooperative, University of Washington
Salmon River Canyon Weed Management Area – Cooperative
Stand Management Cooperative
Swiss Needle Cast Cooperative
Watershed Stewardship Education Program, OSU SeaGrant
Willamette Valley Ponderosa Pine Conservation Association

Others:

British Columbia Ministry of Forests, Silviculture Research Branch
British Columbia Ministry of Environment
Canadian Forest Service
Chehalis Nation (Washington)
Confederated Tribes of Siletz and Grand Ronde
Douglas Project Coalition (Oregon)
GROWISER
International Union of Forest Research Organizations (IUFRO)
Makah Nation (Washington)
Nature Conservancy
New Zealand Forest Research
Plant Conservation Alliance
Quinault Nation (Washington)
Society of American Foresters (SAF)
Squaxin Nation (Washington)
Washington Native Plant Society
Taiwan Forest Research Institute
TRAFFIC, USA/World Wildlife Fund

10. Approach to Solution of Selected RD&A Problems:

RD&A Issue 1: **Management to sustain production of forest products and values depends on improved fundamental knowledge of biology, ecology, and genetics of plants in forested and non-forested ecosystems.**

Element 1.1: Develop new knowledge of how genetics, site factors, and basic plant processes affect establishment, growth, and structure of forest vegetation.

Understory vegetation responses to overstory density and structure: Field studies are underway to determine how overstory trees influence resource availability (light, soil water, and nutrients), temperature, and rainfall interception in the understory. Responses of planted and volunteer seedlings and associated vegetation to these conditions are being measured concurrently to improve understanding of factors that limit understory vegetation abundance, vigor (survival, growth, and reproductive ability), and species composition. Techniques are also being developed to quantify overstory conditions. In Alaska, prolific natural regeneration of conifers after clearcutting dramatically reduces or eliminates understory vegetation important for habitat, subsistence, product, and diversity values. Overstory thinning often promotes additional conifer regeneration, but not the intended increase in non-conifer understory. In order to develop efficient techniques for maintaining or restoring understory vegetation, we are studying the light requirements of understory plants, overstory influence on light availability, and mechanisms of recolonization (seed transport, vegetative propagation, soil seed banks). Overstory canopy development and the rates and effects of canopy closure on understory development are studied to improve our understanding of stand structure dynamics and the relationships between overstory trees and understory vegetation.

General location: SE Alaska, Washington and Oregon

Schedule: Research on several species is ongoing at several locations in Washington and Oregon. Most of these studies are short-term (< 5 years). Some observational studies will be completed in the near future and other studies will begin throughout the charter period. Research on creating more diversified structure in young forests in the Oregon Coast Range by establishing a range of relative densities through thinning and under planting a variety of tree species is nearing completion in a study established 8 years ago.

Root, stem, and crown characteristics of trees as influenced by soil, microclimate, and stand characteristics: The size, structure, and integrity of tree vascular tissue can be limited by competition for limited resources as manifested by soil characteristics, microclimate, or competition with associated vegetation. Root system distribution, stem conductance, and tree size as influenced by factors such as soil structure, soil temperature, soil moisture, and competing vegetation abundance are being investigated in field trials. Newly available techniques to study root systems are being evaluated. In addition, genetic ideotypes are being evaluated to determine how genetic composition influences stand-level productivity.

General location: Washington and Oregon

Schedule: Research on seedling microclimate, sapflow, tree root systems, and on the effect of soil properties on tree growth is ongoing and will be completed shortly. Other projects including those evaluating genetic ideotypes will begin early in the charter period.

Regeneration of neglected woody species: Many native tree and shrub species have not been utilized in past regeneration programs and basic information on their reproduction and early growth is lacking. Field, laboratory, and greenhouse trials are being used to study seed biology, develop seed collection guidelines, determine seed handling and storage methods, and develop appropriate techniques for use in natural and artificial regeneration programs. Many species are being evaluated in Washington and Oregon including Pacific madrone, bigleaf maple, cascara buckthorn, Oregon white oak, and Pacific yew. Of particular concern in southeast Alaska is yellow cedar, a species with poor regeneration success following timber harvesting.

General location: Southeast Alaska, Washington and Oregon

Schedule: Most studies in this sub-element are short-term (less than 5 years). Some work will be completed in the near future and other studies will begin throughout the charter period.

