Appendix F—White Paper on Post-Fire Effects, Including Physical and Biological

Matt Brooks, USGS, Western Ecological Research Center

Susan Cannon, USGS, Landslide Hazards Program

Natasha Kotliar, USGS, Fort Collins Science Center

Issues/Overview

Fire can have significant effects on land, water, and air. Fire also can affect humans as exhibited by their responses to the threats posed by fire, and to fire-management activities designed to minimize these threats at the wildland/urban interface. The purpose of this white paper is to summarize the current and potential future scope of USGS fire-effects research, focusing on our particular strengths in the realms of physical, chemical, and biological sciences as applied to terrestrial and aquatic ecosystems and on the social sciences.

Current USGS Fire-Effects Research

The information presented here was derived from the Science Information System, a July 2002 summary of fire science in the USGS–Biology Western Region compiled by Bob Alverts, an October 2002 USGS-wide email survey, phone interviews, and the personal knowledge of the authors. Our compilation of USGS fire-effects research is undoubtedly incomplete, but it does provide an overview of the range of studies conducted by the USGS. A more comprehensive list of USGS scientists conducting fire research can be viewed at the USGS fire-science Web site (*http://firescience.cr.usgs.gov*).

Terrestrial Organisms

Plants

Effect of fire on plants is perhaps the most common fire research within USGS. Much of the research has focused on fire responses of individual species, especially invasive species, and on post-fire successional patterns and community composition. Some examples of ongoing research include:

- Western coniferous forest response to fire (Craig Allen, Bruce Bury, Jon Keeley, Jennifer Harden, Kristin Manies, Nate Stephenson, Jan van Wagtendonk)
- Blackbrush scrub response to fire (Matt Brooks, Todd Esque, Robert Webb)
- Sagebrush steppe response to fire (Matt Brooks, Steve Knick, Dave Pyke)
- Pinyon juniper response to fire (Craig Allen, Matt Brooks, Todd Esque, Steve Knick, Dave Pyke)
- Hot desert vegetation response to fire (Matt Brooks, Todd Esque, Cecil Schwalbe, Bob Webb)
- Chaparral response to fire (Jon Keeley)
- Wetland vegetation response to fire (Michael Legare)
- Prairie grassland response to fire (Jim Grace, Diane Larsen, Tom Stohlgren)
- Northeastern grassland response to fire (Richard Melecki, Laura Mitchell)
- Florida pineland response to fire (James Snyder)
- Oak savanna response to fire (Ralph Grundel)
- Pacific island vegetation response to fire (Paul Banko, Jim Jacobi)
- Interrelationships between invasive plants and fire (Jayne Belnap, Matt Brooks, Todd Esque, David Fellows, Jim Grace, Jon Keeley, Steve Knick, Robert Mitchell, Dave Pyke, Tom Stohlgren)

Soil Flora and Fauna

- Effects of fire on microphytic crusts (Jayne Belnap, Jeanne Ponzetti)

Animals

Studies of the effects of fire on wildlife cover a broad range of taxa and a variety of ecosystems. Many studies of wildlife are indirectly related to fire because of the influence of fire on vegetation and ecosystem structure and dynamics. Numerous studies, however, are explicitly investigating the effects of fire and fire management on wildlife species. Some studies are limited to either wildland fire or prescribed fire, whereas a few studies compare both. Here we highlight examples of ongoing research:

- Effects of burn severity and spatial variation in burn-severity patterns on avian communities in forested systems of the Rocky Mountains (Natasha Kotliar)
- Effects of wildland fire on wintering grassland birds in Arizona (Janet Ruth)

