

**U.S. Forest Service R&D
Wildland Fire External Peer Review**

June 18-21, 2007

Review Panel

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Executive Summary

The Forest Service Wildland Fire and Fuels R&D Program has a distinguished record of accomplishments, and its impact on fire and fuels management has been significant. This Program had its origin during the era when the 10-AM Policy held sway and the focus of management was entirely on fire prevention and suppression; fire management was viewed primarily as a service to natural resources, notably timber. Over its history, management paradigms have broadened to recognize the beneficial role that fire plays in many forests and, more recently, the negative consequences of fire suppression. Nowadays, the role of and consequences for people and communities has become the prominent theme for fire management. The Forest Service and other agencies are striving to move from rigid approaches to fire and fuel management to adaptive approaches embodied in the concept of “appropriate management response” (AMR).

The Program has a long history of providing information, tools and systems that form much of the basis for modern fire management. It has displayed leadership in the science community, among its partners and collaborators and among the end-users of its knowledge and applications. The Program has played a significant role in the development of partnerships and collaborations with other public agencies and a variety of organizations. It also continues to play a significant role in a number of international programs.

The Program’s various labs and projects have a long history of high quality, peer-reviewed science. That research and the FS scientists who carry it out are widely recognized in and by the broader community of scientists. The credibility of the knowledge generated by the Program rests on this tradition and its importance cannot be overstated. It can also point to excellent examples of its ability to move information from basic science to synthesis and application in the form of tools used by managers.

In general, the Program has in many areas been adaptable to changing needs and paradigms. Its strategic plan is clear and cogent. The Program’s stated commitment to interdisciplinary synthesis and integration is prominent in the documents submitted for this review, and that commitment is evident in a number of areas.

We compliment the Program for these various achievements, but we also acknowledge the need and opportunities for improvement in these and other Program areas. Our specific recommendations for development and improvement for each of the Program’s portfolios are outlined in the report. Our more general recommendations for the Program are briefly stated as follows:

- Evaluate the models and narrative used to describe the Program and align them with Program goals, priorities and future directions.
- Review the proposed Program evaluation criteria and associated assessment tool, and develop specific criteria for the Program and each of its portfolios to align with the assessment tool and to the tangible desired outcomes of the National Fire Plan and USDA Forest Service as a whole.
- Enhance adaptive management. Fire management R&D should be an exemplar of adaptive management in its own programs.

- Explore opportunities to retain knowledge and expertise of retiring scientists at an appropriate level. Advisory committees and appropriate consulting arrangements might be ways to retain that knowledge.
- Reconsider portfolio titles and the language used to describe projects, tools and programs. Titles should provide clear information on program mission, and nomenclature should be consonant with changing management models and paradigms.
- Develop strategies to enhance and regularize involvement of managers and decision makers in the establishment of priorities for research, tool development, and tool delivery.
- Develop and articulate operational criteria to measure relevance success. The production of tools and the delivery of information are necessary, but insufficient success measures. Measures should also include the utility of such tools and information to end users and their impact on management challenges or decisions. Design appropriate instruments to ensure that this criterion is included in the evaluation of the Program and its various portfolios.
- Evaluate and adjust Program structure, management, and/or evaluation so as to encourage more problem-oriented interdisciplinary research.
- Continue to catalyze and build partnerships. The Program can build on its success in this area by strategically identifying partners that add value to Program strengths, building partner capacity in areas not well met by Program resources and expertise, and strategically engaging in international work that builds on Program strengths not met elsewhere.
- Define a few high-priority focal themes for integrative, interdisciplinary research. Input from managers and collaborative partners should be sought in this regard. Potential themes that emerged during the panel's deliberations include: smoke emissions and air quality research, defining Appropriate Management Response, land-use change, climate change and fire suppression

The study of wildland fire and fuels will continue to evolve as fire management responds to societal needs. Just as fire management no longer is perceived solely as a service function to timber, range, water, wildlife, and other natural resources, wildland fire R&D similarly must respond to changes in USFS land stewardship priorities. Many challenges confront contemporary and future fire managers, including but not restricted to information needs and tools for ecosystem restoration.

No other nation on the planet can boast of a wildland fire research organization that rivals the breadth and depth of the USFS fire and fuel RD&A infrastructure. No other nation has adopted a management paradigm so nuanced and daring as AMR. The agency's multiple-use mandate persists because it speaks to societal preferences. For these and other reasons delineated in this report, the USFS fire research organization has much to celebrate in terms of accomplishments to date, but also greater motivation for improvement.

Introduction

Program background¹

USDA Forest Service Research and Development (FS R&D) develops and delivers knowledge and innovative technology to improve the health and use of the nation's wildlands. The scope of the research program is nationwide without respect to land ownership or ecosystem.

Fire and fuels management comprise a significant portion of the overall FS R&D program, drawing on funding from the R&D base appropriation, National Fire Plan funds, the Joint Fire Science Program and, as appropriate, Fire Management program funds.

The Forest Service Wildland Fire and Fuels R&D Program has a long history of providing information, tools and systems that form much of the basis for modern fire management. Examples include the Incident Command System, the National Fire Danger Rating System, and fire prediction tools such as BEHAVE and FARSITE. Additional significant contributions have been made in the areas of fire history, fire ecology, and social aspects of fire management.

In 2005, a strategic planning effort resulted in a strategic document to guide fire and fuels R&D into the future. The "Wildland Fire and Fuels Research and Development Strategic Plan: Meeting the Needs of the Present, Anticipating the Needs of the Future" (USDA Forest Service, 2006) outlines three strategic goals and organizes Wildland Fire and Fuels R&D into five topical portfolios. These portfolios are Core Fire Science, Ecological and Environmental Science, Social Fire Science, Integrated Fire and Fuels Management, and Science Application.

Review goals and performance criteria

The overall goals of this review were clearly stated in our charge. They are to:

- Enhance the relevance, quality, and performance of fire research and development program areas by providing feedback and suggestions for improvements to research managers.
- Provide an opportunity for exchange of views among experts/peers about the fire program area.
- Provide increased opportunities for FS R&D customers and stakeholders to provide input to research and related program area activities.
- Provide a credible, professional, and objective assessment that further improves customer and stakeholder confidence in the conduct of FS R&D research and the outcomes produced.

In addition to its narrative assessment, the panel was asked to evaluate the relevance, quality and performance of the Wildland Fire and Fuels R&D program in a somewhat more quantitative fashion using the following criteria.

Relevance: *The relevance criterion seeks to assess whether the research activity is appropriate in relation to the FS R&D mission, FS and USDA goals and objectives, national priorities related to the field of study, and current and anticipated customer needs. Important dimensions of relevance include:*

¹ Background provided in the charge to the panel

- Evidence (likelihood) of impact
- Evidence (likelihood) of use by managers
- Evidence (likelihood) of use by other scientists
- Alignment with the mission and vision of the Agency and R&D strategic goals
- Customer satisfaction with products and services
- Unique (not redundant with other government or private efforts)
- Focus on most critical needs and emerging issues
- Integration of necessary disciplines

Quality: *The quality criterion seeks to ensure that the research program maintains and uses practices to ensure that high quality research is conducted consistent with disciplinary standards. Important dimensions of quality include:*

- Objectives clearly identified and addressed
- Problem analyses and study plans peer reviewed
- Diversity and quality of partners
- Merit based approaches to allocate funds
- Peer reviewed outputs
- Availability on FS R&D websites
- Capabilities of research staff

Performance: *The performance criterion seeks to ensure that agency management has access to performance measures that indicate progress in meeting program goals. Important dimensions of performance include:*

- Timely delivery of planned products and services
- Expanded knowledge in the specific domain
- Productivity relative to level of resources and capacity
- Financial accountability demonstrated
- Measures that provide insight into program performance to guide improvements without being overly burdensome
- Availability on FS R&D websites

Panel review process

Beginning about a month before its June 2007 meeting, the panel reviewed a variety of documents. The “Wildland Fire and Fuels R&D Review Document” provided a program overview and detailed descriptions of the mission, structure and accomplishments of each of its 5 portfolio areas. Several other documents were available to panel members, most notably the “Wildland Fire and Fuels Research and Development Strategic Plan” and the “Forest Service Strategic Plan.”