Soil water effects on forest productivity: Excess soil water is one of the most important factors limiting forest productivity in southeast Alaska. Field studies are used to determine the effects of soil hydrology and temperature on soil morphology; nutrient transformations and transport; vegetation growth, diversity, and abundance; and carbon storage. Collaborative work is extending this research to examine the linkages between hillslope soil dynamics and the productivity of associated riparian and aquatic ecosystems.

General location: Southeast Alaska

Schedule: Soil characterization and automated measurement of soil hydrological conditions have been conducted for the past five years and are continuing. Studies of soil solution chemistry and vegetation are ongoing. Studies of hillslope-riparian-aquatic linkages are in the planning stage.

Genecology of native forest species. Genetic diversity in natural populations is discernable in a number of ways, including plant form, resistance to disease, and growth and vigor characteristics. In order to make the most effective use of public resources, spatially correlated patterns of genetic diversity must be identified so that locally adapted individuals are grown in the most suitable habitat. Genecology studies (e.g., studies of natural genetic structure) incorporate information derived from common garden trials, molecular studies and field trials to identify appropriate conservation units ("seed zones"). Studies to date have evaluated all commercially important conifers native to the PNW region, and current work emphasizes forest trees (Douglas-fir, ponderosa pine,

western larch, red alder), restoration plants (antelope bitterbrush, milkvetch, lupine), and rare/threatened plants (Brewer's alpine reedgrass).

General location: Washington and Oregon

Schedule: These studies, first initiated over 40 years ago, are ongoing and long-term in nature. Many existing studies have been recently re-measured so data are available for summary and publication. The work will continue beyond the charter period.

Element 1.2: Increase knowledge of how natural and human disturbances affect plant genetic diversity, composition and structure, soil, and long-term productivity of forests.

Natural disturbance dynamics and their response to harvesting: Studies of native forests reveal baseline conditions for comparison with the results of newly developed silvicultural treatments. These studies will determine the damaging agents responsible for small-scale disturbance, their relative importance, and the abundance of various types of structures, in addition to the associated effects on stand-level vegetation structure, composition, and abundance. Several studies of silvicultural alternatives are examining harvest-related changes in damage due to windthrow, mistletoe, and other agents, and are investigating the factors that influence the type and degree of damage.

General location: Washington, Oregon, and Southeast Alaska

Schedule: This is an on-going research topic; some data are currently available for analysis and publication and other data will become available in the next few years. Initial work on damaging agents and structure in Alaskan old-growth forests has been completed and reported as part of the ATC experimental study. This work is continuing to examine harvest-related effects and will be expanded to older even-aged forests (150 to 250 years old) that represent the transition phase to old growth, uneven-aged forests. Collaboration with the MDR Program is essential to the success of much of this work.

Impacts of intensive management on long-term productivity of forest sites: Survival and growth of planted Douglas-fir are being monitored following disturbances of various intensities designed to simulate intensive forest management, including soil compaction, wood utilization and woody debris removal, and competing vegetation control (Fall River Study). Additional treatments include approaches designed to ameliorate potential reductions in site productivity, including tillage and nutrient amendment. An expansion of the long-term site productivity research is being initiated with forest industry at three or more additional sites in western Washington and Oregon. The research will examine how different soil and climatic factors influence Douglas-fir seedling responses to woody debris removal and competing vegetation control.

General location: Washington and Oregon.

Schedule: The research duration is long term (10+ years) given the objective to identify management effects on site productivity beyond stand establishment. Early results from Fall River and other studies will be published early in the charter period.

Management and natural disturbance effects on non-native invasive plants and native plant communities: Studies are being conducted to analyze changes in plant communities in dry forest types receiving the disturbance of wild and prescribed fire and the invasion of exotic weeds. Studies of the competitive interaction of exotic and native species will also include how pollinators and the reproductive cycle of these species are influenced by invasive exotics. Changes in native and exotic plant density and composition are being assessed in dry forest types with historically high fire frequency such as ponderosa pine/grass communities and oak savannas following overstory treatments and fire.

General location: Oregon, Washington, and Idaho.

Schedule: Studies have been initiated for two years but will require three to four more years of field data to adequately assess plant community changes; studies that examine interactions of specific herbaceous species using greenhouse and controlled field experiments will be short to mid-term in length. Collaboration with the MDR Program is essential to the success of this work.

