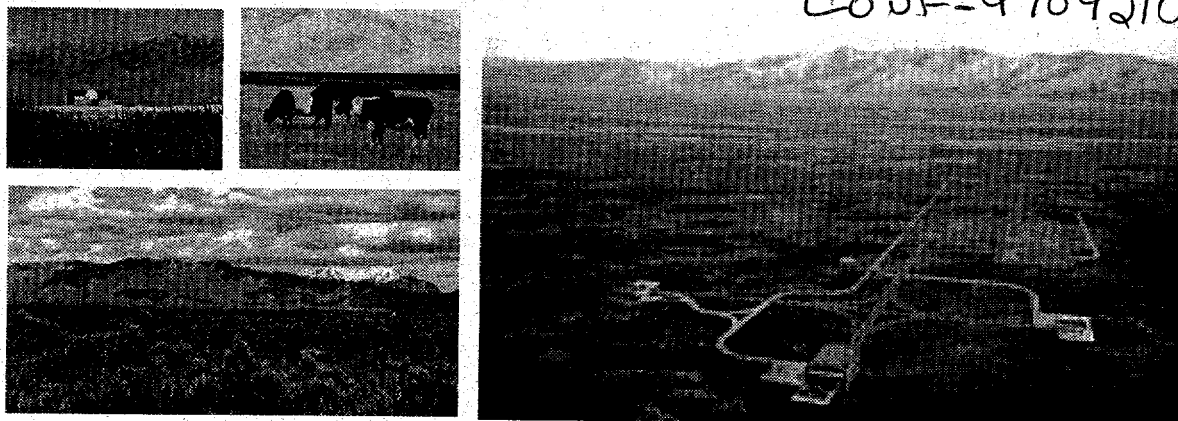


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Developing the Scientific Basis for Long-Term Land Management of the Idaho National Engineering and Environmental Laboratory

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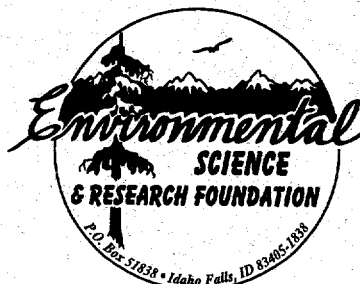
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March 1998

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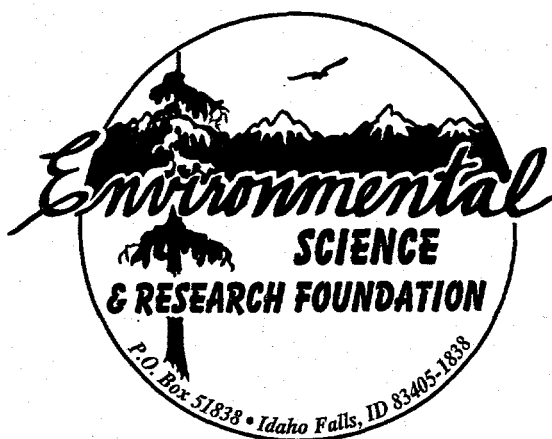
**WORKSHOP PROCEEDINGS: DEVELOPING THE SCIENTIFIC
BASIS FOR SUPPORTING LONG-TERM LAND MANAGEMENT OF
THE IDAHO NATIONAL ENGINEERING AND ENVIRONMENTAL
LABORATORY**

Edited by

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March 1998



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PREFACE

Responses to a survey on the INEEL Comprehensive Facility and Land Use Plan (US DOE 1996a) indicated the need for additional discussion on environmental resources, disturbance, and land use issues on the Idaho National Engineering and Environmental Laboratory (INEEL). As a result, in September 1997, a workshop evaluated the existing scientific basis and determined future data needs for long-term land management on the INEEL. This INEEL Long-Term Land Management Workshop examined existing data on biotic, abiotic, and heritage resources and how these resources have been impacted by disturbance activities of the INEEL. Information gained from this workshop will help guide land and facility use decisions, identify data gaps, and focus future research efforts.

This report summarizes background information on the INEEL and its long-term land use planning efforts, presentations and discussions at the workshop, and the existing data available at the INEEL. In this document, recommendations for future INEEL land use planning, research efforts, and future workshops are presented. We emphasize these are not policy statements, but comments and suggestions made by scientists and others participating in the workshop. Several appendices covering land use disturbance, legal drivers, land use assumptions and workshop participant comments, workshop participants and contributors, and the workshop agenda are also included.

Over 60 participants, mostly scientists and natural resource specialists from state and federal agencies, universities, and private interest groups attended the workshop. Key contributors are recognized in this report for their contributions to the various sections. In addition to these, the following people were influential in this effort: Dr. Jay Anderson and Jim Glennon for their input on disturbance to vegetation; Susan Miller for her leadership on cultural resource issues; Randy Lee and Ron Rope for presentation of geographic information system data; Michael Jackson and Terry Knudsen for compiling legal and environmental data sets; Tom Moriarty, Craig Jacobson, and Rob Logan for their discussions on facilities and analysis of existing INEEL land use plans; Marilynne Manguba and Dena Tomchak for logistical support; John Beller, Marianne Little and Dr. Paul Wichlacz for their long-range planning vision; Drs. Randy Morris and Roger Blew, and Ron Warren, for arranging for the participation of university affiliates. Tamara Sperber developed the annotated bibliography of the ecological impacts of various land use activities in sagebrush steppe (Appendix A).

This workshop was funded by the U.S. Department of Energy, Idaho Operations Office, through the Mixed Waste Focus Area under Contract No. DE-AC07-94ID13223 to Lockheed Martin Idaho Technologies Co. (LMITCO), and a subcontract (K97-177939) to the Environmental Science and Research Foundation, Inc. (Foundation). LMITCO was responsible for organizing the workshop, logistical support, and summarizing the workshop. The Foundation tasks included: organizing the participation of university experts; conducting a literature search and preparing an annotated bibliography on fragmentation and disturbance on the INEEL; providing information for the GIS database; and reviewing, editing, and publishing this workshop summary.

WORKSHOP PROCEEDINGS: DEVELOPING THE SCIENTIFIC BASIS FOR SUPPORTING LONG-TERM LAND MANAGEMENT OF THE IDAHO NATIONAL ENGINEERING AND ENVIRONMENTAL LABORATORY

EXECUTIVE SUMMARY—On September 9 and 10, 1997, a workshop at the Idaho National Engineering and Environmental Laboratory (INEEL) in Idaho Falls, Idaho evaluated the existing scientific basis and determined future data needs for long-term land management of the 2,300 km² INEEL. This report summarizes the presentations and discussions at the workshop, including the legal drivers for resource management and the existing data available at the INEEL. The results of this workshop do not represent policy statements, but are recommendations and suggestions for a forward looking, ecologically responsible, long-term land management policy. The majority of participants at the workshop were unaware of the extent of ecological data that exists from research conducted on and around the INEEL. The use of advanced technologies and the extent of data and information available puts the INEEL in a unique position to appropriately manage its resources. These technologies can be made available to the public using advanced information management systems (i.e., Internet interfaces and geographic information systems). Participants supported seeking additional research dollars for evaluating the importance of the INEEL ecosystem and expressed interest in teaming with facility managers to better understand how growth and facility development can be managed while protecting ecological resources in habitats that are already considered sensitive. An aggressive outreach program to decision-makers, stakeholders, and collaborators needs to be maintained to ensure that a long-term environmental and monitoring research strategy is closely coordinated with, and helps focus, long-term land management plans for the INEEL.

The INEEL, located on the upper Snake River Plain in southeastern Idaho, was established over 45 years ago via purchase of private holdings and withdrawal of Bureau of Land Management (BLM) lands. In 1975, the INEEL was designated as a Department of Energy (DOE) National Environmental Research Park (NERP). Approximately 40 percent of the INEEL has been maintained as a livestock grazing exclusion area since 1957, and has been relatively unimpacted by human activities. This portion of the INEEL provides an important remnant of the sagebrush-steppe ecosystem, which is currently classified as an endangered ecosystem by the National Biological Service (Noss et al. 1995, Saab and Rich 1997). Land around the INEEL is predominantly used for livestock grazing, irrigated cropland, and recreation. The more the lands bordering the INEEL are used and developed, the more the INEEL appears as an island of mostly undisturbed habitat. The workshop was convened to assess what ecological data are available and what data are needed to properly manage these lands.

In 1995, the DOE Idaho Operations office solicited stakeholder input from public forums and the INEEL Specific Advisory Board to develop several future use scenarios for the INEEL (US DOE 1995). These scenarios were then used as the basis for developing the INEEL Comprehensive Facility and Land Use Plan (US DOE 1996a). Although the plan reiterated the DOE policy of managing its lands based on principles of "ecosystem management and sustainable development," the document mostly provided INEEL overview information about land acquisition and land management, current and future INEEL programs and projects, planning forecasts for each area of the INEEL, and detailed information about INEEL facilities.

This INEEL Long-Term Land Management Workshop was organized to evaluate and discuss existing information on the abiotic, biotic, and heritage resources of the INEEL and examine how these resources have been affected by physical disturbance throughout the history of the INEEL. Information from this workshop will help guide land and facility use decisions, identify data gaps, and focus future research efforts. The workshop was intended to provide a forum for the exchange of information among various natural science disciplines to enhance useful application of existing data and to improve the design of future information management systems. The specific objectives of the workshop were to:

- Outline goals, programmatic needs, and regulatory drivers for establishing long-term land management strategies.

- Identify and discuss the usefulness of existing ecological data and analytical techniques.
- Determine how to best use existing data and information to support land management decisions.
- Provide recommendations and priorities for future efforts to support integrated long-term land management for the INEEL.

All objectives were met. Of particular interest were seven broad recommendations developed as a result of this workshop:

- The importance of the INEEL as a critical sagebrush-steppe ecosystem should be evaluated. Partnerships should be developed with the Nature Conservancy, the Idaho Heritage Program, the USGS Biological Resource Division's GAP program, and others to develop a complete biotic inventory of the INEEL and to assess how the INEEL fits into the regional context of ecological resources and management in the upper Snake River Basin and the Interior Columbia River Basin ecosystems.
- The potential role of the INEEL as a groundwater protection area for the Snake River aquifer should also be evaluated. Extensive irrigation and development of agricultural lands is occurring on the north, west, and east borders of the INEEL. Partnerships should be further developed with the U.S. Geological Survey, university water resource groups, and Idaho water users to explore the role of the INEEL in protecting a portion of the upper Snake River aquifer from development.
- The INEEL's site-wide monitoring program should be expanded to include select indicators of ecological change that can provide information about habitat fragmentation, the effects of fire and weather, as well as other issues related to land management on the INEEL. These data also need to support Ecological Risk Assessments and Natural Resource Damage Assessments mandated by law. The monitoring program should be developed with area partners to enhance educational opportunities and collaborative research. A cost-effective, holistic approach that uses selective indicators of ecosystem health to evaluate the status and trends of ecological resources should be developed.
- Develop a consistent information management system that can link data from different data sets (i.e., surface and ground water, vegetation, easements, and rights-of-way) to a web-based server that can easily be accessed through the existing INEEL Comprehensive Facility and Land Use Plan web page. This would facilitate collaboration and coordination of information on the INEEL, vastly improve the ability of the INEEL to respond to future National Environmental Policy Act (NEPA) activities and Natural Resource Damage Assessments, and improve the INEEL's recognition.
- The land use planning process should include an assessment and prioritization of land suitability for present and future uses, including potentially conflicting development (e.g. utility rights of way can reduce future land use options), preservation of natural resources, and ecological research and habitat reference areas.
- The cumulative effects of impacts from small-scale waste management, road construction, and other habitat-fragmenting facility support activities on ecological resources need to be evaluated and managed in an integrated fashion. Under NEPA, cumulative impacts must be considered.
- INEEL provides a unique area for testing and evaluating remedial action and restoration options for natural resource industries in the Intermountain West. Numerous mining, Department of Defense (DoD) training, waste disposal and development activities are impacting natural resources management in the Intermountain region. Ecological engineering (e.g., restoration approaches) can be evaluated for effectiveness. The INEEL should form partnerships with natural resource industries and work collaboratively on developing the knowledge base for conducting restoration activities in semi-arid regions of the Intermountain West.

Workshop participants were polled as to their interest in future workshops focused on long-term management of INEEL natural resources. There was an overwhelming response suggesting that future workshops be held to work through the major issues. Workshops should be held on an annual basis initially, then biannually to report on progress on selected topics (i.e., the role of INEEL in climate change). The INEEL provides an excellent venue for evaluating regional issues and an outdoor laboratory for conducting research on natural resource protection and restoration.