The panel met June 18-21, 2007, in Bend Oregon and the agenda for that meeting is attached as Appendix A. During that meeting, the panel heard presentations from the Deputy Chief for Forest Service Research and Development, the FS Director of Forest Management Sciences, and the National Program Leaders for Fire Ecology and Fire Systems Research. Team Leaders from each of the program portfolio areas—Core Fire Science, Ecological and Environmental Science, Social Fire Science, Integrated Fire and Fuels Management, and Science Application—gave presentations and answered panel questions relative to their respective portfolios. Following

these presentations, the panel worked in plenary and in subgroups to craft its evaluation and recommendations. These were presented orally to FS personnel on the final day of the review and are respectfully articulated in detail below.

Overall Program goals, significance and achievements

The overarching goals of the Wildland Fire and Fuels R&D Program (hereafter, simply called the “Program”) are as follows.

- **Societal Goals:**
 - Reduce the losses to society from fire (lives, property, infrastructure, resources)
 - Improve and maintain resilience and sustainability of wildland ecosystems
- **Outcome Goals:**
 - Science-based fire management to accomplish national goals, which currently include:
 - Improved prevention and suppression
 - Reduced hazardous fuels
 - Restored fire adapted ecosystems
 - Empowered, engaged, and informed communities

The strategic goals of the Program are to:²

1. Conduct basic and applied scientific research, enhancing knowledge for use in developing the next generation of predictive and decision-making tools. FS Fire R&D teams will work with external partners to conduct research in four areas:

- **Core fire science**, including physical fire processes, fire characteristics at multiple scales, and fire danger assessment;
- **Ecological and environmental fire science**, including fire effects on ecosystem components and interactions between fire and the environment;
- **Social fire science**, including public interactions with fire and fuels management, socioeconomic aspects of fires and fuels management, and organizational effectiveness;
- **Integrated fire and fuels management research**, including management strategies and multiple scales, treatment and disturbance effects on ecosystem components, harvesting and use of biomass removed for fuel reduction.

2. Promote application of knowledge and tools (science application) by policymakers, wildland fire managers, and local communities. Work under this goal will ensure that knowledge generated by the Forest Service is transferred to user communities and adopted by them.

3. Provide leadership for development and implementation of a nationally coordinated Wildland Fire R&D Program. Forest Service scientists and research leadership will strengthen collaborations with other agencies and partners to ensure that federally supported R&D programs are efficiently structured to reduce the negative impacts of wildland fire on people, property, and the environment, while working to improve the overall health of communities and the environment.

² Excerpted directly from FS-854, 2006, “Wildland Fire and Fuels Research and Development Strategic Plan.”

Program significance

This R&D program meets critical needs within the Forest Service and for the management of forested lands overall. Currently, “Fire and Aviation” accounts for over 40% of the agency’s budget; that percentage is expected to grow in the years ahead. Beyond that, fire and associated forest health issues are today among the most prominent challenges to sustainable forest management in our National Forests as well as on private and industrial forest lands. Fire and fuels management has always had significant implications for communities, and population growth and recent patterns of suburban and exurban development have made it far more daunting. These challenges extend well beyond the borders of the United States. Thus, the environmental, economic and social costs of scientific uncertainties, inadequate knowledge, and limited decision tools are indeed enormous. Given the urgency and importance of fire and fuel management challenges, the current commitment of resources to the Program seems modest at best. That said, it is also all the more compelling that the Program’s priorities are aligned with key needs and that its research and development portfolios are directed toward those priorities.

The Forest Service Wildland Fire and Fuels R&D Program has a distinguished record of accomplishments, and its impact on fire and fuels management has been significant.

- The Program’s various labs and projects have a long history of high quality, peer-reviewed science. That research and the FS scientists who carry it out are widely recognized in and by the broader community of scientists. The credibility of the knowledge generated by the Program rests on this tradition and its importance cannot be overstated.
- The Program can also point to excellent examples of its ability to move information from basic science to synthesis and application in the form of tools used by managers. Among these examples, fire prediction tools such as BEHAVE and FARSITE are perhaps best known.
- The Program’s stated commitment to interdisciplinary synthesis and integration is prominent in the documents submitted for this review, and that commitment is evident in a number of areas. The Fuels Synthesis Project is a good example.
- The Program has played a significant role in the development of partnerships and collaborations with other public agencies and a variety of organizations. Most notable among these have been the Joint Fire Science Program and LANDFIRE.
- The Program continues to play a significant role in a number of international programs. The Program’s co-sponsorship of numerous conferences, symposia and workshops is especially noteworthy.
- The Program has in many areas been adaptable to changing needs and paradigms. Its strategic plan is clear and cogent.
- The Program has displayed leadership in the science community, among its partners and collaborators and among the end-users of its knowledge and applications

We compliment the Program for these various achievements, while we acknowledge the need and opportunities for improvement in these and other Program areas. Identification of needs and opportunities for improvement, and recommendations to meet those needs and seize those

opportunities are, of course, this panel’s reason for being. They are the focus of the remainder of this report.

Please note that the panel’s findings and recommendations are based almost entirely on the written materials and presentations that it was provided. We were able to assess the budgets and human resources of the Program’s portfolios and larger projects with regard to size and composition as well as criteria and process for setting priorities. We were comfortable evaluating overall research themes and priorities with regard to the relevance, quality and performance criteria described above. The panel was not in a position to evaluate all of the projects within a portfolio, nor was it in a position to assess the quality of individual research programs.

An Evolving Context for Fire Management Science

This Program had its origin during the era when the 10-AM Policy held sway and the focus of management was entirely on fire prevention and suppression. Later, the Program changed as fire management was viewed primarily as a service to natural resources, notably timber. Over its history, management paradigms have broadened to recognize the beneficial role that fire plays in many forests and, more recently, the negative consequences of fire suppression. Nowadays, the role of and consequences for people and communities has become the prominent theme for fire management. The Forest Service and other agencies are striving to move from rigid approaches to fire and fuel management to adaptive approaches embodied in the concept of “appropriate management response” (AMR).

It is no surprise that this fire management history is reflected in the history of the development of the Fire and Fuels R&D Program. Early studies focusing on the development of models of ignition and fire spread gave rise to the Core Fire Science program. Research on ecological and environmental fire effects expanded as the role of fire became more complex. Research dedicated to the human dimensions of fire management can be said to be in a nascent stage, and research and applications to support AMR is a prominent theme in the Program’s planning documents.