Yellow cedar decline: Researchers from the RMP and MDR Programs are jointly examining the role of soil factors, hydrology, and climate, and their possible interactions as causes of yellow cedar decline. Affected and healthy stands are being studied for differences in hydrology, soil physical and chemical conditions, plant chemistry, vegetation conditions, and microclimate. As potential causal factors are identified, greenhouse studies will be used to confirm their roles and to elucidate mechanisms.

General location: Southeast Alaska

Schedule: Collaborative field studies of soil and climate as causal factors of cedar decline are underway. Greenhouse experiments and expanded field studies are planned for the next five years. Collaboration with the MDR Program is essential to the success of this study.

Element 1.3: Develop biological, ecological, and genetic knowledge of native plants for conservation and restoration of under-represented or vulnerable species, including species that are used for non-timber forest products (NTFP).

Conservation biology of listed and Survey & Manage (S&M) plant species: Studies on the genetics, pollination ecology, plant reproductive response to fire, and habitat change of rare and listed plants provide vital information in revising and updating management recommendations and conservation plans for S & M and listed plant species which are receiving ongoing restoration efforts. Using agronomic techniques in conjunction with restoring habitat will be assessed also.

General location: Research is being conducted across the range of these species but focused primarily in Oregon and Idaho.

Schedule: Genetic and reproductive as well as habitat modification and fire-effect studies have been ongoing for several years. Genetics studies for one species will be completed by next year. The habitat and fire response study will also be completed early in the next charter period. Any additional studies on will be short term and completed within the next three years.

Sustainable harvest and conservation of NTFP plant species: Harvest response studies and basic biological research on life-cycle and pollination ecology of selected plant species will be performed to develop an understanding of the basic ecology and biology and the how overstory treatments affect key plant species, as well as to determine measures of sustainability of plant species that are important to nontimber forest products users.

General location: Oregon and Idaho

Schedule: Some components are near completion and others will require several more years. All studies are short- to-mid term in length.

Biology and ecology of Quercus garryana: Research on oak will entail continuation of the range-wide acorn survey and seedling outplanting trials, as well as new field studies on oak root systems, tree growth rates, and water and nutrient relations. Research will also involve field and laboratory studies to understand the effects of fire on tree growth and function.

General location: Washington and Oregon (limited work in southern BC and northern CA).

Schedule: Most of the work is on-going but new studies will also be initiated. Some results will be available in the near term. Several trials are short-term in nature and will be completed in the next few years while a few studies will continue beyond the charter period.

Molecular genetics of plant species integral to landscape restoration and ecosystem health: Informed management and conservation of native flora requires knowledge of population demography, as well insight into the extent and limitations to gene flow, and patterns of population differentiation across highly heterogeneous landscapes. At present, research is being conducted to characterize the genetic health of rare species (*Calamagrostis breweri, Cypripedium fasciculatum*), and to gain insight into patterns of genetic variation in restoration species (*Astragalus*, *Lupinus, Purshia*). Future research will be expanded to evaluate the threat posed by interspecific hybridization in creating new, locally adapted forms of weedy plant species.

General location: Research emphasizes plants native to Oregon and Washington, but also includes species native to northern California, Idaho and Utah.

Schedule: This work represents a new avenue of research for the Program, and most projects are in their first season. Many projects will be completed within a short (1-2 year) time span, but longer term projects will be integrated with related studies on gene conservation (see Element 2.3). These latter studies will likely continue beyond the charter period.

RD&A Issue 2: A wide range of silviculture and genetic practices is needed to provide the variety of conditions, services, and products that will be demanded from forested lands.

Element 2.1: Develop options for increasing the quantity and quality of wood production through the integration of genetics and silviculture.

Remeasurement and analyses of key young-growth studies: Several studies involving series of permanent plot trials have been established throughout the region, including southeast Alaska. These studies are usually part of cooperative research efforts with industrial, state and other federal (NFS) cooperators and represent long-term obligations. Because of the long-term characteristic of stand development and forest management activates, these plots provide basic information on how different levels of growing-stock (density control through precommercial and commercial thinning and plantation spacing) and timing of density control affect the growth of individual trees and stands, yields, mortality, wood quality, stand structure, and understory development. Treatments include a wide range of spacing and some pruning trials. Species include Douglas-fir, western hemlock, western red cedar, Sitka spruce, western white pine, noble fir, Pacific silver fir and red alder [e.g., Levels of Growing Stocks (LOGS) studies and the Southeast Alaska density management (Farr) plots]

General location: Oregon,Washington, SE Alaska

Schedule: These trials have been established for a number of years. They are being monitored and remeasured periodically with the results updated and published throughout the charter period.