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WORKSHOP PROCEEDINGS: DEVELOPING THE SCIENTIFIC BASIS FOR SUPPORTING LONG-TERM LAND MANAGEMENT OF THE IDAHO NATIONAL ENGINEERING AND ENVIRONMENTAL LABORATORY

INTRODUCTION

The Idaho National Engineering and Environmental Laboratory (INEEL) is operated by the U.S. Department of Energy Idaho Operations Office (DOE-ID). It was originally established in 1949 as the National Reactor Testing Station following a nationwide search for a suitable area in which to test new applications of nuclear energy. The name was changed to Idaho National Engineering Laboratory in 1974 to better characterize the mission of the facility. In 1997, an "E" representing Environmental was added to the name. This change highlighted a shift in the post-cold war mission of the INEEL toward environmental science, research, and development activities, and focused attention on the importance of environmental factors in the restoration of areas previously disturbed.

BACKGROUND

The INEEL occupies 2,300 km² of sagebrush dominated rangeland in the Upper Snake River Plain. The mission of the INEEL has evolved from energy development and testing the safety of nuclear reactors to radioactive waste management and environmental cleanup. In 1975, the INEEL was designated as a National Environmental Research Park, one of two in the U.S. supporting a sagebrush-steppe ecosystems. The Park designation established the INEEL as an outdoor laboratory for scientists to investigate the impact of energy development technologies on ecosystem structure and function. In 1994, a new land and facility use policy for DOE was issued by the Secretary of Energy. These changes in DOE's missions and

policies have required the DOE to "manage all of its land and facilities as valuable national resources...based on the principles of ecosystem management and sustainable development" (O'Leary 1994). Because of limited access and development, much of the INEEL is relatively undisturbed and a large expanse of native habitat persists. The INEEL is likely the largest remnant of undeveloped, ungrazed sagebrush-steppe habitat in the Intermountain West (US DOE 1996a). This ecosystem has been listed as critically endangered in the Intermountain West (>98% decline) (Noss et al. 1995, Saab and Rich 1997).

Public rangelands and agriculture fields surround the INEEL (Figure 1). For the past 45 years, cattle and sheep grazing have allowed on about 60 per cent of the INEEL, along the boundary with public lands. Over 1,000 km² of the central core of the site is not grazed by livestock and remains as mostly undeveloped sagebrush-steppe habitat (Figure 2). The average elevation of the INEEL is 1,500 m above sea level. The mean annual precipitation is about 220 mm and the average annual temperature is 5.6° C. Large daily and seasonal temperature fluctuations occur in this cold desert community, with most precipitation coming in the form of snow and spring rains. Vegetation at the INEEL generally consists of mostly a shrub overstory with an understory of perennial grasses and forbs. Communities are commonly dominated by big sagebrush (*Artemisia tridentata*) or green rabbitbrush (*Chrysothamnus viscidiflorus*), but 42 other shrub species are also present. Perennial grasses are the most abundant understory plants, but some exotic weeds are becoming established. Because of the lack of livestock grazing over much

of the site, the INEEL also supports a high diversity of forbs (Anderson et al. 1996). The INEEL provides habitat for only a few threatened and endangered species and species of special concern (Beck-Haas

1997). The INEEL is also important winter range for raptors, sage grouse, pronghorn antelope and elk, and is important for a variety of migratory birds.

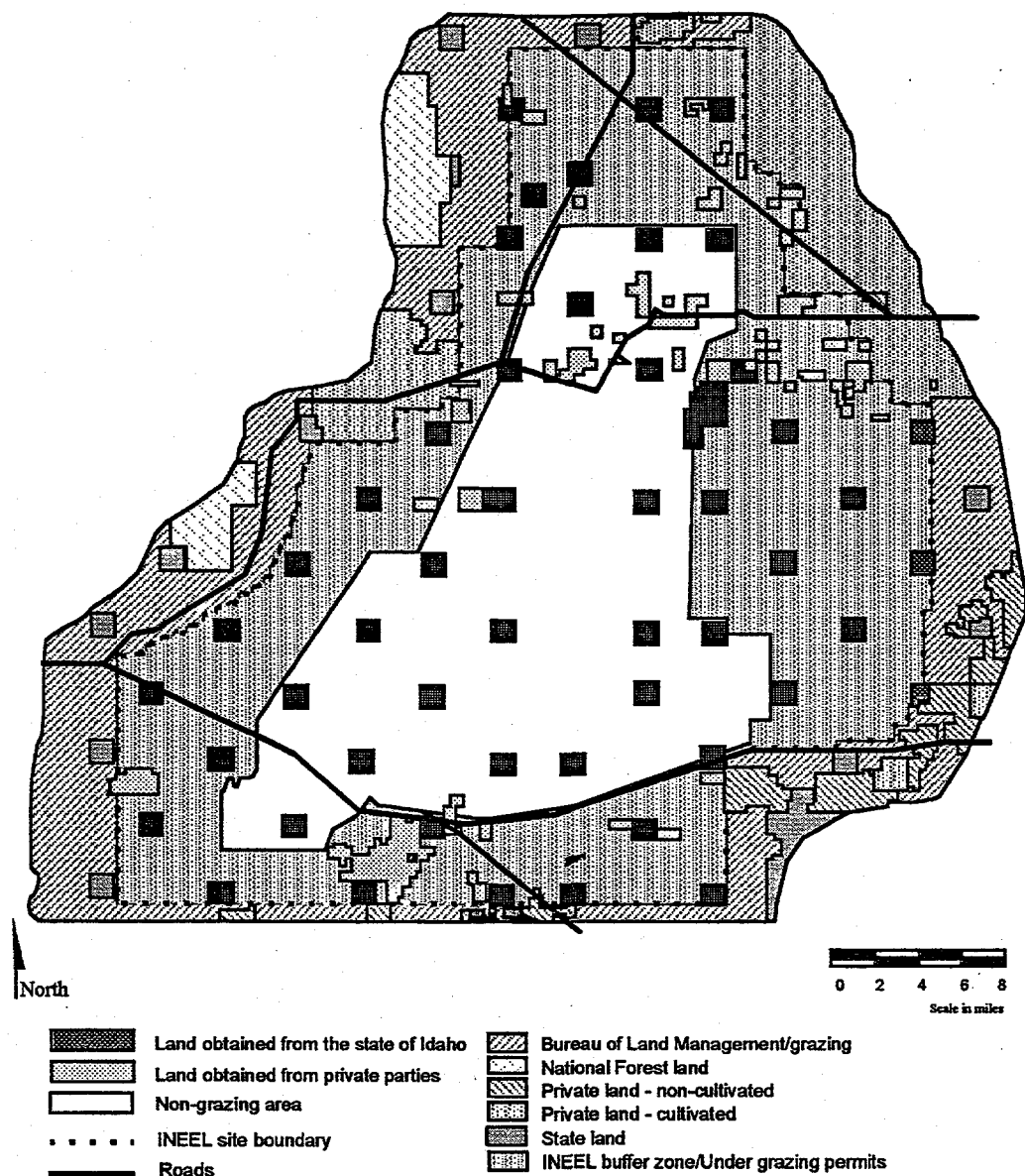


Figure 1. Land ownership and land use on and around the INEEL.

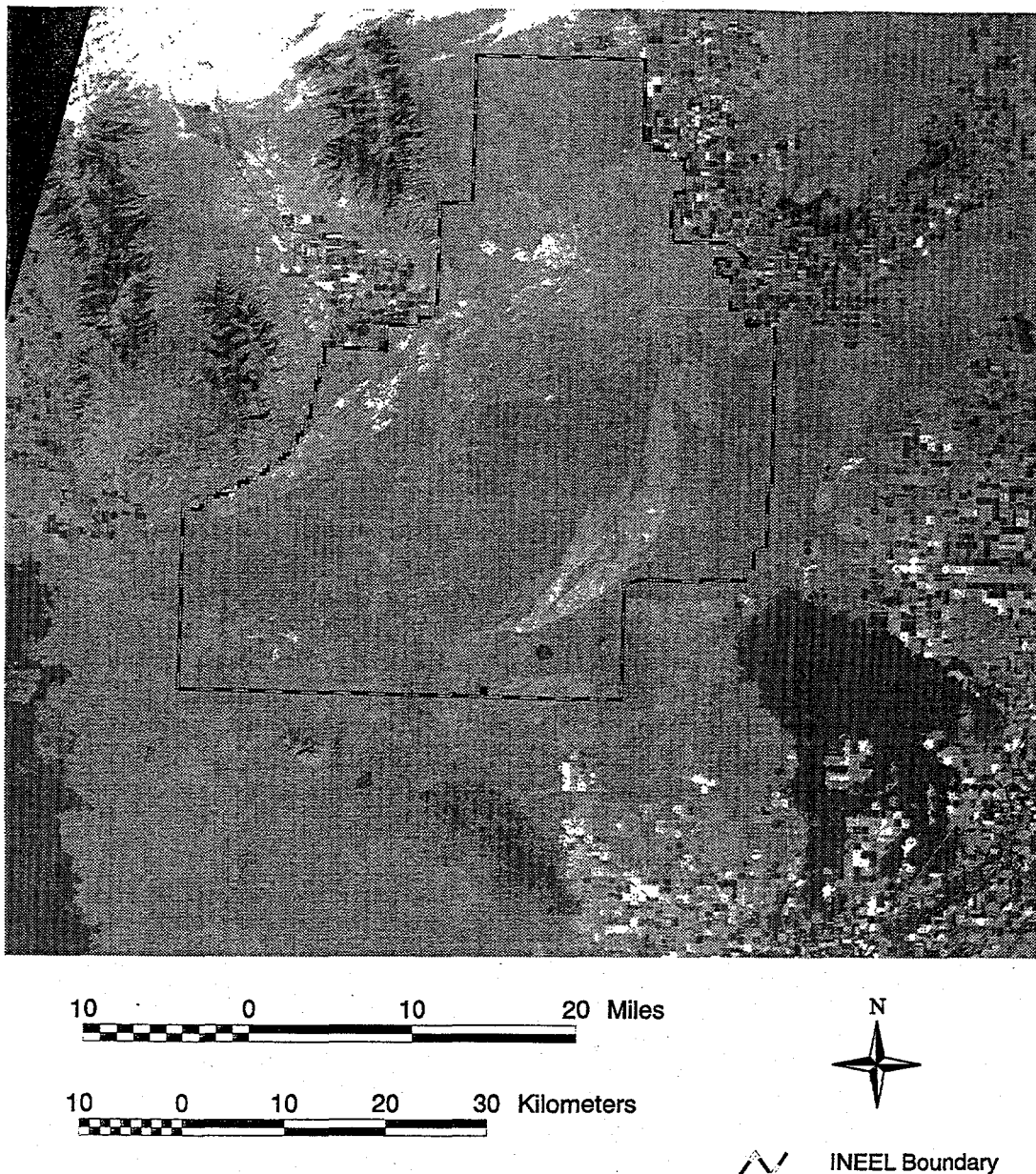


Figure 2. Satellite image of INEEL showing recent fire scars on site and agriculture development pressures around the INEEL periphery (August 1996).

Although much of the INEEL has been protected from development, a variety of physical disturbances, both natural and anthropogenic, have occurred that may significantly and/or permanently alter this shrub-steppe ecosystem. These perturbations include wildland fire, grazing, range improvement, exotic plants, crested wheatgrass seeding, and activities associated with transportation and facility construction, maintenance and operations,

and closure. Appendix A summarizes studies on disturbance and land use on the INEEL, surrounding areas, and similar habitat.

INEEL LONG-TERM LAND USE PLANNING

In 1995, DOE/ID completed an evaluation of the INEEL's long-term land use plan and identified several future use scenarios, with extensive stakeholder and

the INEEL Specific Advisory Board involvement (US DOE 1995). The future use scenarios were used as a basis for developing the INEEL Comprehensive Facility and Land Use Plan (US DOE 1996a), which supports the DOE policy of managing its lands based on principles of "ecosystem management and sustainable development." The INEEL Comprehensive Facility and Land Use Plan provides information about land acquisition and land management, current and future INEEL programs and projects, planning forecasts for each area of the INEEL, and detailed information about INEEL facilities. The 25, 50, 75, and 100-year land use scenarios (US DOE 1995) are considered for each of the major facilities, and the most appropriate development corridor is defined for the overall site. The scenarios, and the analyses used to generate them, illustrate the type and extent of operations the INEEL and its stakeholders find acceptable. The scenarios projected (a) no change to the present INEEL boundaries within the 100-year period and (b) future industrial development most likely concentrated in the central portion of the INEEL and within existing major facility complex areas. The Comprehensive Plan is updated periodically and the latest version is available on the Internet at: <http://wastenot:1025.inel.gov> or may be accessed through <http://www.inel.gov> using the link to Documents and Publications.

INEEL LONG-TERM LAND MANAGEMENT WORKSHOP BACKGROUND AND OBJECTIVES

Specific objectives of Long-Term Land Use Planning Workshop were to:

- Outline goals, programmatic needs, and regulatory drivers for establishing long-term land management strategies for the INEEL.
- Discuss existing ecological data sets and

analysis techniques.