- Effects of wildland fire on caribou within Alaska's boreal forest ecosystem (Layne Adams, Kyle Joly)
- Effects of wildland fire on rare and endangered species, including the red-legged frog, the Point Reyes jumping mouse, and Myrtle's silverspot butterfly at Point Reyes National Seashore (Gary Fellers)
- Effects of fire on long-lived species (for example, desert tortoises), the role of rodents in the restoration of plant species after fires, and how fire and plant invasions affect the diversity and abundance of terrestrial invertebrates, rodents, reptiles, and birds (Todd Esque)
- Effects of prescribed fire on terrestrial salamanders (Robin Elizabeth Jung)
- Effects of prescribed fire on Florida panthers (Joseph Clark)
- Effects of prescribed fire on breeding bird populations in longleaf pine ecosystems (James Grand)
- Effects of prescribed fire on abundance and reproductive success of nongame birds in Southwestern forests (Courtney Conway)
- Effects of prescribed fire on avian communities in ponderosa pine forests across the Western United States (Natasha Kotliar)
- Comparison of the effects of wildland and prescribed fire on habitat quality (availability of downed woody debris) for terrestrial and stream herpetofauna in the Pacific Northwest (Bruce Bury)
- Comparison of the effects of wildland and prescribed fire on avian communities in ponderosa pine forests of the Colorado Front Range (Natasha Kotliar)

Aquatic Organisms

Plants and Animals

- Comparison of the ecosystem properties of boreal coniferous forest that has been burned by prescribed understory fire, burned by stand replacement wildfire, and forest that has not been burned. Response variables include amphibians, aquatic macroinvertebrates, periphyton, and stream conditions (Bruce Bury, Steve Corn)

Atmospheric Response

- Effects on carbon cycling, nutrients, and atmospheric emissions of fires in interior Alaska (Jennifer Harden, Kristen Maines).

Chemical Response

- Examination of the effect of fire on the mobility, transport, and bioavailability of environmentally important metals using comparisons of pre- and post-wildfire stream-sediment and stream-water geochemistry in Idaho (Robert Eppinger, Paul Briggs, Karen Lund) and Alaska (Larry Gough, Rich Wanty, Bronwen Wanty, James Crock); analyses of rainwater and lung fluid leachates from fire ash in Colorado (Geoff Plumlee) and soil chemistry in the Northeast (Bill Cannon and Laurel Woodruff). Epidemiological evaluation of the potential spread of environmentally sensitive compounds after fire (Geoff Plumlee)
- Characterization of the environmental implications of forest-firefighting chemicals (Susan Finger, Ed Little, Craig Johnson)
- Evaluation of the effects of carbon cycling through examination of the interactions between soil drainage, fire, and carbon storage in interior Alaska (Jennifer Harden, Kristen Maines)
- Evaluation of the effects of post-fire runoff (both water and sediment) on water quality (Deborah Martin, Geoff Plumlee)

Physical Response

- USGS scientists are evaluating the potential for runoff, erosion, and sedimentation response of burned watersheds. Data from numerous field experiments and mapping and monitoring efforts in burned watersheds throughout the Western United States are being used to develop quantitative tools and methodologies for predicting both the magnitude and probability of post-fire flooding, sedimentation, and debris-flow events (Sue Cannon, John Elliott, Bob Jarrett, Deborah Martin, John Moody, Chuck Parrett, Ken Pierce, Kevin Schmidt, Janet Slate, Jack Veenhuis)
- Scientists are providing instrumentation for post-fire early warning systems and performing assessments of post-fire hazards (Mark Anderson, Sue Cannon, Catherine Costello, John Elliott, David Grey, Bob Jarrett, Ralph Teller, Al Rea, Mark Smith)

Linkages Between Fire Effects on Biotic and Abiotic Ecosystem Components

USGS scientists have developed tools that provide invaluable baseline information to scientists working over a broad spectrum of studies of burned area response.

- Methods to characterize burn severity using remotely sensed data provide a spatially consistent and replicable data set (Nate Benson, Carl Key, Don Ohlen, Zhi-Liang Zhu)
- Techniques to use remotely sensed imaging spectroscopy to characterize the distribution of post-fire vegetation, mineral, and ash materials provide important baseline data to research scientists (Ray Kokaly, Barnaby Rockwell, Laurie Morath, Ralph Root)
- A project funded by the USGS Venture Capital fund provides an example of integrated, multidisciplinary science. The scope of the project, titled "The Ecological, Hydrological, and Geological Consequences of Burn Severity and Social Applications of These Results," crosses the terrestrial and aquatic ecosystems boundary, and links the fields of chemical, biological, and physical response (Sue Cannon, Geneva Chong, Sandra Haire, Carl Key, Ray Kokaly, Natasha Kotliar, Deborah Martin, John Moody, Jonathan Taylor)

Social Issues

The social effects of fire on humans at the wildland/urban interface are of increasing concern for land managers. A group of USGS social scientists (Jonathan Taylor, John Hogan) have been involved with the following different projects that are related to the implications of fire in the ever-increasing wildland/urban interface.