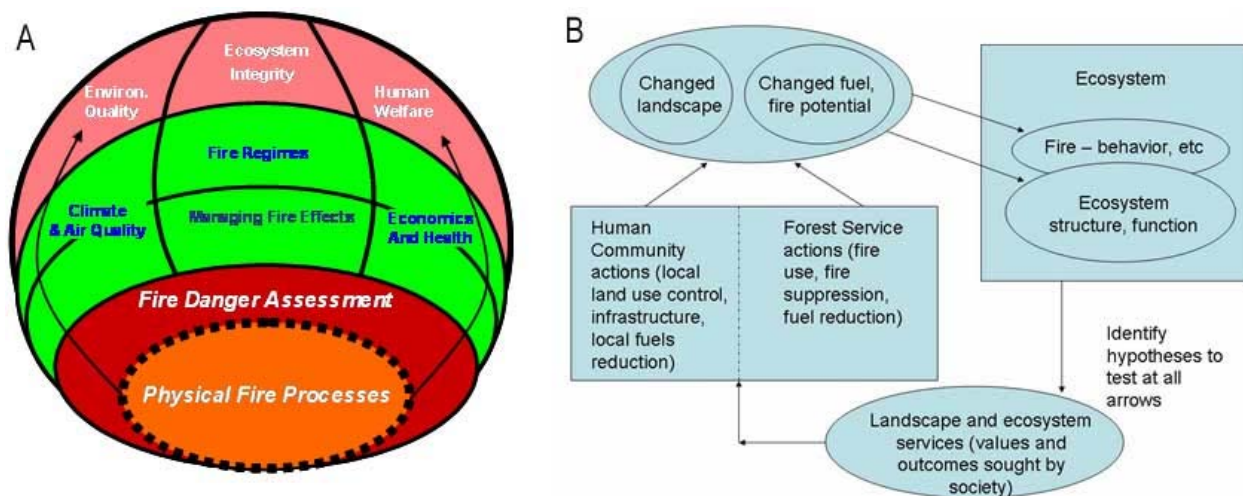


Figure 1. Conceptual models for Program structure. A: Model presented by the Core Fire Science Portfolio. B: Model developed by the panel

We note that current Program structure and nomenclature reflect in many ways this history of change. Figure 1A is a model of information flow shared in the Core Fire Science portfolio presentation. The south pole of this model represents the origin of the Program and history progresses as one moves north. The panel found that this model, which was described as an “onion” with many layers that could be peeled from the core, did not capture the full complexity of fire management issues and that (intended or not) it implied a directionality in influence and information flow. Figure 1B is an alternative model constructed by the panel and reflecting its own sense of actual influences and areas of research need. This alternative model incorporates the importance of broad-based, programmatic hypothesis testing and taking an adaptive approach toward research program development. We contrast these two models here not to advocate our own model, but to call attention to the role that history can play in defining the organizational models we select. We shall argue later in this report that the model depicted in Figure 1A has drawbacks relative to several of the Program’s stated goals and aspirations. Further, Figure 1A will need to be modified if, as our panel suggests, greater prominence is attached to studying the effects of fire suppression across all portfolio areas.

Program Portfolios

Portfolio A—Core Fire Science Research

Achievements. The Rothermel surface fire spread model was developed out of the general research arena represented by this portfolio some 35 years ago. The model facilitated the quantitative prediction of fire behavior for fire operations and fire research, both of which make use of fire spread and growth estimates. The first notable application was in the development of the National Fire Danger Rating System (NFDRS) in 1972 with subsequent revisions in 1978 and 1988. The NFDRS has provided a framework for evaluating the effects of the fire environment (i.e., weather and climate, fuels and topography) on fire spread and intensity potential. Climatological analyses of NFDRS outputs have in turn been used to summarize long-term trends in fire potential and in the development of pocket cards related to firefighter safety, for example. The introduction of the BEHAVE fire behavior prediction system in the early 1980s and its subsequent successors (e.g., BehavePlus, FARSITE, NEXUS, FlamMap, FSPro, FVS-FFE, Fuels Management AnalystPlus, etc.) have readily enabled practitioners to place science in their “toolkit” to supplement their own art in the process of predicting wildland fire behavior. This is a powerful example of the transformation of basic Program science into synthetic models followed by the development of easy-to-use tools that are accessible by fire operations staff. Reflecting the maturity of research in this area as well as its obvious relevance to fire and fuel management, international and interagency partnerships are prominent in this portfolio. Many of the fire behavior prediction systems developed by the Forest Service are also used overseas.

Productivity in this portfolio area as measured by broad applications through end-user training and to a lesser extent the number of peer-reviewed publications is high. Many Forest Service publications—particularly those related to the Rothermel model and its application—are widely circulated and used amongst other fire scientists and managers. The research on characteristics of emissions from wildland fuels and wildfire plume dynamics that has facilitated the collaboration with the EPA on BlueSky is particularly noteworthy. The same can be said for research to characterize fuels at ground, surface, and crown levels (e.g., fuel inventory procedures, photo series, FCCS), the mapping of fuel condition classes nationwide, models for

predicting fuel consumption (CONSUME, FOFEM), and criteria for determining firefighter safety zones and wildland-urban interface standards.

Challenges. The Rothermel surface fire spread model has undergone limited performance evaluations under low to moderate burning conditions (principally in slash, grass, and shrub or shrub-like fuelbeds involving small experimental plots) coupled with a few after-the-fact comparisons based on wildfire case study documentation (e.g., 1980 Mack Lake and 1994 Butte City wildfires). However, it has never undergone rigorous field testing, suggesting the need to evaluate or assess the potential for over-extension, robustness, and other validation metrics. In spite of its popularity, the Rothermel model has been largely accepted on blind faith for far too long, especially in coniferous forests involving long-needle pine ecosystems. For example, the model, through its various system forms, has been widely applied to ponderosa pine fuel complexes and yet there are no published accounts of its performance against either outdoor experimental fires, prescribed fires or wildfires in any ponderosa pine fuel types.

The Rothermel crown fire rate of spread model released in 1991 is widely used by other fire scientists and fire managers, and has been incorporated into virtually all fire behavior decision support systems used in the United States. The model, which is based on a limited empirical wildfire dataset, was deemed by its author as a “first-order approximation”. Recent evaluations have shown it to be insensitive to changes in burning conditions while under-predicting by a factor of 2.5-3. Furthermore, in the materials entitled “Meeting the Challenges of Wildland Fire and Fuels Management Through R&D” provided to the panel review team, the Program managers acknowledged that when it comes to predicting fire behavior and effects “... we now have a “system” of independently developed, linked models that were never intended to work together, are sometimes based on very limited data, and may propagate errors beyond acceptable limits” (3rd paragraph, p. 167). The review panel concurs. For example, when Van Wagner’s empirically-based model for predicting crown fire initiation is implemented in the context of the various U.S. fire behavior decision support systems, it grossly underestimates the presumed onset of crowning. A similar problem occurs with the implementation of Van Wagner’s model for predicting crown scorch height.

Fire behavior related research within the Forest Service is carried out by a number different groups at a number of different locations. There appears to be a lack of internal coordination amongst the different parties (e.g., 40 standard fuel models vs. FCCS fuelbeds). For example, research into crown fire behavior is being undertaken at Riverside, Seattle and by two separate research units at Missoula without any apparent collaboration or cooperation.