- Determine how existing data and information can be used to support land management decisions and identify and prioritize additional data to be gathered and analyses to be done.
- Provide recommendations and priorities for future research and management efforts that support a long-term INEEL land management strategy.

Disturbance has been defined in various ways depending on the frame of reference. These include both natural (e.g., lightning caused fire, geologic faulting, tornadoes, etc.) and human caused (e.g., prescribed burns, grazing, power transmission line construction, and maintenance, etc.) disturbances. In order to establish a common ground for workshop participants we used the following definition for disturbance:

A controllable or uncontrollable event that causes a measurable change from the normal condition in an ecosystem or landscape. It is the sum of the natural and human influences affecting the ecological system and is assessed on both spatial and temporal scales. It includes individual or combinations of such characteristics as (1) type of disturbance (fire, excavation), (2) frequency and periodicity (spring flooding, dry season fires), (3) size (microhabitat to landscape), (4) intensity (surface burn vs. soil sterilization fire), and (5) duration (short term, long term).

WORKSHOP PRESENTATIONS

Because of the diversity of backgrounds of workshop participants (e.g., facility planners, research ecologists, archaeologists, regulatory personnel) several introductory keynote presentations were given to establish a common understanding

of the scientific basis for making land management decisions. The topics and presenters are listed below followed by a brief summary discussion of each presentation.

BIOTIC ISSUES

*Dr. Jim MacMahon, Dean, College of Science, Utah State University--*The INEEL is an island. It is a transition zone from arid to semi-arid areas, where changes of both species and structure occur. To look at the larger picture, the INEEL must be interpreted in a regional context, as an island in the ecoregion. Effects of climate change can be seen here first. With the low precipitation, when and where it occurs, high variations in other systems can be seen. The INEEL must explicitly define its land management goals. Concentration must be placed on fundamental studies on how the system works. With its proximity to surrounding areas, vegetation transects should be at increased distances from the site to place the INEEL in its regional context. Studies at the INEEL in reclamation and restoration can be used at other DOE and DoD sites, etc.

INDICATORS OF ECOSYSTEM CHANGE

*Dr. Amrita DeSoyza, USDA ARS Jornada Experimental Range, Las Cruces, NM--*Many western rangeland ecosystems are fragile and readily susceptible to human or naturally induced deterioration. Land use changes are frequently associated with both opportunities for improvement in ecosystem health and new risks of degradation. Many of these risks cannot be predicted. Consequently for sustainable management of rangelands, early detection of the deterioration of ecosystem health is essential. However, because ecosystem health is difficult to quantify, a surrogate ecosystem function which can be more

easily quantified should be used. The ability of an ecosystem to function depends on the existence of soil and water resources that are necessary to support the biological components. Based on principles related to the retention of soil and water resources (e.g., perennial vegetation cover, soil stability in water, relative infiltration capacity, and soil penetrometer resistance) several sensitive, repeatable, and easily quantified indicators of ecosystem function have been developed. These indicators include a rare patch index, relative cover of plant functional groups (e.g., long-lived grasses, vegetative reproducers, etc.), water infiltration capacity, penetrometer resistance, and an index of soil stability. Although careful interpretation is needed, the indicators appear to be sensitive to the early stages of ecosystem deterioration. Using these indicators, early detection of ecosystem deterioration would allow timely and cost-effective action by land managers and the best chance to avoid significant and irreversible changes to an ecosystem. Several of these indicators have been tested on the INEEL. By using a selective set of key indicators, the status and trends of ecological processes on the INEEL can be established in a cost-effective manner.

HERITAGE RESOURCES

*Ms. Sue Miller, INEEL--*Heritage resource management contributes to INEEL long-term land management by archiving and coordinating the use of cultural resource and historic preservation information toward compliance with the National Historic Preservation Act of 1966 (NHPA) and the National Environmental Policy Act of 1969 (NEPA). This includes (1) identifying site and facility locations/types, (2) conducting site evaluations and maintaining resource integrity, (3) predictive modeling of site locations and densities, and (4) obtaining historic preservation interest and group

input into planning and management processes. Heritage, or cultural resources include objects, sites, landscapes, and knowledge which document human activity and are valued by a culture or community for traditional, religious, educational, or scientific reasons. Because cultural resources are unique and non-renewable, a number of federal laws have been passed for their protection, management, and use. Federal agencies, including DOE, must determine what impact their programs and activities might have on sites, artifacts, and documents. Land managing agencies must also protect cultural resources by conducting scientific research and sharing information with employees and members of the public through educational programs and other awareness efforts. Specific regulations outline the collection and curation of artifacts and documents, permit archaeological excavations, and guide the solicitation of information and comment by American Indians and other organizations interested in federal cultural resource management. In addition, DOE requirements protect cultural resources that may be affected by INEEL activities and preserve the historical, cultural, and scientific values they represent.

The INEEL Cultural Resource Management Office provides and uses paleoecological data from paleontological and archaeological sites to (1) characterize past environmental conditions and human response to environmental change, (2) contribute to interdisciplinary studies of climate change, and (3) to develop predictive models to provide guidance for present and future land and waste management decisions.

INSTITUTIONAL ISSUES AND CURRENT PLANNING STATUS

Mr. Tom Moriarty, INEEL Facility

Planning--Several different entities occupy and manage remotely located facilities on the INEEL. The INEEL instituted an integrated facility and land use planning process to enable better management of its land and disparate facility resources, to identify the most functional and cost-effective projects, to effectively manage and protect environmental and cultural resources, and to communicate integrated plans to internal and external stakeholders. The results of that integrated planning process are collected and reported in continuously updated editions of the INEEL Comprehensive Facility and Land Use Plan (US DOE 1996a). The Comprehensive Facility and Land Use Plan provides an INEEL overview and information about land acquisition and land management, environmental and cultural resources, current and future INEEL programs and projects, planning forecasts for each area of the INEEL, and detailed information about INEEL facilities.

A large percentage of the INEEL is undeveloped land. The original intent for obtaining this expanse of land was to provide a large safety-and-security buffer between the facility areas within the INEEL boundaries and non-INEEL lands. The general open space at the INEEL still serves this function today. But the undeveloped nature of this land and its restricted access also provide a fringe benefit: preservation of important habitat for plants and animals.

Because most of the INEEL is relatively undisturbed rangeland, the site serves as a refuge for plants and wildlife. The core of the site arguably constitutes the largest area of undeveloped sagebrush steppe outside of national parklands in the Intermountain West. Also, because the INEEL is located at the mouth of several mountain valleys, large numbers of migratory birds and mammals are funneled onto the site.

The Endangered Species Act provides federal protection for certain species of plants and animals and their critical habitats, and authorizes the Secretary of the Interior to develop and implement recovery plans for each listed species. By law, all federal agencies are required to consider in their management plans those plants and animals regarded endangered, threatened, or proposed for such status. Accordingly, environmental protection and preservation is a significant consideration in all INEEL development projects and land planning. The most current INEEL environmental information is also solicited from internal and external experts and included in each edition of the Comprehensive Facility and Land Use Plan.

LEGAL DRIVERS

Mr. Roger Twitchell, U.S. DOE, Idaho Falls--Prior to being designated a national laboratory, INEEL lands were under a mixture of private and public ownership. Currently INEEL lands are either owned by DOE outright, or withdrawn from the public domain and managed by DOE (Figure 1). Because of its history and connection to BLM lands and management agreements, land management decisions on the site are governed by a variety of legal drivers. This section provides a brief summary of these drivers. A more complete comparison of how regulations pertain to land use planning and management of natural resources is in Appendix B.

There is a strong precedent and specific legal mandate for land use planning associated with management of federal lands. The BLM must comply with the Federal Land Policy and Management Act which states, "the national interest will be best realized if the public lands and their resources are periodically and

systematically inventoried and their present and future use is projected through a land use planning process coordinated with other federal and state planning efforts" (43 CFR). The USFS Forest and Rangeland Renewable Resources Planning Act (Forest Management Act) (36 CFR) also deals with land management issues. The DoD has USMC Orders, Army/AF Regulations and NAVFAC instructions requiring base master planning, and the DOE has the Secretarial Land and Facility Use Policy and DOE Order 430.1 which states that, "asset management performance measures shall ensure...comprehensive land use planning process with stakeholder involvement."

All agencies have to deal with multiple issues when conducting land management planning. BLM issues include grazing, mining, wilderness study areas, endangered species and critical habitat, big game winter range, cultural resources, power line rights-of-way, easements, real estate, recreation, and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Forest Service issues include timber, big game summer range, roads, roadless areas, watershed, wetlands, and recreation issues. DoD issues involve such things as housing, industrial complex training areas and ranges, airspace, land use compatibility/encroachment, noise, endangered species habitat, ordnance contamination, discharges/emissions, permitting, historic structures, security, and National Priorities List--Resource Conservation Recovery Act (NPL-RCRA) sites. DOE must deal with such things as nuclear reactors, radioactive material management, treatment and disposal facilities, radiation fields, emissions, discharges, floodplains, groundwater, seismology, and security. Yucca Mountain Project Office issues include a 10,000-year planning horizon, climate change, seismology, groundwater, land withdrawal,

USAF range & NTS site management, and NRC institutional control/loss of control.

A land use plan must identify the regulatory compliance necessary to implement the plan, but does not trigger regulatory compliance unless there is either a proposed action, or the plan is implemented by undertaking an action. Land use planning is usually conducted for extensive tracks of land, for example:

- Interior Columbia River Basin Ecosystem Management Project—144 million acres, half of which (72 million acres) are BLM & Forest Service land.
- California Desert Plan—24 million acres, 12 million acres of BLM land.
- Henry Mountain Resource Area—1.9 million acres.
- INEEL Comprehensive Facility and Land Use Plan—569,295 acres.

Regulatory compliance, on the other hand, is usually intensive and related to site specific activities, for example:

- Floodplains.
- Critical habitat.
- Biodiversity.
- Point source discharges or emissions.
- Cultural resource sites.
- RCRA or CERCLA sites.
- Wetlands.
- Maximally exposed individual.
- Seismic risk (Nuclear Regulatory Commission license).

For proposed activities that can affect the long-term management of federal lands, land use planning activities and NEPA may be integrated and result in a Record of Decision (ROD) which will trigger regulatory drivers at several levels. For the preferred option and alternatives, the NEPA analysis identifies regulations with which to comply, and required surveys, and analyzes environmental impacts and predicts the

degree of compliance with regulations. During the implementation phase, the action requires detailed surveys, permits, and licenses. During the operating phase, it is often required that performance be tied to permits and committed mitigation standards.

A generic decision flow chart has been developed for proposed actions on the INEEL that may impact natural resources and have consequences for long-term land disturbance. Three major issues are addressed: (1) Will the proposed activity result in any direct, indirect, or cumulative impacts to:

- Historical or cultural resources?
- Threatened, endangered plant or animals, or species of special concern (including game), or the habitat they occupy?
- Critical or unique habitats (e.g. caves, breeding areas, winter range, migration corridors, wetlands, waters of the US)?

(2) Will the proposed activity measurably reduce biodiversity? (3) Will the proposed activity impact communities or ecosystems (e.g. fragmentation, patchiness, barriers to migration)? The decision flow chart also addresses issues associated with data needs for compliance with numerous regulatory drivers, for example:

- Environmental Checklist (NEPA)
 - o *Cultural Resources:*
Archeological Resource Protection Act (ARPA), Native American Grave Protections and Repatriation Act (NAGPRA), National Historic Preservation Act (NHPA), Tribal consultation
 - o *Biological/Ecological Resources*
Endangered Species Act (ESA), species lists, consultations
 - o Wetlands EO 11990 10 CFR 1022
 - o Floodplains EO 11988 10 CFR

- o Clean Water Act 404 permit, Idaho Administration Procedure Act (IDAPA), discharge, effluent, water, sewage treatment
- o Clean Air Act 40 CFR 60, IDAPA, air emissions, new sources, air operating permit limit
- Environmental Justice EO 12898
- Protection of Children from Environmental Health Risks and Safety Risks EO 13045
- CERCLA (National Resource Damage Assessment [NRDA]), RCRA, Toxic Substance Control Act (TSCA), Federal Facility Compliance Act (FFCA)
- Noise Control Act
- The non-regulatory world—rights of way, easements, land status, encroachment, etc.

ECOLOGICAL RISK ASSESSMENT

Ms. Robin Van Horn, INEEL—Ecological risk assessment (ERA) is a relatively new science focused on evaluating the risks to ecological resources from anthropogenic activities. Ecological risk assessments provide important information by evaluating risk to flora and fauna. Because humans often occupy the same areas of the environment and use biotic resources as food and cultural resources, ecological risk assessments can also support evaluating risk to human health.