Management of genetically improved seedlings and trees: Current management practices take advantage of planting stock from the regions tree improvement programs. However, much of the information we have to develop management strategies comes from past research done on unimproved stock. In addition current improved stock have been selected from and for traditional silvicultural practices where clearcutting dominates. Silvicultural systems involving residual overstory are becoming increasingly common in the Douglas-fir region. Knowledge is needed on the effects of overstory density on the subsequent development of different families planted in the understory. The genetic variation in response to varying overstory densities and levels of shade is being explored in Douglas-fir along with the implications for expected gains from genetic

selection under different silvicultural systems. Other nursery studies of genetic variation in response to light are being done for western hemlock and ponderosa pine. To improve our ability to prescribe treatments using improved stock, trials are being established that test how stand development might differ for different genetic families under different silvicultural treatments, such as density.

General location: Oregon and Washington

Schedule: The Capitol Forest Overstory Density Study was recently established near Olympia, Washington, and early results are forthcoming. It is designed to be a long-term study. Nursery studies on genetic variation in response to light were recently completed and will be reported soon.

Silvicultural treatment effects on wood quality: Data are being collected on stem, branch and wood characteristics from research installations that have histories of various treatments. This work includes evaluation of epicormic branching in Sitka spruce and the development of stain in western hemlock after thinning in southeast Alaska. For various species, wood density and microfibral angle are being investigated in trees from different management strategies (e.g. thinning densities) that result in different growth rates and from different genetic families that have been deployed in past regeneration programs. Pruning is a specific silvicultural treatment that offers a way to begin producing clear, more valuable wood at young ages for a variety of species; it can also influences the amount of light reaching the forest floor and the plant communities that can be supported. Research trials have been established in various species to investigate how pruning impacts growth response of individual trees, the time for branch wounds to heal and the time for trees to begin producing clear wood, and the impacts on the quality and amount of wood produced. New work will evaluate understory responses to pruning. These data sets on wood quality are being analyzed to see how silvicultural treatments impact wood quality for selected species (e.g., Douglas-fir, western hemlock, Sitka spruce, red alder, western red cedar). This will lead to recommendations on how management and breeding practices can be modified to enhance wood quality or reduce impacts. We are also looking at the relationships among growth rates, wood properties and subsequent strength properties. This work will allow us to better allocate timber resources to appropriate end products.

General location: Oregon, Washington and SE Alaska

Schedule: Several data sets have been compiled and analysis is ongoing. This work will continue throughout the charter period with some studies completed early in the period. Efforts are currently underway to analyze and publish information on early pruning results. Collaborations with the HNRI Program and with the Forest Products Lab are essential to the success of this work.

Element 2.2: Develop and evaluate silviculture practices that restore, maintain, or enhance multiple forest values, including wood production, fish and wildlife habitat, biological diversity, visual quality, and long-term productivity.

Operational silviculture for sustaining wood production and other values: Several large-scale studies have been implemented to jointly assess production of wood and other values. These include: Alternatives to Clearcutting (ATC) for old growth in Southeast Alaska, Silviculture Options for Production Forests (DNR Capitol Forest), Olympic Habitat Development Study (Olympic National Forest), Clearwater Study of Silvicultural Alternatives (Gifford Pinchot National Forest), and DEMO (Demonstration of Ecosystem Demonstration Options) for mature and young-growth in Oregon and Washington. These trials compare a range of silvicultural treatments (or stand conditions) on tree growth, development of understory vegetation, and other factors, such as wildlife habitat, visual quality, logging costs, and soil and stand disturbance.

General location: Southeast Alaska, Washington and Oregon

Schedule: This work is on-going and long-term in nature. Several short-term assessments will be published during the charter period. A major symposium is planned for 2004 that will bring scientists together who are working on large-scale harvest experiments to share results and communicate the value and application of large operational silviculture experiments to achieving ecological and economic objectives in forest management. Collaboration with the ECOP Program is essential to the success of DEMO.