Forest Service fire behavior research has a number of notable accomplishments to its credit as alluded to above. Development of models for predicting fire spread, fire growth and other fire phenomena (e.g., spotting) have revolutionized the ways in which we think about and manage fires. In the 35 years since the publication of the Rothermel surface fire model, there has been overall only a modest level of effort in regards to fundamental or basic research into the processes involved in free-burning fire behavior. In other words, to an outsider, things appeared to have been stalled for a very long period of time no doubt due in part to the perception by both fire managers and research managers alike that the “fire behavior prediction problem” had been solved back in 1972. The immediate present day challenge is to balance the efforts to develop a new, more flexible physics-based approach while at the same time providing a moderate level of support for the existing systems without resorting to a major overhaul to extend the life of their usefulness. While the physical-based models developed by the National Institute of Science and

Technology (NIST) and the Los Alamos National Laboratory show great promise as means of guidance in developing a new, process-based model one should avoid “putting all your eggs in one basket”.

Some of the terminology used in descriptive materials is not consistent with the evolving character of fire management programs nor does it clearly communicate the role of this portfolio. “Core Fire Science,” for example, is uninformative at best and possibly misleading. Research in this area clearly has an integral role in fire management, but it is no more “core” than studies of fire effects on ecosystems or the human dimensions of fire management. We encourage Portfolio team members and Program managers to consider a more informative title (e.g., Physical Fire Fundamentals or Models for Predicting Physical Fire Phenomena). Furthermore, perhaps it is time to reevaluate the use of terms such as “fire danger” (as in the National Fire Danger Rating System) and fire risk with terms that are more precise and that have less emotional or value-laden meaning.

Recommendations.

- Expand portfolio commitment to comprehensive fire model development. The next generation fire model is sorely needed and the stakes are high. Research on fire behavior must be done well, and it must command the confidence of those engaged in other aspects of wildland fire research. Issues that need to be considered include:
 - Goals. The goal should be to develop a seamless “system” that makes no distinction between the characterization of fire behavior and fire danger. Such a model would directly support fire effects research and other applications and also directly respond to firefighter safety concerns. The next generation fire model should be comprehensive in terms of considering all fire behavior characteristics (i.e., rate of advance, flame size/shape, residence and burnout times, fuel consumption, spotting, propensity for crowning) and must consider the impact of ignition pattern on fire behavior characteristics (e.g., single point source vs. multiple points vs. converging lines).
 - Timeframe. The 15-year time frame suggested for this sort of project during the presentation to the review panel by the Team Leader of this portfolio is much too long. It must be the highest priority within this portfolio and given the kind of approach taken by the “Manhattan Project” during World War II where a large concerted effort in terms of resources had a limited time to accomplish the task at hand. The possibility of developing an international consortium to address model development should be explored.
 - Verification. A comprehensive problem analysis and associated study plans which include verification, evaluation or testing protocols (including the use of archived data) needs to be completed as soon as possible. Commensurate with the effort is the need for better service-wide coordination of Forest Service activities with respect to wildland fire behavior.

- Completion. The next generation fire model need not be the “final complete answer” but it must constitute a quantum improvement over the existing state-of-our-knowledge³.
- Keep people working on the problem after the initial deliverables are met, so that program legacies are not lost when individual staff move or retire.
- Evaluate the title of this portfolio as well as the terminology it uses to describe itself and its products. The applications of this work extend well beyond fire suppression.
- Continue and expand on international and interagency partnerships and cooperatives. Much is being done here in this regard, but the needs and opportunities are great to enhance the added-value of this portfolio to the international wildland fire community.
- Reevaluate the content of this portfolio. For example, consider moving the fire emissions component of Element A1, the remote sensing component of Element A2, and the FCAMMS component of Element A3 in this portfolio to Portfolio B.
- Maintain and develop information technology capacity. Computation and information technology needs in this area are very significant, and success in the development of the next generation of fire models will depend on the Forest Service keeping pace with these needs.

Portfolio B—Ecological and Environmental Science Research

Achievements. There is a remarkable range of topics embedded in this portfolio. Fire effects research spans studies of biophysical processes, fire-vegetation interactions and watershed functioning. The fire-environment interactions sub-program includes weather and climate interactions, fire history and fire regimes, and fire emissions and air quality. This portfolio includes a large and very productive group of researchers who are widely known and respected in the general fire ecology and fire effects research community. We note that collaborations and partnerships play a significant role in this portfolio. For example, about 20% of the portfolio budget is dedicated to cooperative programs with universities and outside groups. Individual research projects have played a central, even catalytic role in the development of major initiatives such as the National Fire and Fire Surrogates Program and LANDFIRE.

Challenges. The current and future research directions that were presented to the panel are incredibly broad and encompassing. We recognize the value of and need for an ambitious agenda, but we were troubled that priorities were not clearly articulated. More troubling, a clear process for setting such priorities was not apparent. Where would an increment of knowledge make the greatest difference in our ability to manage the nation’s forests? That question should

³ “How, then, can one decide when the job is done? The answer is that it is never done, for three basic reasons. The first is that any research result or practical output comes under immediate pressure for continuous improvement as soon as it is made public, from either the scientific community or the practitioners and users. The greater the success, the greater the pressure. The second is that a pool of expertise cannot be maintained in any other way than by conducting research. The first is that research, by its very nature, implies a succession of breakthroughs that cannot be foretold. These may at any time confound the most careful planning and change the course of the research into new, more fruitful directions.” (from: Van Wagner, C.E. 1984. Forest fire research in the Canadian Forestry Service. Can. For. Serv., Petawawa Natl. For. Inst., Chalk River, Ont. Inf. Rep. PI-X-48.)

be central to a priority setting process, and it cannot be answered without a clearer connection to the priority needs of decision makers, managers and communities.

This portfolio is rife with potential opportunities for integration with the other portfolios. However, it not clear that this potential is being realized or that it is a high priority. This was particularly evident in discussions of smoke management and air quality. In one form or another, these matters and their significant policy and management implications arose throughout the presentations. The need for a program that connects physical studies of emissions with their ecological, economic and human health effects is compelling. We note that the BlueSky program is discussed by Portfolios A and B, but we are not able to judge the nature or extent of collaboration.

Appropriate Management Response (AMR) is a remarkably complex approach to managing fire that requires an operational definition of “appropriate” in the context of incomplete and uncertain knowledge (i.e., adaptive management). Portfolios B and C must play a central role in providing operational criteria for defining what is appropriate, as well as the methodologies for evaluating management actions against such criteria. Here again, the opportunities for inter-portfolio collaboration are significant.

Relevance and application are central themes in the overall Program strategic plan. Although its products are widely recognized in the research community, the actual impacts of this portfolio on achieving management objectives are very difficult to quantify because specific, quantitative goals for doing so are not formulated in an operational manner, and tools for such an assessment currently do not exist.

Recommendations.

- The portfolio should develop a process that clearly connects priorities to the desired outcomes of the National Fire Plan and the needs of managers and decision makers. We call attention to this issue here because the challenge was particularly obvious in this portfolio, but we note that this challenge extends across the entire Program. Thus, we discuss specific strategies to pursue this recommendation in our discussion of the Program as a whole.
- Overall portfolio goals with respect to relevance and application and the general goals of priority research areas (e.g., Biophysical Processes, Fire-vegetation Interactions, etc.) need to be articulated around specific and measurable objectives. This is being done at the level of individual research projects. But success at higher levels of organization is currently difficult to assess.
- There is significant opportunity for long-term synthetic research in this portfolio styled after the NSF Long-Term Ecological Research (LTER) program. Longitudinal studies are certainly being done within this portfolio, and a number of portfolio B researchers participate in LTER studies. No LTER-style program has been dedicated to explicit studies of fire, however. Further, such a long-term synthetic approach would be critical if, as suggested by our panel, the study of fire suppression impacts becomes a Program priority.
- There is also a significant opportunity to better utilize, integrate and leverage the Forest Inventory and Assessment (FIA) program and data.