In 1989, the INEEL was placed on the CERCLA national priority list. The Federal Facility Agreement and Consent Order (FFA/CO) was established as the action plan for clean-up. The FFA/CO divided the INEEL into 10 waste area groups (WAGs). Within a WAG, the multiple sites of contamination are grouped by similar contamination problems or boundaries and are called operational units (OUs). Contaminated sites range from large

facilities to small rubble piles. CERCLA requires that baseline risk assessment characterize the current and potential threat to human health and the environment, and specifies that environmental risk assessment be performed to "assess threats to the environmental, especially sensitive habitats, and critical habitats of species protected under the endangered species list" (40 CFR Part 300.453[e][2][i][g]).

The INEEL has a team implementing a phased approach to conducting ERAs using the step-wise approach stressed in EPA guidance documents (US EPA 1992, 1996). The first phase is the WAG ERA. Each site is evaluated. First, sites without a potential exposure route or pathway are eliminated from further consideration. Second, contaminant concentrations at each site are compared to ecologically-based screening values (EBSLs). Third, sites and/or contaminants not eliminated are assessed for risk to ecological receptors at the WAG using more realistic modeling parameters. Currently, WAGs 1, 2, 3, 8, and 9 are in various phases of the final ERA. WAGs 4, 5, 6, and 10 are currently in preliminary stages of evaluation.

The final phase of the process at the INEEL will be the performance of the WAG 10 ERA (OU 10-04 ERA). WAG 10 includes areas in and around the INEEL that cannot otherwise be addressed on a WAG-specific basis. The sites that did not fall under a specific WAG are also evaluated at this time. The boundaries are the INEEL's boundary or beyond as necessary to include issues such as the regional Snake River Plain aquifer. The 10-04 ERA will integrate results from the individual WAGs and any additional available. Three major sources of data will be used to support the 10-04 ERA: 1) The results of the WAG ERAs will be used to identify exposure pathways and sites contributed risks to ecological receptors.

This information is based on sampling performed as part of the human health risk assessment activities at the INEEL, 2) The extent of contamination movement within the biota will be primarily characterized using studies performed by the Environmental Science and Research Foundation. The Foundation has conducted radiological and descriptive ecological studies on the INEEL. To date, at least 37 reports or papers have been written on these studies that are considered useful to ERA, 3) Field sampling and evaluation are being performed as part of the 10-04 ERA. The selection of species and resources to be sampled was based on food web models. Abiotic and biotic sample data collected in 1997 are intended to support the literature-generated values that were used in the ERA models.

During the analysis step, a preliminary spatial evaluation of the extent of contamination will be used to assess the percentage of certain populations of species at risk. This evaluation will be based on hazard quotients calculated in the ERAs. Each contaminant of primary concern will be evaluated using both a conservative and a more realistic value. A "forensic" risk assessment will be performed using the data available from the Foundation studies. This assessment will allow reconstruction of dose to ecological receptors outside of the WAG facilities and also allows for estimation of current dose. Sensitive or threatened and endangered species shown to be at potential risk from levels of contaminants will be evaluated using more detailed exposure modeling. Species-specific information will be input into the exposure models and results of the 1997 field sampling will be used where applicable.

In the characterization phase, the potential risk will be summarized in the larger perspective. The implications of the

assumptions and uncertainties involved in the ERA will be discussed. More importantly, the proposed future land use of the INEEL will be discussed, including the importance of considering this information when making decisions related to impacts to or protection of ecological receptors.

WORK AT OTHER LABORATORIES

Participants from other laboratories were invited to the workshop to provide information on land use and management activities at their laboratories. This was also an opportunity to share information among laboratories and exchange important ideas about establishing priorities and research recommendations related to land management. Invitations were extended to the Pacific Northwest National Laboratory (PNNL) in Richland, Washington and Oak Ridge National Laboratory (ORNL) in Oak Ridge, Tennessee. These laboratories were selected because of the recent experience at Oak Ridge in addressing landscape level issues associated with land use planning and the similarity of habitat between PNNL and the INEEL.

This section is a brief summary of their land management activities and includes suggestions of important information that can help support the INEEL effort.

OAK RIDGE NATIONAL LABORATORY

Ms. Pat Parr, ORNL, Oak Ridge, TN.-- The vision for the ORNL land use plan is based on the laboratory as an irreplaceable resource in order to address national science and technology missions. Land use planning will identify and prioritize needs for preservation of reservation lands to meet the requirements of existing and future scientific facilities, environmental research, education, and other compatible uses. The goals of the ORNL plan include:

- Incorporate the Oak Ridge Reservation vision.
- Comply with all environmental safety and health regulations.
- Contribute to regional economic development.
- Cluster similar activities and uses.
- Reuse disturbed areas, preserve clean areas, and optimize future use options.
- Minimize pollution.
- Provide innovative approaches to remediation and rehabilitation of disturbed areas.
- Be compatible with adjacent uses.

The ORNL land use plan has three priorities:

- Preserve and protect land by meeting the requirements of existing and future DOE mission-related facilities and programs which require large, biologically and physically diverse protected land areas, so that DOE can continue to meet its local, regional, and national mission obligations.
- Maintain land and facilities to promote sustainable economic development for the region through enhanced DOE missions, as well as through technology transfer and reindustrialization.
- Protect the environment, meet the requirements of scientific and technical education, and support educational research opportunities on the Oak Ridge Reservation.

The Oak Ridge Reservation is one of seven National Environmental Research Parks and has conducted extensive research on Reservation ecological resources. Much of this information is available in published reports and current land use maps that are available in the Oak Ridge Reservation Management Plan (ORNL 1997) and Draft Oak Ridge National Laboratory Land and Facilities Plan. ORNL collaborated with the

Nature Conservancy to evaluate the number of plant and animal species on the reservation. Over 270 significant plant and animal species were identified on the Oak Ridge Reservation (The Nature Conservancy 1995). This information has been compiled as geographic information system layers of the Nature Conservancy's biodiversity ranking and landscape complexity maps. The research park and potentially endangered and known endangered species habitat and wetlands on the reservation are similarly layered. This information is being incorporated into the land use plan to provide recognition of ecological resources on the reservation.

PACIFIC NORTHWEST NATIONAL LABORATORY

Dr. Larry Cadwell, PNNL, Richland, WA.--
The PNNL and the Hanford Reservation are located in Washington State near Richland on the northwest boundary of the Great Basin ecosystem. The Hanford Reservation shares many ecological conditions with the INEEL in its upland areas where the predominant vegetation is sagebrush-steppe. The Hanford Reservation integrated its comprehensive land use plan with the Hanford Remedial Action Environmental Impact Statement (HRA-EIS). The purpose of the Hanford plan is to:

- Guide Hanford's land and facility use decisions.
- Designate existing and future land use based on analysis of land use suitability.
- Use analysis of environmental impacts resulting from remediation activities.

The goal of the Hanford plan is to fully integrate the comprehensive land use plan with the baseline environmental management report, the Hanford strategic plan, and the HRA-EIS being conducted in support of the NEPA process. Existing

(1996), proposed (1997), and projected (for the next 50 years) land use was evaluated. The site was evaluated as a contiguous parcel of land. Hanford has taken some aggressive and innovative steps in its land use planning. In order to ensure that it is complying with all applicable federal regulations, PNNL contracted with a private legal consulting firm for a review of laws, regulations, executive orders, and policies that potentially affect the management of biological resources at Hanford. The draft Biological Resource Management Plan provides a good review of applicable laws and a good template for the INEEL to follow in its assessment of issues that need to be considered. PNNL also collaborated with the Nature Conservancy to help them identify important flora and fauna resources and critical habitat on the reservation. This information has been compiled and is presented in their Hanford Site Biological Resource Management Plan (US DOE 1996b). This plan required extensive resources and took several years to complete. The biological resource document has numerous GIS-generated maps that support management decisions and evaluation of options for land management on the reservation. The analysis represented by the maps provides a good example for the INEEL to consider when developing land management documents.

WORKSHOP DISCUSSIONS

The workshop included three breakout sessions covering biotic issues, abiotic and landscape issues, and heritage resource issues. The biotic section was the largest with approximately 25 participants, the abiotic and landscape level group had approximately 15, and the heritage resource group had approximately six participants. A number of participants migrated among the breakout groups. All breakout groups were

tasked with addressing the following questions:

- Are the 15 assumptions in the INEEL Comprehensive Land Management Plan still valid?
- What information exists that supports the scientific basis for making long-term land management decisions for the INEEL?
- What necessary information is missing to support the scientific basis for making long-term land management decisions?
- How would you prioritize the research needs and information requirements for addressing long-term land management needs?

DISCUSSION OF INEEL COMPREHENSIVE FACILITY AND LAND USE MANAGEMENT PLAN ASSUMPTIONS

The DOE's legal responsibility and the agenda of the current administration govern DOE's obligation for long-term land management for the INEEL. Accordingly, environmental remediation activities are emphasized heavily. The Comprehensive Facility and Land Use Plan (US DOE 1996a) provides a detailed discussion of DOE's legal responsibility and the ensuing legal decisions that the State of Idaho has negotiated with DOE for management of the INEEL. Starting in 1992, the DOE Idaho Operations Office conducted analyses to project reasonable land use scenarios at the INEEL for the next 100 years. In 1995, the specific issues, assumptions, and constraints developed through these analyses and the resulting facility and land use scenarios for the next 25, 50, 75, and 100 years were published as the Long-Term Land Use Future Scenarios for the Idaho National Engineering Laboratory (DOE 1995). The scenarios project (1) no change to the present INEEL boundaries within the 100-year period and (2) future industrial

development most likely concentrated in the central portion of the INEEL and within existing major facility areas, as compared to other portions of the site.

As part of the effort to develop the long-term land use future scenarios, the DOE Idaho Operations Office convened a Long-Term Land Use Team that, in conjunction with local, county, state, and federal agency representatives, and the Environmental Management Site Specific Advisory Board, developed a set of relevant issues and resultant planning assumptions for the INEEL. The 15 assumptions were reviewed by workshop participants to determine if they were still valid or if additional input was needed from stakeholders to revise them. Workshop participants suggested some changes to a number of the assumptions to better address ecological and cultural resource issues and for clarification of the assumptions. An additional assumption was suggested to recognize the unique nature and status of the INEEL ecosystem and the unique opportunities for long-term ecological studies that can address local, regional, and global environmental issues. Detailed comments regarding the assumptions by the workshop participants are in Appendix C.

In general, The biotic group concluded:

- The INEEL contains a unique, protected ecosystem within its borders that provides rare opportunities for research on climate change effects, impacts from industrial and energy development, global pollutants, and other important ecosystem scale questions (e.g., landscape fragmentation effects).
- The INEEL is designated as a National Environmental Research Park and its ecosystem is already valued for its unique, relatively undisturbed characteristics.

- The value of this system will increase with time as further development and encroachment continues on the lands surrounding the INEEL and other areas throughout the Great Basin.
- The basin big sagebrush ecosystem has been identified as one of the most endangered ecosystems in the U.S. The Comprehensive Facility and Land Use Plan should consider the implication of this in future development and restoration activities and elevate its relative importance to other considerations in the Land Use Plan.

Because of the recognized unique ecological resource contained within the INEEL borders, the biotic group agreed additional emphasis should be placed on its value and protection. As a result, an additional assumption was recommended to ensure this resource is recognized and appropriate planning and studies occur to protect and understand its value. The general concept of this assumption was stated in two different ways:

(1) The unique nature and status of the INEEL ecosystem deserves recognition as an important biological resource and preserve. Unique opportunities exist for long-term ecological studies that can address local, regional, and global environmental issues. Due to its local and regional importance, construction and facility development activities will be away from, to the extent practicable, undeveloped areas of the INEEL; large undeveloped blocks of land will remain intact.

(2) Increases in INEEL activities may further fragment a relatively intact ecosystem resulting in long-term consequences including: an increase in exotic species, reduction in native species, and eventual degradation or loss of an ecosystem considered at risk.

Based on the land use assumptions, the following are general issues requiring ecological information to support land use management plan development and implementation:

- New Facilities Development.
- Cleanup and Restoration.
- Environmental Risk Assessment.
- NERP status/Ecological Research--impacts from legacy and defense missions, energy development, industry development, and global change.
- Landscape/Ecosystem Level Change--relative ecological significance of the INEEL to surrounding region.
- Cultural Resources.
- Boundary Changes.
- Grazing Management.
- Encroachment: local/regional development.

EXISTING DATA

The three breakout groups discussed collective knowledge about existing data. Over the 40+ years, scientists have collected a wealth of data on ecological and cultural resources. The groups compiled a list of data and made statements about GIS coverage. A summary of the discussions about availability of GIS coverages is presented in Table 1. There is an extensive amount of information on individual environmental studies that are lumped in Table 1. Additional information on studies associated with resources of the INEEL can be found in publications by the Environmental Science and Research Foundation (ESRF 1994, ESRF 1997) which are frequently updated.