Silvicultural practices for riparian buffers and headwater forests: Multiple scale approaches are used to study the role of silviculture and riparian buffers within landscapes containing dense and extensive networks of intermittent and perennial streams that occupy a majority of westside forests in the Pacific Northwest. Program researchers use both large-scale operational silviculture and buffer treatments in riparian and headwater forests that extend across multiple stream drainages and finer scale stand level treatments that focus on the attributes and dynamics of single stream reaches and the adjacent riparian areas in response to silviculture and buffer creation (Agenda 2020 Commercial Thinning and Regeneration… Headwater Forests Study in cooperation with Weyerhaeuser Co. researchers). These studies examine a range of silvicultural options and buffer approaches in managed Westside forests on riparian habitat, water quality microclimate, stand development, and organisms in and adjacent to these Riparian Reserves and riparian buffers. The studies are part of a large multi-disciplinary, multi-cooperator research project on both publicly and industry managed lands to resolve issues related to riparian areas and the management of young forests in the areas dominated by Douglas-fir and western hemlock. Information from both study approaches will increase our understanding of riparian processes and increase the knowledge for modeling the effects of silviculture on streams and riparian areas.

General location: Western Oregon, mainly BLM and industry managed lands. The large-scale studies are on BLM and Forest Service lands. Finer scale stand

level studies conducted under the Agenda 2020 program are on both BLM and industry lands

Schedule: Early short-term (3-5 years) post-density management and riparian buffer establishment results from the larger scale BLM study will be reported during 2003. The Agenda 2020 headwater forests study will be completed in FY'2004. Because major developments in stand structure and diversity are not expected until about years 6-8 after treatment, work will continue throughout the charter period

Silvicultural practices for production of multiple values in young-growth forests: Basic research concerning the effects of silvicultural treatments on development of young-growth stands has been underway for several decades. Results from many of these studies are being synthesized to provide better understanding and guidelines for treating young stands in western Oregon and Washington and SE Alaska. Additionally, information on production and costs associated with treating small-diameter, overstocked stands is being compiled and synthesized. Existing plot-level field trials on new practices for stand establishment and management (including multi-aged stands), growth and response to management of neglected species (such as Oregon white oak, western red cedar, red alder and other broadleaved species, Pacific yew, noble and Pacific silver fir, and western white pine), and growth and implications of species mixtures will continue to be evaluated and published. A limited number of new trials will be established as needed to better understand understory development and understory production of needed value.

General location: western Washington, western Oregon, and SE Alaska

Schedule: This work is ongoing and long-term in nature. Many existing studies have been recently re-measured so data is available for summary and publication. The work will continue beyond the charter period.

Element 2.3: Develop and evaluate options for the management of populations that maintain or enhance genetic diversity in the long-term while providing the basis for genetic improvement in health or productivity of forest systems in the short-term.

Conservation of genetic resources: Information derived from genecology and molecular genetic studies are being used to identify populations harboring regionally significant genetic variation (disease resistance, growth characteristics, vigor), as well as populations that may be threatened by management oversight. These traditional studies are being merged with GIS-based approaches to identify *in situ* genetic reserves, and to characterize gaps in protection. If gaps are present, the team assists clients in developing appropriate follow-up studies and conservation measures. Studies typically (but not always) are done in conjunction with the NFS and/or client groups such as the Pacific Northwest Forest Tree Gene Conservation Group and the Willamette Valley Ponderosa Pine Conservation Association.

General location: Washington and Oregon

Schedule: Initial GIS gap analyses of the PNW region have been completed, and results are in the process of being written for publication. Molecular surveys of regionally significant conifer germplasm (Willamette Valley ponderosa pine, Washoe pine) have been initiated and will be completed in the near-future (2-3 years), and additional similar studies are likely to include Port-Orford Cedar.

Breeding for disease and insect resistance: Studies examining inheritance patterns are typically done in collaboration with clients. Research includes the development of appropriate screening techniques when such techniques are lacking. This research assists clients in deploying trees that are capable of producing healthy forests in light of increased disease and insect pressure from native and exotic pests. Current studies are examining Swiss needle cast (SNC) tolerance in Douglas-fir use and weevil resistance in Sitka spruce.