- Smoke and air quality and the definition and measures of success of AMR are particularly important areas of research opportunity and need.

Portfolio C—Social Fire Science Research

Achievements. Although clearly nascent and small in size, this portfolio is making significant progress in advancing social science fire research, and there is an opportunity to take advantage of its relative youth to strategically build capacity and to define portfolio priorities that are not currently weighed-down by historical legacies. Recognizing the need to understand not only the consequences for people, but also the constraints and opportunities that people create, fire managers are paying much more attention to this portfolio's products. Although a work in progress, there is ever increasing recognition by managers of the relevance of social science research. The quality of research and the productivity of this portfolio are reflected in a highly favorable ratio of peer-reviewed publications to budget. This is another indicator of the demand for this work within the FS. We also note the recent publication of several important books and reports from this group that present state-of-the art syntheses and that advance understanding of fire risks and fire economics.

There are outstanding examples of synthesis and collaboration between researchers in this portfolio and others. The synthesis documents on fuel and fuel treatments are particularly notable.

Significant progress is being made on the economics of optimizing fuel reduction, as well as the optimization of fire management costs and benefits. The panel recognizes that thorough economics studies of fire effects and fire management alternatives are also a critical element in defining AMR and is pleased to see the emphasis that this is being given.

Challenges. Dollars allocated to social science research generally do not reflect the dominance of problems increasingly recognized by managers as relating to social issues and values. Predicting fire spread and evaluating environmental consequences of fire (or its absence) are important, but such information must be set in the context of future fire trends and consequences that will be driven by human attitudes, behavior and patterns of development. "Conventional wisdom" and "urban myths" are often taken as genuine knowledge by the public and managers, and this often presents significant obstacles to initiating social science research and to on-the-ground fuels, fire and ecosystem management in the public interest. Further, the tendency of conventional wisdoms to persist despite social science research to the contrary makes social science application an especially challenging task.

Despite their few numbers, many researchers in this portfolio are also doing work unrelated to fire. This undoubtedly creates challenges to the efficient development of research focus and assignment of priorities.

There are unique barriers to social science research, particularly the increasingly stringent requirements for OMB and human subjects review. This has often created major disincentives for such research due to the time and effort consumed in meeting such requirements; in some cases it has inhibited the development of collaborative arrangements with university researchers.

The identification of this group as its own unique portfolio is both an asset and a liability. Its identification as one of 5 portfolio areas is recognition of its emerging importance, and must provide some leverage in the acquisition of resources. Nevertheless, some of the most

compelling questions cry out for integration of the work of social scientists with natural scientists.

Recommendations.

- Commit to further growth and development of social science research. Continued and strategic growth of resources (funding and personnel) is essential if the full potential of this portfolio is to be realized.
- Continue to recognize social fire science research as a unique portfolio, but stress integration of its work with that of other research areas. This need for interdisciplinary collaboration around cross-cutting problems exists in all portfolios, but is particularly obvious here. We recommend strategies to facilitate it in our discussion of the overall Program.
- Prioritize research efforts. As with portfolio B, there is need for prioritization of research within this portfolio. This priorities discussion could uncover opportunities for research in this area that have potential to produce significant cost savings or efficiencies in fire management or fuels management programs.
- Look outside for lessons. There are also opportunities to learn from other cultures and their relationships to fire to develop effective, innovative strategies to solve conflicts between social and ecological values for fire (e.g., Australian “stay-and-defend” and community self-sufficiency approaches to fire management).
- Build the capacity to do mid-range analyses, i.e., work in the area between the short-term, quick turn-around projects undertaken by the agency’s “policy analysis staff” and the longer-term hypothesis-driven research typically reflected in the portfolio.
- Consider and prioritize new areas for research development. Examples to consider include:
 - Public administration – organizational and accountability analyses to aid in fire management and improve internal organizational effectiveness.
 - The institutional adjustments needed to move to ARM. What is the entire spectrum of the institutional arrangements around fire suppression, and how would they be impacted or required to change with ARM? Identify incentives that create efficiencies or inertia in serving the public interest.
 - Social and economic implications of Appropriate Management Response
 - The social, economic, and organizational effects of promoting fire-adapted communities.
 - Risk attitudes and behavior of decision-makers, line officers and fire crew – analyses necessary to increase crew safety and improve fire management efficiencies.
 - Experimental economics (lab and field), incentives research for all aspects of fire management within communities. Leverage opportunities to design social science experiments in conjunction with fire and fuel management actions that are already ongoing.

- Socio-political and economic effects of fire suppression, fuel and ecosystem management, particularly in light of human and ecosystem responses.
- Application of social science research on perceptions to support fire education and outreach.

Portfolios D and E—Integrated Fire and Fuels Management Research and Science Application

Please note that we are discussing these two portfolios together in part because they are so clearly interconnected, but also because the panel had some difficulty understanding intended boundaries.

Achievements. It is these portfolios that explicitly focus on the USDA Forest Service Research and Development Branch mission statement to “develop and deliver knowledge and innovative technology to improve the health and use of forest and rangelands.” Portfolio E is specifically designed to handle fire’s contribution to deliver tools (innovative technology) and knowledge. This portfolio is appropriately emphasized as it has had no explicit home in the past. This formal recognition of the need for and commitment to application is salutary and is exemplified by the location and rapid development of the Wildland Fire Management Research, Development, and Application Program in Boise, ID. The Wildland Fire Management Research, Development, and Application Program shows promise and reflects an ability to be agile and responsive to the need to deliver knowledge and innovative technology.

Historical success of the activities that comprise these portfolios is evident throughout the wildland fire management program in the United States. These include the National Incident Command System (ICS), the Fire Weather Book, National Fire Danger Rating System (NFDRS), and the Fire Behavior Prediction System. Recent success is illustrated by work on optimizing fuel treatments on the landscape, updating the Rainbow Series, developing natural fuels photo series, and developing decision support for wildland fire management. However, we note that many of the recent landscape scale applications and decision support tools are derived from the single set of science products (i.e., the Rothermel model) produced in the late sixties and early seventies. More recently the application of remote sensing is being used to provide data to fulfill the input requirements of these models. Data availability has improved greatly over the recent past and thus the use of these tools has increased in direct proportion.

The location and rapid development of the Wildland Fire Management Research, Development, and Application Program in Boise, ID shows promise and reflects an ability to be agile and responsive to need.

Challenges. The boundary between portfolios D and E is unclear. The goal of D is to integrate landscape analysis and integrated interdisciplinary research to quantify the interacting effects of management strategies on ecology, environment, and society. E appears to overlap in the area of development and to move on to information transfer and application. This confusion can be reduced. For example, E1 is written too broadly and elements of this section could easily be moved to portfolio D. D also overlaps with initiatives within portfolios A, B and C.

How knowledge moves from D -- or, for that matter, A, B, and C -- to E is not clear. There is need for the development of an explicit process for this handoff. Although the overall strategies seem to be working, without being explicit there is a risk of creating duplication and “working

alone.” This may be a factor in the current confusing plethora of tools. Currently there are several ways to estimate fire behavior, including FARSITE, BEHAVE, BEHAVE Plus, FMA Plus, NEXUS, FS Pro, and others. Users have trouble differentiating among these tools and confusion results. To reduce this confusion, a process needs to be developed to screen existing tools for applicability and recommendations need to be made on the appropriate tool for the analysis at hand.