RESEARCH AND DATA NEEDS AND REQUIREMENTS

A general need for INEEL is a central repository for INEEL data. To address

INEEL land use plans, additional more site-specific questions need to be answered and a process and/or method(s) developed to address them. The following research questions, data needs, and comments were put forward by the group.

Biotic Resources

In order to determine research questions and data needs, the ultimate goals for different areas of the INEEL need to be considered. Relative values need to be placed on INEEL resources (e.g., species, habitats, biodiversity, landscape diversity, intact blocks of landscape, clean air/water) and their protection. In addition, disturbance of these resources needs to be quantified for the INEEL ecosystem. A comprehensive evaluation needs to determine the availability and usefulness of existing data to support needed studies and long-term land management decisions. Habitat use requirements should be developed from a number of the existing studies and integrated with the INEEL GIS data base. New data collection efforts should have requirements to ensure the data is spatially referenced and integrated into the GIS data base for current and future needs. New studies also need to consider the usefulness of data for site-wide, local, and regional ecological questions.

A large amount of data is available and GIS compatible for many species on the INEEL. However, detailed information on birds is limited. Bird species habitat requirements, use, and relationships need to be studied. Data is especially needed for migratory and nocturnal birds. When addressing long-term land management decisions, specific bird species may need to be considered. Whether these species must be classified as threatened and endangered, species of special concern, keystone species, or obligate species needs to be determined.

Table 1. Existing resource and facility data in INEEL GIS

Base Coverages
Topography
Hydrography
Soils (coarse level map)
Geology: surficial, bedrock, faults, seismic
Roads
Facilities and Infrastructure
Satellite Imagery (Landsat MSS, TM, and Spot)
Aerial Photography
Public Land Survey
Caves
Wells
Monitoring stations (meteorological, hydrology, air)
Fauna
Raptor nests (incomplete)
Sage grouse leks (incomplete)
Reptiles (incomplete)
Deer (incomplete)
Elk (incomplete)
Bobcats (incomplete)
Flora
Site-wide vegetation classification (unverified)
Long-term vegetation transect (1955-1995)
Sensitive species
Habitat
Wetlands/playas/waters of the U.S.
Caves
Vegetation map/topography/soils
Riparian
Cultural Resources (incomplete)
Abiotic
Temperature, Moisture patterns
Ambient air quality monitoring data
INEEL stationary and mobile emissions inventory
Wind patterns (near surface and winds aloft, wind speed)

Fire is an important part of the sagebrush-steppe ecosystem. Fire management decisions should utilize information learned about recovery and human impacts from recent fires. This information should include:

- Effects of fragmentation caused by fire.
- Effectiveness and need for restoration efforts.
- How exotic/native species are affected by the fires and restoration activities.
- How prescribed burns affect the system (fragmentation, native vs. exotic).

Fragmentation may be caused by roads/trails, power corridors, fire scars, construction areas, barrow pits, wells, and dense exotic species patches. Higher biodiversity occurs where the largest unfragmented blocks of land exist. The blocks of contiguous land on the INEEL need to be identified and prioritized for protection. The size of land blocks that should be preserved needs to be determined. In addition, more inventory data is needed for a number of key species and community level indicators (e.g., patch size and connection, vegetation) to support understanding of disturbance and fragmentation impacts. Comparison studies, including the following, could be used to help understand the effects of fragmentation on the INEEL.

- Compare with Birds of Prey area fragmentation study.
- Compare INEEL highly fragmented areas with unfragmented areas.
- Compare INEEL areas with surrounding areas.

The biotic group focused on several comprehensive questions that should be addressed in order to implement an ecologically-sound long-range land management plan. Data collected to support

smaller, less comprehensive studies should also support an increased understanding of these questions.

- What is the significance and context of the INEEL ecosystem with respect to local and regional biodiversity?
- What is the relative importance of the INEEL ecosystem?
- What are impacts of local fragmentation on INEEL flora/fauna, as well as the entire ecosystem?

These questions are associated with understanding the function of the INEEL ecosystem with respect to site specific, local and regional biodiversity, and population dynamics. These are important issues that need to be addressed by a long-term land management plan. Without this understanding, land management decisions will be made with a limited scientific basis regarding cumulative impacts to the system.

The group suggested the following information is needed to properly address the management questions posed above.

- More complete inventory data for flora and fauna, identifying key indicator species, and selecting study areas for comparison.
- Indicators for fragmentation effects (e.g., populations of exotic and native species). The impact of fragmentation and its extent on the INEEL need to be determined. A comparison of the size and distribution of patches within the central, ungrazed area to the grazed portions of the INEEL, local, non-INEEL areas, and regional sites within the Columbia River Basin could help in understanding the impact and extent of fragmentation.
- A comparison of INEEL populations, their distributions, and genetic biodiversity to local and regional

populations, distributions, and genetic biodiversity.

- Long-term trends on global, regional, and local scales.
- The impacts of disturbance on the INEEL need to be determined with emphasis on invasive and exotic species and their distributions.

Abiotic Factors

Landscape-level analysis-- The INEEL's role in a regional context of development and ecosystem management must be considered in the management of INEEL resources. Landscape-level assessments have not been conducted to determine the importance of the INEEL in maintaining migration corridors for wildlife resources and winter habitat. Selected studies on the movement of large ungulates have been conducted, but this information has not always been looked at in a regional context. Landscape-level assessments that look at indicators such as patch dynamics and connectivity between ecological units need to be conducted to determine the importance of the INEEL in the upper Great Basin ecosystem and establish its role in maintaining connectivity between populations in the mountainous regions surrounding the site.

Air--Air monitoring data needs to be considered in a source-receptor framework in which pathways from the sources to their impact areas can be clearly defined. Data is available, but additional analyses need to be conducted to establish concentration isopleths for unit releases of contaminants on a regional basis (i.e., emissions to the north, south, east, or west) at various times and under various meteorological circumstances. This important information establishes the INEEL's contribution to impacts in surrounding Class I areas including the Craters of the Moon National

Monument and wilderness areas to the northwest and northeast.

Soils and Geology--The INEEL is the only area of eastern Idaho without a complete official soil survey. An official soil survey for the core section of the INEEL and the west and north grazing boundaries has not been done. An official soil survey would support EIS work and assist in facility siting. A coarse-level survey for the entire INEEL was conducted (Olson et al. 1995). However, an accuracy assessment is needed and there are several new range sites that need to be verified. An official soil survey is critical for siting new facilities and long-term management planning, and can serve as a basis for identification of potential vegetation and borrow resources, such as sand and gravel. The Natural Resources Conservation Service (NRCS) would need to be involved in such an effort. The soil surveys provide the base map to which much of the vegetation and habitat data are correlated. The NRCS has range site designations to identify how ecological units are compared throughout the western region. Many of the areas in the southern and eastern part of the INEEL have been identified, but in the center core of the INEEL there are dry areas that will probably require establishment of several new soil series and probably some new range sites. Preliminary surveys conducted over the past several years by soil scientists and vegetation experts have identified several range sites that are in excellent ecological condition and can in general serve as reference sites for the upper Great Basin ecosystem and in particular serve as reference sites for INEEL land management activities. The Department of Energy and NRCS management should discuss this issue and identify priorities relative to other issues currently being addressed by the different agencies. The survey would reduce the cost and improve

the accuracy of many future NEPA documents and could be coordinated with a biotic survey to identify those portions of the INEEL that are most likely in a natural condition or have the most potential of being restored to a natural condition.

Long-term events--Numerous changes in climatic history have occurred on the INEEL. Paleo records indicate that much more of the INEEL was once pinon-juniper (i.e., a woodland ecosystem). Uplifts from mountain ranges along the Pacific Ocean trapped moisture resulting in a much drier climate in the area around the INEEL. Climatic changes based on projected increases in CO₂ have the potential to change precipitation patterns on the INEEL. Looking at these projected changes in a long-term context is important in planning for long-term waste management activities.

The INEEL should be looked at from both a paleo- and a recent history perspective. Paleorecords should be evaluated to determine the range extremes in moisture and temperature over the past 10,000 years. This will provide insight into changes that may occur that need to be considered when waste storage and treatment facilities are designed.

Recent events that have impacted the INEEL have included development around the borders and an increased use of groundwater for agriculture. Studies using aerial photography and satellite imagery from the last 30-40 years should be conducted to look at physical changes that have occurred. Growth rates and changes in land use in surrounding areas can be assessed and easily portrayed using a geographic information system. Linked with this discussion should be a characterization of changes in water resource management in and around the INEEL, including stream corridors,

hydropower development, and the Big Lost River riparian and sinks areas. This information can be used to identify key biological/ecological resources and potential effects of new facilities and development on water resources on and around the INEEL.

Cultural Resources

Full-scale cultural resource inventory, description and evaluation of affected lands/facilities need to be conducted prior to any change in INEEL legal status. Incorporating and updating cultural (and other resource) information into an INEEL-wide centralized GIS data base accessible to decision-makers and planners will allow data to be used to create scaled cultural resource "sensitivity" zones. This would be useful for quick-look status of inventory, level of effort, and estimation of compliance cost and scheduling. A complete inventory of INEEL nuclear/engineering facilities needs to be conducted to evaluate significance and eligibility to the National Register. This information should be in a format and location to be available to landlords, environmental compliance personnel, decontamination and decommissioning personnel, etc. Management plans for historically important facilities and their components and documents which cover prospective activities from maintenance to demolition should be developed. This action, as well as immediate management needs on the INEEL, require that an assessment and ruling be made on the "custodianship" of INEEL land and its cultural and natural resources, including present status, interim responsibilities, and final disposition and transfer of requirements.

A legal ruling on land, natural, and cultural resource "ownership" under several scenarios of present and future INEEL size

and land/facility use and the definition (natural and cultural resource) of "restoration" need to be completed. Impacts on resources from transfer of land/facilities to other entities and on existing resources if buffer lands are released and used in other ways should be considered. Consultation on Tribal and other stakeholder issues needs to be solicited. If the use or size of the INEEL changes, effects on custody and preservation of cultural resources, Native American access to sacred sites, and traditional use areas, etc. need to be examined.

A history/historic context for the INEEL needs to be developed that covers themes and events to meet DOE statutory responsibilities in historic preservation compliance and give historic preservation reviewers. This document should be used to identify and justify historically significant facilities, and the impacts to them under alternatives of rehabilitation/reuse or demolition. Any future short- and long-term decisions regarding land use, waste management, and resource preservation will need adequate models of past abiotic and biotic conditions, their causes and magnitude, and human responses to these conditions and changes. Paleontological and archaeological sites, along with their geologic and temporal contexts, contain information applicable to assessing and evaluating future scenarios under varying climatic regimes. Some of this information is currently available; additional data should be sought through a multidisciplinary effort.

RECOMMENDATIONS FOR FUTURE DIRECTION

The concluding session of the workshop reconvened all participants to compile discussion results and reach a consensus on three topics (1) recommendations for future research and data needs; (2) recommendation to improve information

management; and (3) future workshop interest. A list of research topics was generated, consolidated, and the group rated the topics as high, medium, or low priority. An average value from the group was obtained. These priorities are provided as specific recommendations and include a short discussion of an approach developed from participants input during the workshop

RESEARCH AND DATA ACQUISITION AND MANAGEMENT

- Evaluate the importance of the INEEL as a large protected portion of critical sagebrush-ecosystem and its significance in a regional context. A principal component of this evaluation would be to complete a detailed basic biotic inventory to support identification of how habitat fragmentation due to disturbance has affected the integrity of the site. This information should be used to identify potential areas to be set aside as long-term ecological research and reference areas and provide an applied laboratory for evaluating the importance of the INEEL in a regional context.

Discussion--Participants from the BLM, Idaho Department of Fish and Game, Indian tribes, universities, Nature Conservancy, and USGS Biological Resource Division made strong recommendations that a follow-up workshop should be held to identify how to develop additional financial support to conduct a biological resources inventory for the INEEL and place it in a regional context. Given the INEEL's advanced computing capabilities, it should be feasible and useful to develop historic vegetation maps by tying the INEEL's study in with larger studies like the Interior Columbia River Basin Environmental Impact Statement, the Natural Heritage Program, the Biological Resource Division's GAP analysis, and the Nature

Conservancy's Heritage Program. A recommendation was made that the Nature Conservancy along with the INEEL and other participants seek support similar to that obtained to conduct biological surveys on DoD lands. The Nature Conservancy would also team with the INEEL to host a workshop to evaluate INEEL's role in a regional context. The workshop would help identify funding and opportunities for the INEEL to establish long-term funding to support ecological research on the site.

- Evaluate the potential role of the INEEL as a groundwater protection area for the Upper Snake River aquifer.