- Working with "survivors" of the Cerro Grande (N. Mex.) and the Green Knoll (Wyo.) burns to determine: (1) knowledge and implementation of fire risk, and (2) effective communication at the time of the fire event
- Collaborative research with other USGS researchers to develop effective public education instruments for information dissemination to communities at risk of fire. This includes the effects of fire of different burn severities. Public groups with fire experience will help develop communication tools for other communities in the wildland/urban interface

Information on research described in this section can be accessed online at *http://cris.csrees.usda.gov/star/brd.html*

Potential Research and Collaboration

Develop closer collaborations with land managers in conducting and evaluating the effects of prescribed fires.—The focus of the National Fire Plan on fuels treatments and fire restoration points to the need to evaluate the physical, chemical, and atmospheric impacts of prescribed burning. In addition, fire effects are strongly influenced by environmental conditions before, during, and after fires; yet most fire research does not include all three of these temporal phases. Much of what is known about fire effects at landscape scales comes from post-hoc studies, which do not allow for detailed descriptions of the conditions that produced the observed fire effects. Prescribed fires conducted for fuels reduction or resource benefits offer important opportunities to develop well-replicated and documented studies on a wide range that would be nearly impossible for scientists to implement as purely experimental research burns.

Develop the "rapid response" capability to study fire effects during and immediately after wildfires.—Utilize wildfires as opportunities to collect fire-effects information and to validate the information derived from prescribed fires and post-hoc studies of wildfires.

Participate on Burned Area Emergency Response (BAER) projects.—Participation will allow scientists to opportunistically collect fire-effects data and will help them develop and further solidify relationships with land managers that could lead to future fire-effects research opportunities.

Improve collaborations with USDA Forest Service fire scientists.—Through better collaboration, the USGS and USDA Forest Service could improve their abilities to deliver effective fire-science tools to land managers. Even in the absence of a coherent fire-science program, USGS scientists have already established strong collaborations with personnel from the NPS, BLM, BIA, NRCS, NWS, USBR, State Geological Surveys, State and County Offices of Emergency Services, and numerous universities. However, the USGS and USDA Forest Service uniquely share the common purpose of providing science support for agencies in the DOI and USDA, and we feel that the quality of science produced by the two science agencies would be greatly improved through the development of additional collaborative efforts.

Improve links between pre-fire risk assessment/fuels mapping, fire-effects research, and post-fire rehabilitation/restoration.—The USGS has scientists with strong capabilities in each of these three research areas. By explicitly linking these areas of research, more powerful fire-management tools can be developed.

Actions Needed to Improve USGS Post-Fire Research

The capability to conduct integrated research is a hallmark of the USGS, which should be applied to the study of fire effects. Individually, the various disciplines and research groups within USGS have the expertise and ability to address specific physical or biological research questions, but poor integration and communication between them hinders their ability to address more complex interdisciplinary questions. Poor integration is in part due to inadequate funding. A truly

integrated, multidisciplinary program requires considerable funding and substantial resources. A strong leadership commitment is necessary to achieve the potential of such a program. Specific actions include the following:

1. Establish a Fire Science Program that is well and consistently funded.

2. Provide funding for the establishment of interdisciplinary research teams to focus on high priority DOI fire research needs, especially those that necessitate the integrated study of pre-fire hazard assessments, fire effects, and post-fire restoration. Potentially direct place-based funding to accomplish this goal.

3. Promote collaborations between USGS and USDA Forest Service fire scientists to address significant cross-cutting research issues common to the DOI and USDA agencies.

4. Increase communication among USGS researchers, collaborators, and end-users through up-to-date Web pages and conferences focused on sharing scientific advances and management tools.