There are also opportunities to develop an integrated theory for achieving effective applications. For example, what might be the best balance of traditional training versus “learning-by-doing” approaches to technology transfer? How are specific landscape applications chosen and prioritized relative to their relevance as demonstrations to the broader fire community and as models across representative ecological systems?

Recommendations.

- Clarify the relationship between portfolios D and E. We believe that the intent is for D to integrate and develop and for E to apply. For example, we envision a tool such as LANDFIRE being developed and tested in D, and the application of it being transferred to E.
- Clarify relationships between portfolio D and integration efforts in A, B and C. Indeed, D might be the catalyst for realizing the increased integration across these other portfolios (see above). However that role and the means by which such integration would occur needs to be more clearly articulated.
- Clarify the boundary between these portfolios and training and support functions in management. The National Wildfire Coordinating Group Enterprise Architecture can be helpful in accomplishing this.
- Develop a process to screen existing tools for applicability and utility. This should also include a formal process for product, tool or data acceptance.
- Create and develop effective technology transfer processes that make best use of both traditional training and “learning-by-doing” approaches. Approaches that emphasize the ways that adults best learn should be utilized.
- Establish metrics to assess successful transfer of science and knowledge into decision-making and policy.

The Program as a Whole

Recognizing the many achievements of the Forest Service Fire and Fuels Research and Development Program a number of overarching and cross-cutting challenges and opportunities for improvement emerged from our evaluation of the 5 portfolios. A more integrated vision for the structure of and flow of knowledge through the organization is needed. Standards and processes to measure program performance need clarification. Processes for setting priorities and resolving conflicts among priorities should be clarified. The Program is undergoing continuous change in its human resources, and the Program must capitalize on this change to meet long-term needs and be flexible to change. This Program is poised to realize leadership

with respect to relevance, change and innovation, and not fall prey to chasing dollars merely to maintain or grow current staff capacity. These challenges and opportunities are discussed below.

An integrated vision

Admitting that there is logic in the current identity and arrangement of portfolio areas within the Program, there are also many artifacts of the history of Program development. Furthermore, this organization (captured in the “onion” in figure 1) implies boundaries and directionality of information flow that is contrary to the overarching goals of integration and the development of “science you can use.” The problem here is not so much with the identity and organization of portfolios (although this can be clarified), but with the Program vision (i.e., the story it tells) about the relationships among the portfolios, and the processes the Program implements to realize its vision and adapt through time to changing social, ecological and budget environments.

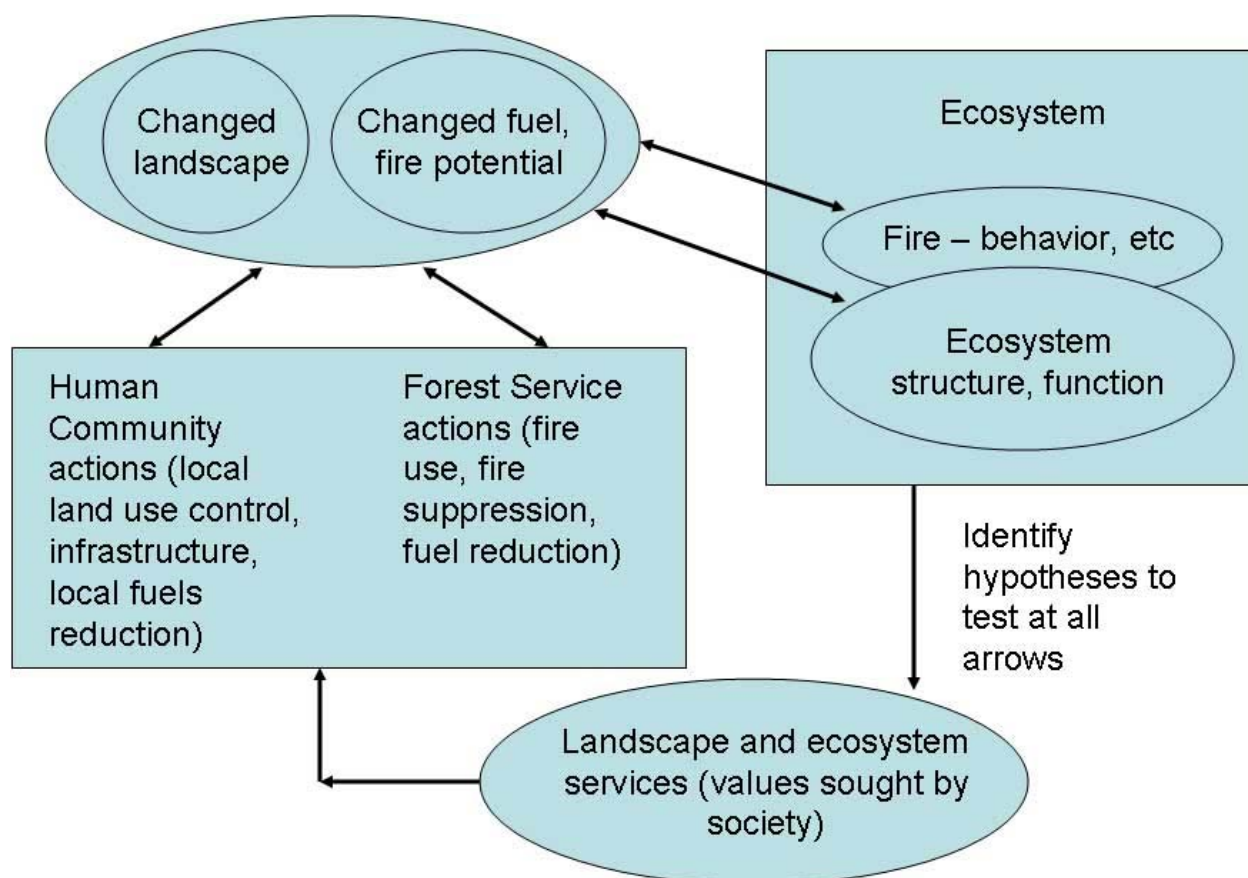


Figure 2. Integrated fire science for society. This figure is offered to stimulate thought about a framework for integrated research across disciplines and focused on the interacting human and natural systems affecting outcomes sought by society.

Unencumbered by history or the existing realities of programmatic boundaries, “silos” and “fiefdoms,” the panel imagined its own model vision or story based on stated program goals (Figure 2). We find this diagram attractive for several reasons. First, it captures all the elements described in the various portfolios (admittedly D and E are not explicit). Each of the arrows and compartments corresponds to existing or proposed research programs and potential new areas for priority research within these programs. More important, it emphasizes the connectivity among

these elements without assigning primacy to any particular one. It focuses research across disciplines (and portfolios) on the values and outcomes that society seeks from forest ecosystems and landscapes influenced by Forest Service actions. The key suggestion here is to identify a conceptual framework that would naturally lead individual researchers and research teams to pursue projects focused on the combined ecosystem and human-system and the management and policy tools essential to the public interest. Finally, it aligns with cross-cutting challenges such as smoke and emissions management or implementation of AMR policies.

As indicated, this diagram does not explicitly convey a sense of how knowledge flows among program components. For that, we suggest a complementary model in which the roles of portfolios D and E are more obvious (Figure 3). This is actually a rather simplified version of the fire research, development and application model depicted in Figure 1 (p. 25) of the Program's Strategic Plan. This model emphasizes that the needs of managers and decision makers should inform the priorities for research and tool development priorities. The panel found this useful in clarifying the roles of portfolios D and E.