Discussion--Partnerships with the U.S. Geological Survey, university water resource groups, and Idaho water users should be used to explore the role of the INEEL in protecting a portion of the upper part of the Snake River aquifer from development. Extensive irrigation and development of agricultural lands is occurring on the north, west, and east borders of the INEEL. Recently more groundwater is being used in development around the INEEL as a source for irrigation or domestic use. Outflow from several watersheds empty onto the INEEL and terminate at the sinks. These areas provide important habitat for the region and serve as an aquifer recharge area. This evaluation needs to consider how development around the INEEL is affecting the surface and related groundwater recharge. Historic growth patterns and effects of this growth should be used to develop reasonable projections for the area around the INEEL and the importance of the INEEL. The overall conjunctive management of the Upper Snake River Basin waters should be evaluated.

- Expand the INEEL's site-wide monitoring program to include selected

indicators of ecological change. This information should be developed with regional partners to enhance educational opportunities and collaborative research opportunities for the INEEL and surrounding area.

Discussion--Management issues and opportunities related to maintaining ecological health in the face of increased disturbance are equal to or greater than issues and opportunities currently focused on contaminants. Many parts of the INEEL have not been impacted by human activities for over 40 years. Other areas have been highly impacted due to waste management and construction activities. Monitoring at the site has historically focused on contaminants in the environment and potential impacts to human health. The Hanford Site Biological Resource Management Plan presented at the workshop provides a logical framework to adapt to the INEEL to address biological resource management monitoring ecological health. The review of legal drivers conducted by PNNL provides excellent guidance for identifying the importance of expanding monitoring programs to include protection of natural resources. This information should be made available to the public and collaborators through an Internet link connected to the existing land use plan.

- Develop a consistent information management system that serves as the link between different data sets and identify and/or fill data gaps. This information should be put into a web browser with links to appropriate data sets.

Discussion--The INEEL Comprehensive Facility and Land Use Plan is currently available to the public and has links to various other supporting documents. An additional workshop should be held on

educational outreach and data linking to ensure that an approach is established and implemented that would (1) allow updates of environmental resource documents currently on the INEEL and (2) link INEEL's land use information to supporting documents being developed by state and federal agencies, universities, Tribes, and private organizations.

The INEEL has numerous advanced technologies that can be applied to management of its environmental data. These include using advanced computing software, such as the Mediator technology, to access different data sets, MapObjects, and watershed assessments to make its GIS data layers available via an Internet link. This information could be tied in with the existing land use plan to extend knowledge about INEEL's ecological resources to communities beyond the site boundaries. As part of this effort, critical information needs should be identified and transmitted to decision makers (e.g., complete soil survey of the INEEL, rights-of-way easements including documentation of its legal basis, systematic and comprehensive biotic inventory).

- Develop procedures to (1) ensure NEPA assessments for long-term land management including cumulative impact analysis and (2) ensure INEEL land management scenarios including ecological change models.

Discussion--Individual impacts from facilities are not the greatest overall concern to ecological resources on the INEEL. Cumulative impacts due to disturbance over long periods of time that fragment habitat and cause long-term chronic insult are likely much more damaging. Within the INEEL's land management and land use plan, the scenarios from 25, 50, 75, and 100 years should be modeled for cumulative impacts to ecological resources. Ecological

succession models are currently available and could be modified to operate on the INEEL. This could be tied into a GIS and would enhance collaboration between the lab and area universities. These models could also be used to project how climatic change and other activities affect not only ecological resources but may affect long-term storage of waste materials. Economic development models should also consider the area around the site under various development scenarios and how this relates to economic build-out in the region. Currently LANDSAT images show development (e.g. conversion to irrigated cropland) around the INEEL. Projections could highlight the issue of groundwater withdrawal and concomitant impacts on ecological resources. Risk assessments should include the potential impacts of emissions from facilities under various development scenarios. This is especially true when addressing concerns associated with design and operation of large-scale waste treatment processes such as the proposed mixed waste treatment facility.

- Use the INEEL restoration program as a test case for restoration management of other natural resource industries in the Intermountain region.

Discussion--The economy of the Intermountain region is heavily dependent on its natural resource base. This includes: mining, logging, agriculture, and recreation. All of these activities have disturbance factors associated with roads and the footprints from operations. The INEEL provides an excellent test base for evaluating alternative restoration options in cold desert ecosystems. For example, how to maximize reestablishment of native vegetation and minimize the intrusion of and impacts from exotic weeds; and how to best use fire as a management tool. The INEEL could use existing technology and resources data to develop models to predict

the location of sensitive biotic and cultural resources

RECOMMENDATIONS FOR IMPROVING INFORMATION MANAGEMENT TO SUPPORT INEEL LONG-TERM LAND MANAGEMENT PLAN

The INEEL Land Management Plan was recognized as an excellent start in pursuing stewardship of INEEL resources. Participants applauded the INEEL's use of an internet server to make information available. Due to the extensive amount of information that is available for environmental resources on and around the INEEL, the group discussed five issues related to improving management of the data and information needed to support the Comprehensive Long-Term Land Management Plan for the INEEL. The issues, presented as questions, and group responses were:

- What can be done to standardize collection and formatting of data to be GIS-compatible?

A long-term financial source must be located to support long-term data management and archiving. Current information exists at universities, in individual researcher's libraries, and in various agency archives. The workshop group suggested a web site be developed to access information and students be employed to work on making existing data compatible. For new information, metadata standards need to be universally accepted for any work relative to land management on the INEEL. The group recommended the current federal metadata standards be adopted as a minimum requirement, and researchers from agencies, private organizations, or universities be informed of these metadata standards. The data standards and format requirements must be reasonable and developed with researcher

input. In order to implement this, senior management for DOE contractors needs to recognize the importance of metadata standards.

- What process can be used to centralize data integration for land use planning and future research?

It is important to have information easily accessible that shows sensitive areas, habitat requirements, and areas identified for development or protection. This should be a simple exercise. The group did not feel it would be best to consolidate all information into a single, central repository. Rather, it was agreed the metadata standards should include links to other data.

- What can be done to enhance collaboration and integrate studies to support complex questions in a regional context?

Idaho Fish and Game has agreements, through the Natural Heritage Program, to share data with most federal agencies, but currently not with the Department of Energy. The Nature Conservancy also has partnerships it has developed with some of the other national laboratories. Both of these organizations should collaborate with the INEEL to conduct another workshop to develop important regional scientific questions that INEEL resources could be used to address. Examples include: questions associated with climate change, fire management, conjunctive management of water resources, and seismology associated with resources extraction in the Intermountain region? Questions should be developed to support a detailed science plan, and possibly coordinated through the DOE/NSF/EPA research program currently managed at DOE headquarters.

- How do we support and maintain the INEEL data sets?

It is critical to identify appropriate support for long-term maintenance of data sets. Because some data management schemes, such as GIS, need periodic software upgrades, some type of long-term funding should be established. The group suggested that Facility Management and DOE consider some type of adder that would support maintenance of these data sets in perpetuity. Currently there is little support for data maintenance. This is inexplicable, considering the legal requirements for maintaining data sets that support long-term land use management. Lessons from Hanford and Oak Ridge enforce the INEEL's needs to improve this commitment and illustrate possible collaboration with other labs to minimize its expenditures.

- What should the quality assurance requirements be for data sets collected in support of long-term land management decisions?

The requirements for quality assurance standards should be in program documentation. Standards should be tied to metadata requirements. Some data, e.g., soil classification and testing, must comply with existing requirements, such as those established by the National Resource Conservation Service. Techniques used for data collection and analysis need to be clearly documented and coupled with metadata standards. This would ensure that future studies could be cross-referenced and made compatible with existing studies. These documentation bridges between new and old studies are crucial quality assurance considerations, often overlooked in collecting data associated with long-term management of INEEL resources.

INTEREST IN FUTURE WORKSHOPS/INFORMATION MEETINGS

Comments were solicited from all

participants regarding the workshop. An overwhelming majority ($\geq 90\%$) of respondents thought the workshop was beneficial and additional follow-up workshops would be useful. Workshop participants also indicated they would like a written summary of the workshop. This document responds to that request.

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APPENDIX A

A REVIEW OF LAND USE AND DISTURBANCE RESEARCH IN A SAGEBRUSH-STEPPE ECOSYSTEM

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SUMMARY—The Idaho National engineering and Environmental Laboratory (INEEL) occupies 890 mi² of relatively undisturbed sagebrush-steppe in southeastern Idaho. These lands have been under the jurisdiction of the U.S. Department of Energy, and its predecessor agencies, for nearly 50 years. Until recently the primary mission of the INEEL was energy related research and technology development. Although DOE and the M&O contractor have in the past developed forward looking plans for mission development, facility construction, and land use, few planning efforts have included long-term land stewardship and ecological land management issues. Recent policy and mission changes for DOE in general and the INEEL in particular now present an opportunity to seriously address long-term land management policies, strategies, and plans for the INEEL.

Fundamental to a forward looking land management plan is a credible scientific basis for present and future land management decisions. Toward this end, the Environmental Science and Research Foundation was asked by Lockheed Martin Idaho Technologies Company (LMITCO), the present INEEL M&O contractor, to assemble a database of research titles and summaries related to ecological aspects of land disturbance. This database provided the foundation for discussion in a LMITCO sponsored workshop: Collecting the scientific basis to support long-term land management of the Idaho National Engineering and Environmental Laboratory, September 9 and 10, 1997.

The database was the result of a literature search limited to studies conducted on the INEEL, surrounding areas, and similar sagebrush-steppe habitat. Publications evaluating habitat fragmentation and patchiness and their corresponding effects on ecosystem components were also included. In addition to helping in future long-term land management decisions for the INEEL, this database will help identify data gaps and research needs for informed management decisions.

The database consists for four sections: a narrative summarizing the ecological effects of specific land disturbance activities, a matrix (Table 1) providing citations for specific ecological resources impacted by various disturbance events, an annotated bibliography, and a topical reference index. Numbers in the matrix and topical index correspond to the numbered citations in the annotated bibliography.

The Idaho National Engineering and Environmental Laboratory (INEEL) occupies 2,300 km² located on the northeast end of the Snake River Plain. In the past, the U. S. Department of Energy's (DOE) mission has evolved from developing nuclear reactors and weapons to radioactive waste storage and clean up. In 1975, the INEEL was designated as a National Environmental Research Park for ecological research and study of environmental impacts of energy development and restoration of contaminated areas. In 1994, a new land

and facility use policy for the DOE was issued by the Secretary of Energy. These changes in DOE's missions and policies have required the DOE to "manage all of its land and facilities as valuable national resources...based on the principles of ecosystem management and sustainable development" (O'Leary 1994). Because of limited access and development, much of the INEEL is relatively undisturbed and a large expanse of important habitat has been preserved. The ungrazed sagebrush-steppe ecosystem in the Intermountain West is

listed as critically endangered (>98% decline) by the National Biological Service (Noss et al. 1995).

The INEEL is surrounded by public rangelands and agriculture fields. For the past 45 years, cattle and sheep grazing have only been permitted on the periphery of the INEEL. Although about 60 per cent of the INEEL is open to livestock grazing, most of the central core of the site is a large expanse of undeveloped sagebrush-steppe habitat. This represents approximately 400 mi² (over 100,000 ha) and is likely the largest undeveloped, ungrazed sagebrush-steppe outside of national parks in the Intermountain West (DOE 1996). The average elevation of the INEEL is 1,500 m above sea level. The mean annual precipitation is about 220 mm and the average annual temperature is 5.6° C. Large daily and seasonal temperature fluctuations occur in this cold desert community, with most precipitation coming in the form of snow and spring rains. Vegetation at the INEEL generally consists of a shrub overstory with and understory of perennial grasses and forbs. Communities are commonly dominated by big sagebrush (*Artemisia tridentata*) or green rabbitbrush (*Chrysothamnus viscidiflorus*), but 42 other shrub species also occur there. Perennial grasses are the most abundant understory plants. Because of the lack of livestock grazing over much of the site, the INEEL also supports a high diversity of forbs (Anderson et al. 1996). The INEEL provides habitat for a number of threatened and endangered species and species of special concern (Beck-Haas 1997). This habitat is also important winter range for sage grouse, pronghorn antelope, and elk, and may be crucial for a variety of migratory birds.

Although the INEEL has been protected from development, it has been subjected to a

variety of physical disturbances, both natural and anthropogenic, that may significantly and permanently alter this shrub-steppe ecosystem. Fire, grazing, sagebrush control, exotic plants, crested wheatgrass seeding, and facilities/human presence are some examples of disturbances on the INEEL and surrounding areas. The purpose of this report is to summarize existing information available on the effects of these disturbances on the ecological resources of the INEEL. Because habitat fragmentation, a result of disturbance, continues to occur at the, publications on this topic and habitat patchiness were also included. We conducted this literature search and assembled the database in preparation for an INEEL workshop on long-term land use. Because of time constraints, this literature search is not inclusive. The attached database is the result of a literature search limited to studies conducted on the INEEL, surrounding areas, and similar sagebrush-steppe habitat. Not all information on similar sagebrush-steppe habitat and the effects of disturbance are summarized here. However, most of the studies conducted addressing disturbance on the INEEL are included in this report. In addition to helping in future long-term land management decisions, this database will help identify data gaps and research needed to make informed management decisions.