General location: Washington and Oregon

Schedule: The SNC genetic research will continue for the next 3 years in cooperation with the SNC cooperative. Work on weevil resistance will take place over the next 10 years as potentially "resistant" hybrids are developed and deployed.

Breeding and deployment strategies for reforestation and restoration: Current management practices may unknowing lead to putting ecosystems onto undesirable trajectories. It is important that land managers understand the various potential consequences of management options. Current studies are investigating the impact of breeding and seed orchard (or seed procurement) practices on genetic diversity and other risks associated with altering gene frequencies. Computer simulation is used to investigate ways to increase both genetic gain and diversity. Future work will examine the impact of current restoration practices on the genetic structure of the resulting ecosystems.

General location: Washington and Oregon

Schedule: The studies are ongoing in nature. Presently research is being directed at optimizing operational Douglas-fir breeding programs and will continue for a few more years. New work is examining the impact of restoration efforts on the native gene pool.

RD&A Issue 3: Developing research models, databases, measurement techniques, and analysis tools is needed to evaluate forest management options.

Element 3.1: Develop techniques for measuring and modeling structural and spatial characteristics at the plant, stand- and landscape-level.

Stand and tree development models: Results of current and past silvicultural experiments will be utilized to evaluate and develop models of tree growth. Much of the work will be done cooperatively with other organizations and will focus on previously under-represented species, young stands and increasingly complex stand structures. Incorporating wood quality attributes will allow for the evaluation of pruning treatments and the impacts of silvicultural treatments on wood quality.

General location: Oregon, Washington, and Alaska

Schedule: The accumulation of data sets from throughout the region have contributed significantly to past modeling projects and continue to be in high demand. Newer data sets from more recent silviculture trials will be used to test and develop new model capacities. Revisions to existing growth models will be produced throughout the current charter period and beyond as remeasurement data from existing trials are collected.

Vegetation structure and terrain measurements: Remote sensing technologies are being evaluated for their utility in measuring and monitoring forest vegetation change over time and space. Such terrain and vegetation data are needed for accurate modeling and visualizations of silvicultural alternatives at stand- and landscape-levels and for use in forest fire behavior models. Studies have been initiated that utilize ground vegetation data collected on established silvicultural trials and Joint Fire Sciences Program sites (Capitol Forest, Fort Lewis, Clearwater, Mission Creek FFS site). Measurements describing the horizontal and vertical distribution of fuels are being used to properly locate standing and down fuels within stand- and landscape visual simulations, with efforts initially focused on development of spatial distribution models for use with output from the Fire and Fuel Effects (FFE) extension to FVS consisting of overall fuel weights in various size and condition categories. Such models are important for predicting fire intensity and behavior.

General location: Oregon and Washington

Schedule: Many field studies are short-term and will be completed in the near future. Other studies are ongoing and will continue throughout the charter period and beyond as existing silvicultural trials are monitored.

Element 3.2: Develop strategies and tools that integrate research results into development products that allow better planning, visualization, evaluation, and monitoring of silviculture practices and forest operations.

Stand and landscape visualization tools: Development of stand- and landscape-level visualization systems that are integrated with existing growth and process models is ongoing. New linkages to understory and fuel distribution models are just beginning. Such visualization systems enable better understanding of forest development and communication of silvicultural options to diverse publics. The team's models are integrated with and distributed as part of the Forest Vegetation Simulator (FVS), developed by the Rocky Mountain Research Station and supported by the Washington Office Forest Management Service Center, and provide visualization capability for all regions and stations.

General location: Washington

Schedule: Development of improved visualization systems is ongoing and will continue throughout the charter period. Integration of visualization systems with other models describing understory vegetation characteristics and fuel distribution is just beginning and will continue throughout the charter period.

Communication of research results via advanced technologies: Research on biology, silviculture, and modeling generates databases, specialized programs to manipulate data, and summaries of short-term research results that would be of interest to other researchers, managers, and students. These databases will be maintained and updated, and data, programs, and summaries will be provided via the web, on CD, or in other electronic formats (with associated documentation). Research databases, for use within the program by other station programs, are also important assets that need to be properly documented and archived.

General location: Washington

Schedule: This is an on-going effort. Several products (databases and software packages) are currently available on our website. Others will be added each year to our website or distributed via other formats.