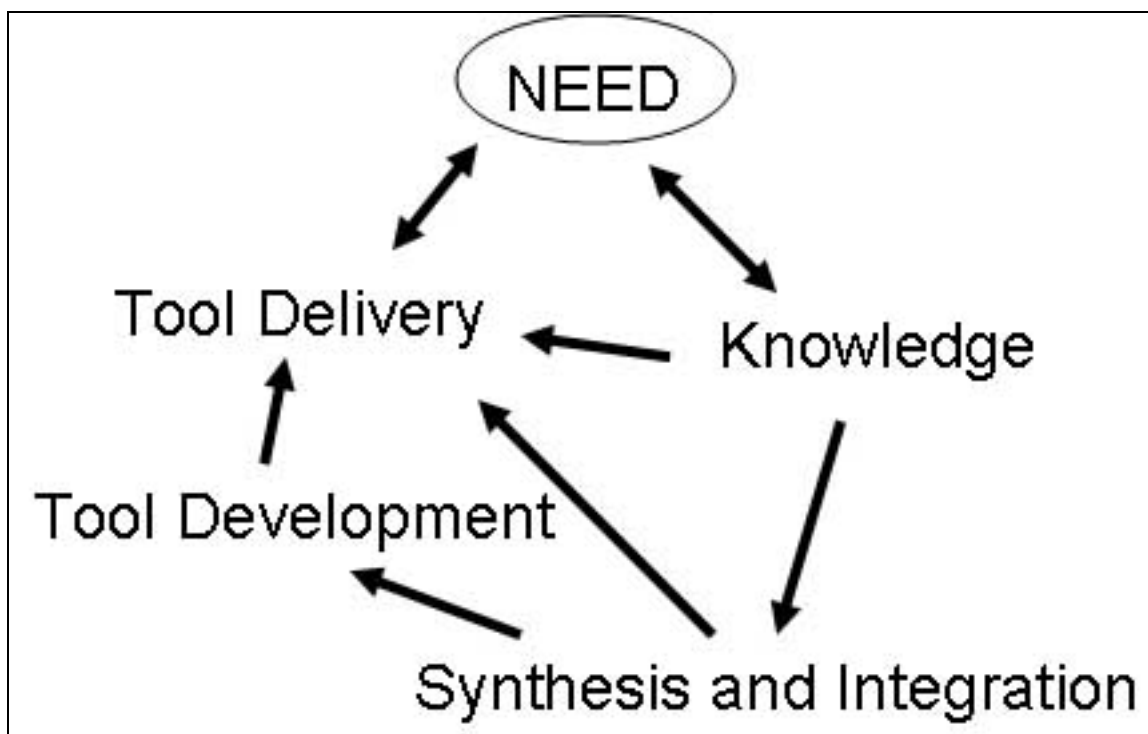


Figure 3. In this model, knowledge and tools respond to the needs of managers and decision makers, and those needs inform priorities for knowledge acquisition and tool development and delivery.

The most important feature of figure 3, however, is not the specific categories that are represented on it, but the significance of the arrows. The arrows call out the need for explicit structures and processes to ensure the information transfer that they imply.

Recommendation.

- Evaluate the models and narrative used to describe the Program and align them with Program goals, priorities and future directions. The models presented in figures 2 and 3 are possible alternatives, but are not necessarily advocated by the panel.

Measuring Program performance and success

The panel was asked to evaluate the Program and its component parts with regard to recently developed criteria for relevance, quality and performance. The panel recognizes that these criteria and the associated assessment tool were only recently communicated to the Program. However, because they were not used to structure written materials or oral presentations for the review, the panel struggled to align the criteria with the material it received. Furthermore, we were not in complete agreement on the appropriate metrics for assessment of each of the criteria.

This struggle and disagreement notwithstanding, the panel sees great merit in this evaluation tool. The overall criteria—relevance, quality and performance—are consistent with overall Program aspirations. The merit of the assessment tool will be realized with the development of much more explicit criteria and benchmarks for the Program and for each of the portfolios. This will not only facilitate future evaluation, but will also provide a clear framework for planning.

Recommendation.

- Review the proposed evaluation criteria and associated evaluation tool, and develop specific criteria for the Program and each of its portfolios to align with the assessment tool and to the tangible desired outcomes of the National Fire Plan and USDA Forest Service as a whole.

Setting priorities, resolving conflicts

There is a multitude of uncertainties and knowledge gaps in fire science, and the information and tool needs of forest managers are many. Even with significant increases in funding and human resources, there cannot be capacity to fill all these gaps or meet all these needs. Thus, assignment of priorities is critical. The panel found that processes and criteria for setting priorities were missing or inadequate (or at least not apparent to the panel) in some areas.

There is general agreement that the needs of managers and decision makers should be significant determinants of program priorities. Science cannot “push” knowledge or tools onto users that they don’t need or think they need. That said, it is not the case that managers and decision makers can or should by themselves set Program priorities. In many cases, need is generated by new knowledge, understanding and synthesis. This is certainly the case with our evolving understanding of the role of fire in ecosystems. Explicit processes that ensure two-way exchanges of information between scientists, managers and decision makers are needed.

Other potential challenges to priority setting in the Program were apparent to the panel, but it had no means of evaluating their importance. For example, the Joint Fire Science Program and the National Fire Plan have contributed to the Program’s overall budget during the past 4 years. It is clear that these programs have had a significant effect on Program priorities, but it is not clear in what ways or by what means priorities would be reassigned if funding from these or other sources were to change significantly. Also, the panel recognizes that conflicts between the priorities of research stations generally and the Fire Program specifically are inevitable, but the mechanisms for resolving such conflicts are not obvious.

Leadership

The third and final goal in the Program's strategic plan is to "provide Federal leadership for collaborative, coordinated, responsive, and forward-looking wildland fire-related R&D for all ownerships, now and in the future." The interest in and commitment to leadership is apparent in the many documents and presentations received by the panel, but it is not clear how this is being realized, where Forest Service leadership fills a unique niche, or in what ways this is a priority. Here, we suggest three areas in which program leadership is occurring or has the potential to occur and recommend strategies to enhance that leadership.

Leadership—relevance. Leadership to produce "science you can use" requires a significant measure of "followership." Interest in meeting the needs of managers and decision makers is well established in Program culture, and there are notable examples of success. Nevertheless, additional strategies to ensure relevance can be developed, operational measures of success can be much more explicit, and this element can be a more visible part of the evaluation of the Program and its parts.

Recommendations.

- Develop strategies to enhance and regularize involvement of managers and decision makers in the establishment of priorities for research, tool development and tool delivery. Such strategies might include:
 - Expanded workshops with presentations by researchers and end-users that encourage communication in all directions.
 - Program advisory committees with strong end-user membership in addition to other constituencies.
 - Training for scientists to enhance skills in communicating with (not just to) non-technical audiences.
 - Incentives for both scientists and managers to participate in the above. This can be as simple as providing released time for participation, but should also be included in personnel evaluations.
 - Use benchmarking with private industry as a way of discovering successes. The pharmaceutical and aerospace industries may offer good examples to follow.
- Develop and articulate operational criteria to measure relevance success. The production of tools and the delivery of information are necessary, but insufficient success measures. Measures should also include the utility of such tools and information to end users and their impact on management challenges or decisions.
- Design appropriate instruments to ensure that this criterion is included in the evaluation of the Program and its various portfolios.

Program priorities and values should not be set entirely by the user community. That it be substantively informed by that community is, however, a necessary prerequisite to relevance leadership.