This database consists of a four sections: summary narrative, matrix (Table 1), annotated bibliography, and topical index of general land disturbance categories and literature citations. The narrative is divided into disturbance factors (e.g. fire, grazing, sagebrush control) and presents a synthesis of the results from the various studies. The matrix lists major disturbance factors and the resources impacted by that disturbance, as well as listing the studies examining those impacts. Numbers in the matrix and the topical index correspond to the

numbered studies in the annotated bibliography.

SUMMARY NARRATIVE

IMPACTS OF WILDLAND FIRE

The effects of fire were addressed in 33 articles and included effects on:

- Vegetation (Blaisdell 1953, Wright and Klemmedson 1965, Klebenow 1970, Wright 1972, Harniss and Murray 1973, Wright 1974, Young and Evans 1974, Sturges 1975, Young and Evans 1978, Hedlund and Rickard 1981, Castrale 1982, Humphrey 1984, Winter 1984, Bunting 1985, Klebenow 1985, Winter and Best 1985, Petersen and Best 1987, Whisenant 1990, Sime 1991, Hobbs and Huenneke 1992, Yensen et al. 1992, Gurr and Wicklow-Howard 1994, Hosten and West 1994, Rosentreter 1994, Knick and Rotenberry 1995, Ratzlaff and Anderson 1995, Fischer et al. 1996).
- Birds (Klebenow 1970, Wright 1974, Castrale 1982, Gates 1983, Winter 1984, Starkey 1985, Winter and Best 1985, Petersen and Best 1987, Sime 1991, Yensen et al. 1992, Fischer et al. 1996).
- Small mammals (Wright 1974, Hedlund and Rickard 1981, Ream 1981, Gates 1983, Starkey 1985, Yensen et al. 1992).
- Large mammals (Wright 1974, Gates 1983, Klebenow 1985).
- Insects (Winter 1984, Fischer et al. 1996).
- Soil (Blaisdell 1953, Brown et al. 1985, Whisenant 1990, Gurr and Wicklow-Howard 1994, Wicklow-Howard 1994).
- Exotic plants (Young and Evans 1978, Bunting 1985, Klebenow 1985, Anderson and Inouye 1988, Whisenant 1990, Hobbs and Huenneke 1992, Yensen et al. 1992, Hosten and West 1994, Rosentreter 1994, Knick and Rotenberry 1995, Ratzlaff and Anderson

1995).

Vegetation

Fire plays an important role in sagebrush-steppe communities and can be beneficial or detrimental to native vegetation and animals. Hot, dry summers historically promoted recurring fires with estimated frequencies from 20 to over 100 years (Houston 1973, Wright et al. 1979). In some areas the establishment after fire of communities of exotic annual grasses such as cheatgrass (*Bromus tectorum*) has reduced the interval between fires as few as three to five years. This decreased fire interval has been an important factor in converting native sagebrush-steppe to nonshrub annual grasslands.

For over 35 years, cheatgrass has increased in distribution and abundance on the INEEL. However, an 11 year study in central Utah indicated that cheatgrass cover declined over a long period of time. The authors suggested changes in precipitation may have been the cause. On the other hand, these unusual results may reveal the lack of long-term studies on community changes in sagebrush-steppe ecosystems. Cheatgrass is a fine fuel that, unlike widely spaced, native, perennial bunchgrasses, carries fire continuously between shrubs and increases fire intensity. This, in turn, increases the natural fire frequency and causes more uniform, larger burns with fewer patches of unburned vegetation remaining. Loss of species richness, genetic diversity, structural diversity, and landscape patchiness are the results. The decreased fire interval is detrimental to most native plants and shrubs by altering successional patterns. Perennials do not have time to become reestablished between fires and the vegetation may become a "self-perpetuating annual community."

The most noticeable effect of fire is the change in vegetation. The effects of fire on vegetation greatly depend on the climatic conditions, habitat type, and severity of the fire. Incomplete prescribed burns and low intensity wildfires can create mosaics of patches of burned and unburned sagebrush with open areas of forbs, grasses, and bare ground. Overall shrub density and cover are reduced by fire. Shrub production after a fire is low unless there is a high abundance of resprouting shrubs present prior to the fire. Fire does not usually harm resprouting shrubs such as rabbitbrush (*Chrysothamnus* sp.) and horsebrush (*Tetradymia canescens*) that can reestablish rapidly after fire. However, shrubs that have to generate from seed can be severely damaged by fire. Big sagebrush (*Artemisia tridentata*) and antelope bitterbrush (*Purshia tridentata*), both nonsprouting shrubs, are unable to reestablish if fires are frequent. Because of the continual removal of seeds, nonsprouting plants may never become dominant if fires are too frequent. In one study, up to 30 years after a fire, unburned areas still had the highest number of mature sagebrush. The loss of dominant shrub species, such as sagebrush, can have a detrimental effect on species dependent on it. Losing shrubs can reduce forage production, soil stability, diversity, biomass production, mineral cycling, and cover for wildlife.

Native grasses are initially injured by fire, but, lacking invasion by exotic grasses, generally recover within a few years with higher production rates than unburned areas due to an initial release of nutrients and reduced competition with sagebrush. Perennial forb productivity and the amount of bare ground also increase after fire. Grass and forb production gradually decrease as sagebrush and other shrubs recover. Plant biomass production of a burned sagebrush-grass habitat does not

return to preburn levels until sagebrush is re-established.

Soil

Soil characteristics are also affected by fire. Fire can increase erosion and sediment yields by increasing the amount of bare ground and reducing infiltration rates. Organic matter, nitrogen, and soil moisture are significantly reduced in the upper soil surface on heavily burned sites. Cryptogam ground cover may also decrease with high fire frequency. Fire and other disturbances, such as, overgrazing or vehicle use, can also reduce the mycorrhizal inoculum potential of the soil. Ninety-five percent of dominant plant species, including sagebrush, in semiarid grasslands require vesicular-arbuscular mycorrhizal infection to colonize disturbed areas. Without this infection, it could take longer for desired plants to reestablish after a fire. On a disturbed site, only about one percent of the colonizing plants are mycorrhizal compared to about 99% on undisturbed sites. Some disturbed sites have had no vesicular-arbuscular mycorrhizae for up to 10 years.

Birds

Fire's most significant impact on wildlife is the alteration of habitat, not direct mortality. There are a number of sagebrush obligate bird species occupying the sagebrush-steppe habitat. Sage grouse (*Centrocercus urophasianus*), sage thrashers (*Oreoscoptes montanus*), sage sparrows (*Amphispiza belli*), and Brewer's sparrows (*Spizella breweri*) rely on sagebrush habitat for food and nest sites. A dramatic decrease in shrub cover after a fire can significantly affect these obligate species. Incomplete burns that result in a mosaic of burned and unburned areas may increase bird species diversity because of the increase in habitat diversity, but fragmented habitat may also

increase nest vulnerability to predation. These types of burns are the least damaging to nongame bird populations. However, if the area denuded by fire is more complete, species diversity can be decreased. Bird species responses to a change in sagebrush habitat may vary and can usually be explained by the differences in requirements of shrubs for nesting. In one study, for example, the placement of sage sparrow nests was significantly affected by fire. Before the burn, all the nests found were placed within sagebrush canopies. After the burn, only 79% were located within sagebrush canopies, nearly all of the other nests were found on the ground in depressions. Sage grouse and Brewer's sparrows are able to continue breeding in areas with a mosaic of burned and unburned patches, but prefer areas with more sagebrush cover. Fires that burn large patches would be damaging for both species because of feeding requirements and the reduction of sagebrush cover and appropriate microclimate conditions for nesting.

Seasonal distributions of sage grouse are largely determined by vegetation patterns and food availability, both of which may be weather related. Survival of wintering grouse is best in areas dominated by sagebrush. Sagebrush communities support diverse insect fauna that provides an important food source, in addition to forbs, for sage grouse chicks. Fire can have a negative impact on insects important in sage grouse diets for several years. Reductions in the abundance and diversity of forbs are also destructive to sage grouse brood and winter habitat. One year after a fire, use by sage grouse may increase on a burned site due to an increase in forb production, but only if winter range area was not severely affected and not all sagebrush was removed.

When determining management

objectives for preserving native bird communities, close attention should be paid to sagebrush obligate species. Removal of large areas of sagebrush-steppe can be especially damaging to species that rely on sagebrush as sources of food, nesting sites, and winter habitat.

Small Mammals

Fire does not directly damage small mammals that can escape to below ground burrows. A study in south-central Idaho found that fires reduced food availability to Townsend's ground squirrels the following spring and replaced native vegetation with annual species, which are unstable food sources. Squirrels that live in burned areas are vulnerable to erratic fluctuations in food biomass and low food plant diversity, which result in high amplitude population fluctuations. Townsend's ground squirrels are an important prey item to several birds of prey. Fluctuations in their populations could negatively affect these birds. Pygmy rabbits are negatively affected by fire because of their use of sagebrush for food and cover. Jackrabbit use of burned areas could increase because of increased production of grasses and forbs. While the initial effect of fire may be decreased small mammal densities, the overall long-term response is increased densities due to the surge in plant growth and seed production.

Large Mammals

Fire does have an effect on game animals. Fire may improve some seasonal forage for mule deer, mountain sheep, and pronghorn antelope by increasing spring grass production. However, fire may also damage important cover in summer and winter habitat. Fire in summer ranges could remove critical cover for mule deer, negatively affecting the population. In winter ranges, sagebrush and antelope

bitterbrush, usually removed by fire, are usually the only hiding and thermal cover available. The long-term effects of fire can be beneficial. Fires maintain the diversity of vegetation, and rejuvenate old bitterbrush-sagebrush stands thereby increasing winter forage. Wildlife use of a burn may initially be lower because of damage to forbs. Patchy burns are more beneficial to wildlife because of increased forage in the burned areas while the remaining habitat can be used for cover.

Perhaps because fire is a very noticeable, publicized, and sometimes drastic event, there has been a great deal of research done on its effects. The literature pool on this topic is very broad but does not encompass the effects on all components of the sagebrush-steppe ecosystem. More research is required on the effects of large and small mammals, insects, and herptiles. Fire effects can also be scale dependent. Looking at a fire on a small scale, the effects may be seen as damaging. On a larger scale, fire may be seen as beneficial. This area also needs research.

SAGEBRUSH CONTROL

Sagebrush control and its effects were addressed in 11 articles including effects on vegetation (Tabler 1968, Best 1972, Young and Evans 1974, Sturges 1975, Castrale 1982, Parmenter and MacMahon 1983, Wiens and Rotenberry 1985, Swenson et al. 1987), birds (Klebenow 1970, Best 1972, Schroeder and Sturges 1975, Castrale 1982, Wiens and Rotenberry 1985, Swenson et al. 1987), small mammals (Parmenter and MacMahon 1983), insects (Best 1972), and soil (Tabler 1968, Sturges 1975, Brown et al. 1985).

Large expanses of sagebrush-steppe habitat have been treated mechanically, chemically, or biologically to increase

forage production for livestock or to create croplands. Starting in earnest in the 1950s and continuing into the 1980s, these activities were typically followed by reseeding the area with crested wheatgrass. Sagebrush control methods include burning, chaining, plowing, and spraying. As much as 30% of historic sagebrush rangeland has been impacted.

Spraying is considered the best technique for sagebrush control in a watershed because it minimizes soil disturbance and has minimal impact on infiltration rates and sediment yields. Spraying with 2,4-D increases grass production, kills sagebrush, and greatly reduces forb growth as long as two years after treatment. This could be detrimental to organisms that depend on forbs, such as sage grouse chicks, and other birds that depend on sagebrush for nesting habitat. Sagebrush canopy coverage is severely reduced by spraying, but can still offer cover and acceptable nest sites for shrub dependent birds for a limited time. Nesting of sage grouse may stop or almost completely stop on sprayed areas. A decrease of sage grouse in sprayed areas is most likely due to the lack of shrub cover and food. Large areas that were treated with herbicide showed a decrease in Brewer's sparrow, but not the vesper sparrow. Habitat where only portions of sagebrush were sprayed did not result in a decrease in sage grouse, Brewer's sparrows, or vesper sparrows. Total kill may reduce nest cover or flora diversity with possible negative effects on insect fauna. Vesper sparrows were not as affected by this reduction in cover due to less rigid requirements of cover for nests than the Brewer's sparrow. In addition, the increase in grass seed, an important food source for vesper sparrows, after spraying was beneficial. Brewer's sparrows decreased because of insufficient nest cover and the negative effects on insect fauna. There may be time lag in the

response of bird species to habitat change possibly caused by site fidelity, which may outweigh habitat selection responses and lead individuals to remain in areas where the habitat has been significantly altered. It could take at least 10 years for a sprayed area to recover its original carrying capacity, depending on the degree of original kill, the amount of remaining shrubs, and the speed of sagebrush recovery.