Leadership—change. As with ecosystems, the sustainability of programs depends on their capacity to adjust and adapt to new challenges and information, and their ability to let-go of programs that have out-lived their relevance or can be transferred to others in the public or

private sector. Successful change management depends on the ability to maintain an historical context without being constrained by it. Few areas of forest management have undergone as much change in both challenges and understanding over the past several decades as those related to fire. The Program has demonstrated considerable flexibility and adaptability, but there is need and opportunity for more. Despite recognition that there has been declining trends in staffing at lower grade levels and increasing trends in staffing at higher grade levels, there is no clear vision of the desired organizational composition needed for optimal science development and delivery. Assuming that employing a greater number of staff at higher grade levels will always be better for science does not recognize the need to remain flexible in the face of resource limitations. Trends in staffing between disciplines are also not clearly supported by a clear vision relative to their relationship to achieving desired program outcomes (e.g., greater increases in physical scientists relative to other disciplines through time). The Program is the beneficiary of a rich history which should inform its future.

Recommendations.

- Enhance adaptive management. Fire management R&D should be an exemplar of adaptive management in its own programs. This will require:
 - Articulation of operational goals at every level in the Program – the panel believes the OMB evaluation tool should be the basis for crafting such operational goals.
 - Explicit evaluation strategies at the portfolio and project level. Evaluation strategies for individual researchers and for the overall Program (e.g., this panel) appear to be in place.
 - The expertise embedded in portfolio C provides opportunities for rigorous self study – seize them.
- Explore opportunities to retain knowledge and expertise of retiring scientists at an appropriate level. Concern was expressed to the panel that important “indigenous knowledge” is sometimes lost with retirements. Advisory committees and appropriate consulting arrangements might be ways to retain that knowledge.
- Reconsider portfolio titles and the language used to describe projects, tools and programs. Titles should provide clear information on program mission, and nomenclature should be consonant with changing management models and paradigms.

In complex organizations, change and transformation can only rarely occur in quantum jumps. More often it is incremental and depends on the recognition of the importance of each personnel and programmatic decision. Such decisions, regardless how small, must constantly be scrutinized in light of overarching goals for change.

Leadership—integration and innovation. The challenges for fire and fuel management have changed significantly as the values we seek from public and private lands have become more diverse and as our increasing numbers have increased our demand for those values. Solutions to these challenges do not reside with a single discipline; rather they demand integrated and interdisciplinary collaboration and new partnerships, and the innovation that derives from such collaboration and partnerships. Here too, the Program has demonstrated leadership, but it must pursue opportunities to expand it.

Recommendations:

- Evaluate and adjust Program structure, management, and/or evaluation so as to encourage more problem-oriented interdisciplinary research. The panel notes that the design and titles of portfolios A, B and C reflect disciplinary “silos,” and that the grand challenges of fire management are relevant to each of them and not captured fully by any of them, with possible exception of A and its inclusion of basic thermophysics research. We are, however, hesitant to recommend organizational change – every organizational structure runs the risk of simply creating new silos. Exploration and expansion of “processes” that facilitate integration across portfolios may be more productive. We note that portfolio D intends such integration but can more clearly provide an umbrella for interdisciplinary endeavors. In any case, incentives for programs and people must be aligned with this goal.
- Continue to catalyze and build partnerships. The Program has played a central and catalytic role in the development of partnerships and international programs. It can build on this success by strategically identifying partners that add value to Program strengths, building partner capacity in areas not well met by Program resources and expertise, strategically engaging in international work that builds on Program strengths not met elsewhere, and partnering more often! The Program has shown success in partnering with fire managers who recognize Program contributions enough to, in some cases, contribute resources to research. A true measure of success in interdisciplinary research will be the expansion of this level of tangible buy-in by non-fire resource programs such as wildlife, watershed, invasive species and recreation.
- Define a few high-priority focal themes for integrative, interdisciplinary research. Input from managers and collaborative partners should be sought in this regard. Potential themes that emerged during the panel’s deliberations include:
 - Smoke emissions and air quality research
 - Defining Appropriate Management Response
 - Land-use change
 - Climate change
 - Landscape and ecosystem values sought by society
 - Fire suppression

The panel was especially excited about the possibilities for integration and innovation associated with the topic of fire suppression. It is a recognition that fire and fuel management is not just about fire, but also about its absence. A program in this area could evaluate individual fires and fire season with respect to such matters as the impacts of suppression activities and the balance of costs and risks to public benefits and interests in forest health.

In most countries, the fire suppression prerogative is mostly unquestioned and, therefore, not researched. We are no exception. Thus, the USFS fire and fuel RD&A research agenda, despite its strengths, is not currently positioned to provide an objective, interdisciplinary assessment of fire exclusionary practices and their effects. We feel that the time is right to coordinate such an

inquiry among the priorities established for Portfolios A, B, and C. Such a research program is essential to the full implementation of AMR.

Concluding remarks

The study of wildland fire and fuels will continue to evolve as fire management responds to societal needs. Just as fire management no longer is perceived solely as a service function to timber, range, water, wildlife, and other natural resources, wildland fire R&D similarly must respond to changes in USFS land stewardship priorities. Many challenges confront contemporary and future fire managers, including but not restricted to information needs and tools for ecosystem restoration.

No other nation on the planet can boast of a wildland fire research organization that rivals the breadth and depth of the USFS fire and fuel RD&A infrastructure. No other nation has adopted a management paradigm so nuanced and daring as AMR. The agency's multiple-use mandate persists because it speaks to societal preferences. For these and other reasons delineated in this report, the USFS fire research organization has much to celebrate in terms of accomplishments to date, but also greater motivation for improvement.

Appendix A

Wildland Fire R&D External Peer Review, June 18-21, 2007
Riverhouse Hotel • Bend, Oregon

Agenda**Monday, June 18th**

5:30 – 7:00 p.m.

Opening Session

Welcome & Agency Overview, *Ann M. Bartuska*
 Deputy Chief, Forest Service Research & Development

7:00 – 9:00 p.m.

Group Dinner

Tuesday, June 19th

8:00 – 8:30 a.m.

Description of Charge/Overview

Carlos Rodriguez-Franco, Director, Forest Management
 Sciences, Washington Office
Susan G. Conard, National Program Leader, Fire Ecology
 Research, Washington Office

8:30 – 10:00 a.m.

Presentations – Representatives from Portfolio Groups

Portfolio A – *Colin Hardy*, Research Forester
 Rocky Mountain Research Station, Missoula, MT

Portfolio B – *Edward J. DePuit*, Program Manager
 Pacific Northwest Research Station, Wenatchee, WA

Portfolio C – *Sarah M. McCaffrey*, Research Social
 Scientist, Northern Research Station, Evanston, IL

10:00 – 10:30 a.m.

BREAK

10:30 – 11:30 a.m.

Portfolio D – *David Peterson*, Team Leader
 Pacific Wildland Fire Sciences Lab, Seattle, WA

Portfolio E – *Michael W. Hilbruner*, National Program
 Leader Fire Systems Research, Washington Office

11:30 – 12 N

Q&As

1:00 – 4:30 p.m.

Panel Discussion and Deliberation

Wednesday, June 20th

8:00 a.m. – 4:30 p.m.

Panel Work

Writing and Deliberation

Thursday, June 21st

8:00 – 10:00 a.m.

Panel Writing and Close-out

10:00 – 10:30 a.m.

BREAK

10:30 – 12 N

Summary/Meeting with R&D Executive Team and Staff