Plowing of sagebrush steppe can be detrimental to sage grouse if there is a loss of sagebrush on their wintering ranges. The largest long-term declines in sage grouse populations occurred where sagebrush was plowed. Sagebrush does not usually recover on plowed land because this land is generally cultivated annually. Plowing and seeding with crested wheatgrass causes the greatest impact on infiltration rates and sediment yields. Chaining is not as damaging to birds dependent on sagebrush because more rapid regeneration of sagebrush can occur.

The effects of burning were previously discussed. This form of sagebrush control causes long-lasting changes in steppe habitat because of the loss of shrubs and reduction in litter and seeds. Burning and seeding with crested wheatgrass has some impact on infiltration rates and sediment yields, but not as much as plowing.

Changes in rodent populations after shrub removal could be the result of the loss of food or cover provided by sagebrush. Long-term rodent distribution may be indirectly affected by shrubs. Herbaceous vegetation, a major food source for rodents can be affected by shrub removal. Shrubs provide litter accumulation for seed germination, shading, nutrients, higher soil moisture, and microhabitats for arthropods—all beneficial to small rodents.

Very little information on the effects of various sagebrush control methods on large and small mammals, herptiles, insects, or soil is available. No studies located at the INEEL or its surrounding areas were found in the literature.

CRESTED WHEATGRASS

Sixteen articles were found on the effects of crested wheatgrass seedings. The components of the ecosystem impacted by crested wheatgrass seedings are vegetation (Reynolds 1979, Reynolds and Trost 1979, Reynolds and Trost 1980, Reynolds and Trost 1981, Wiens and Rotenberry 1985, Anderson and Marlette 1986, Marlette and Anderson 1986, McAdoo et al. 1989), birds (Howard and Wolfe 1976, Reynolds and Trost 1979, Reynolds and Trost 1980, Reynolds and Trost 1981, Wiens and Rotenberry 1985, McAdoo et al. 1989, Sime 1991), small mammals (Reynolds 1980, Reynolds and Trost 1980, Parmenter and MacMahon 1983, Koehler and Anderson 1991), large mammals (Reynolds and Trost 1979, Reynolds and Trost 1980), herptiles (Reynolds 1979, Reynolds and Trost 1980), insects (Reynolds 1979, Reynolds and Trost 1980, Parmenter and MacMahon 1983, Fielding and Brusven 1992, Fielding and Brusven 1994), and soil (Brown et al. 1985).

Crested wheatgrass has been planted on millions of acres of chemically or mechanically treated rangelands in the western United States to improve forage for livestock. At the INEEL, crested wheatgrass has also been planted for soil stabilization and hydrologic benefits after disturbances, such as fire, roadside rehabilitation, or shallow land burial sites. Changing native sagebrush rangeland to a crested wheatgrass monoculture results in a reduction of plant species diversity. Seed banks in crested wheatgrass seedings are mostly dominated by crested wheatgrass

with very few native propagules. Reestablishment of native vegetation could be slow or totally prevented. Crested wheatgrass seedings invaded by sagebrush are suitable habitat for both shrub-nesting and grass-nesting bird species. Grass-nesting species are favored following the initial conversion of native habitat to crested wheatgrass. If sagebrush is able to re-invade, shrub-nesting bird species are restored.

Habitats with shrub cover and an understory of perennial grasses supported the lowest densities of grasshoppers with a lower proportion of pest species than crested wheatgrass or annual grasslands. Planting crested wheatgrass could increase the density of grasshoppers and increase the proportion of pest species. Invertebrate fauna relative density was increased in crested wheatgrass plantings. Short-horned and sagebrush lizard populations in crested wheatgrass seedings were below densities found in the sagebrush habitats. Ants, primary prey items for lizards and sage grouse chicks, were less abundant in crested wheatgrass than native sagebrush habitats. Areas of crested wheatgrass had a reduction in diversity and density of nesting birds. Crested wheatgrass stands do not meet the winter needs of sage grouse, but may occasionally be used for strutting grounds. Crested wheatgrass plantings also had a lower density of large and small mammals. Sagebrush habitat supported larger densities of small mammals than areas of crested wheatgrass. Crested wheatgrass seedings were the least used out of native, crested wheatgrass, and disturbed habitat, but still received a significant amount of use. The only small mammal that increased in number in crested wheatgrass plantings was the western harvest mouse, all other species decreased, reducing species diversity. Seeding rangelands with crested wheatgrass plantings has a larger impact on vertebrate

populations than sheep grazing.

GRAZING

The effects of grazing were discussed in 18 papers, including effects on vegetation (Harniss 1968, Young and Evans 1974, Reynolds 1979, Holechek 1980, Reynolds and Trost 1980, Anderson and Holte 1981, Reynolds and Trost 1981, Johnson 1982, Abdel-Magid et al. 1987, Fleischner 1994, Hosten and West 1994, Anderson and Inouye In press, Rotenberry In press), birds (Holechek 1980, Reynolds and Trost 1980, Reynolds and Trost 1981, Fleischner 1994), small mammals (Holechek 1980, Reynolds 1980, Reynolds and Trost 1980, Ream 1981, Johnson 1982, Fleischner 1994), large mammals (Holechek 1980, Reynolds and Trost 1980, Fleischner 1994), herptiles (Reynolds 1979, Reynolds and Trost 1980, Fleischner 1994), insects (Reynolds 1979, Holechek 1980, Reynolds and Trost 1980, Fleischner 1994), soil (Holechek 1980, Warren et al. 1986, Abdel-Magid et al. 1987, Fleischner 1994, Wicklow-Howard 1994, Rotenberry In press), and exotic plants (Hobbs and Huenneke 1992, Fleischner 1994, Hosten and West 1994, Rotenberry In press).

Grazing occurs on about 60 per cent of the INEEL, around the perimeter and on adjacent public and private lands. Grazing changes plant species composition of communities by decreasing density and biomass of species, species richness, and altering community organization. Ecosystem functioning and structure are also disrupted by grazing. Community organization is changed by the elimination of native species and the invasion of exotic species. Grazing decreases plant diversity by reducing competition from native vegetation, thereby opening up habitat for species such as cheatgrass. Long-term grazing can alter patterns of ecological

succession by maintaining early seral vegetation.

Several studies of vegetation dynamics along permanent vegetation transects have been conducted at the INEEL. This sagebrush-steppe area has been protected from grazing since the 1950's. In a study 15 years after the exclusion of livestock, most vegetation changes were attributed to precipitation patterns. Cover was dominated by shrubs. Grass cover was low, but had increased slightly from 1950. Sagebrush cover increased until 25 years after exclusion. Sagebrush decreased due to a widespread die-off after 1975. Rabbitbrush cover consistently increased since 1950. Perennial grass cover increased 20-fold up to 1975, then decreased and fluctuated almost 4-fold over the past 20 years. Cheatgrass distribution and abundance increased over the last 45 years. A correlation between vegetation cover and precipitation patterns suggested there may be a delay in response of vegetation of 3- to 5-years. Species richness increased per plot, but remained fairly constant for the entire study area. This may be the result of populations that were initially small and isolated increasing in size and distribution. After 45 years of livestock exclusion, shrubs were still dominant, but perennial grass cover had increased overall. The increase in plant diversity and decrease in percent similarity between plots suggested trends vegetative changes may be largely the result of recovery from drought and livestock grazing. Even without major disturbances, significant fluctuations in plant species abundance and composition would be expected.

Overall density and diversity of small mammals, birds, raptors, lizards, and snakes have all been lower in grazed areas than in non-grazed areas. Grazing in riparian zones also has a negative impact on fish. Wildlife

response to overgrazing is species specific, but usually the effect is negative.

Overgrazing is damaging to ground-nesting birds because it reduces cover and increases predation. Studies conducted on the INEEL indicated spring grazing in sagebrush habitats was not severely detrimental to bird populations. In addition, seasonal sheep grazing did not significantly affect short-horned and sagebrush lizard populations or ant mounds, a prey source for lizards. Sheep grazing had a smaller impact on vertebrates than converting native vegetation to crested wheatgrass stands. Another study on the INEEL found that seasonal cattle and sheep grazing did not appear to limit important small mammal distributions because small mammal abundance is highly site specific. The effect of grazing on insect populations depends on several factors and is not clear.

Grazing damages microbiotic crusts and decreases crust cover and species richness. Human footprints, vehicle tracks, and overgrazing can easily stop nitrogen fixation by microbiotic crusts and reduce the mycorrhizal inoculum potential of the soil. Increases in soil erosion, compaction, and decreases in soil stability and porosity are also results of overgrazing. Heavy stocking rates and continuous grazing increases surface runoff and decreases water infiltration.

Controlled grazing may be beneficial. It can loosen surface soil in dry areas, remove excess dead vegetation, reduce fire, insects, and rodents. The effects of grazing are largely determined by the intensity, duration, and stocking rate. Continuous grazing with high stocking rates would be more damaging than seasonal grazing with low stocking rates.

FACILITIES/HUMAN PRESENCE

Few studies have been conducted on the

impact of facility/human presence at the INEEL and surrounding areas. Only six studies, both on and of the INEEL, were found. All concerned birds/raptors (Howard and Wolfe 1976, White and Thurow 1985, Holthuijzen 1989, Bosworth 1994, Hansen 1994, Belthoff et al. In press).

The impact of possible development and construction at the INEEL on threatened and endangered species and species of special concern further increases the need for research in this area. Breeding bird surveys at the INEEL indicate that human activity near major facility complexes can affect the composition of avifauna compared to remote sites with no human activity. Raptors usually occurred more on remote routes, with "human-associated" species commonly found on facility complex routes. However, a raptor use study found that raptors did not appear to be affected by site facilities. A high frequency of raptors within 10 km of site facilities was probably due to increased power pole densities in these areas, as power poles were often used as perches. Ferruginous hawks did, on the other hand, avoid human development when choosing nest sites. A study on ferruginous hawks in south-central Idaho found that hawks did not increase their tolerance to disturbances over time, but became more sensitized.

In addition, human presence in caves can produce premature arousal of bats at the end of a torpor bout. Even low levels of disturbance could have a negative impact on the bat's winter energy budget. Human disturbance by handling increased bat activity for at least 48 hours after the disturbance.

FRAGMENTATION/PATCHINESS

Fifteen publications were found on fragmentation and patchiness of habitat

(Wiens 1976, Rotenberry and Wiens 1980, Wiens and Rotenberry 1981, Abugov 1982, Wiens et al. 1985, Stamps et al. 1987, Burgess 1988, Burke 1988, Quinn and Harrison 1988, Whisenant 1990, Hobbs and Huenneke 1992, Rosentreter 1994, Wiens 1994, Knick and Rotenberry 1995, Rotenberry In press). However, few specifically addressed shrubsteppe habitat (Rotenberry and Wiens 1980, Wiens and Rotenberry 1981, Whisenant 1990, Rosentreter 1994, Knick and Rotenberry 1995, Rotenberry In press); none dealt with the INEEL.

Several studies have suggested that the diversity of a community is maximized with some modest disturbance. If conditions are static, plant communities are static and dominated by lasting species. Fugitive species, competitively inferior species able to colonize newly disturbed areas, are dominant at high disturbance rates. Temporal patterning of disturbance, in addition to rate of disturbance and the characteristics of component species, are important in determining the response of a community to disturbance.

The theory of island biogeography was developed in the 1960's by MacArthur and Wilson. This theory suggested that the number of species present on an island is a function of island size, age, and distance from a source of replacement species. Scientists in the past have applied this theory to terrestrial islands. That is, patches of natural habitat surrounded by disturbed land. However, terrestrial islands are very different from true islands. They are more vulnerable to influences of the surrounding areas because the boundaries are more permeable. Terrestrial islands are not surrounded by a body of water and dispersal to these islands does not necessarily mean long-distance travel from another "island." In addition, terrestrial fragments tend to

support fewer species than islands because terrestrial fragments are usually smaller than true islands. Evidence from terrestrial studies support species/area curve relations (i.e. larger areas support more species than smaller ones) rather than the island biogeography theory of terrestrial habitat fragments.

Boundary permeability reflects the degree to which the boundary repels movement of physical forces or animals and is a function of these "vectors" and boundary features. A permeable boundary allows easy transfer from one side to the other. Patches can be closed or open systems. The more impermeable a boundary is, the more localized and self-contained the activities within the patch become and the system closes. This isolates the patch and more sharply defines the boundary. Disturbances are less likely to spread over a spatially patchy area than over a more homogeneous area. The more sharply defined patch boundaries are, the less likely the spread of disturbance.

Fragmentation is important because it results in loss of habitat and jeopardizes species dependent upon that habitat. Corridors between fragments are believed to improve recolonization of empty patches and reduce the risk of extinction. Fragmented reserves, with density dependent reproduction and survival, according to a simulation model, are more likely to become extinct than continuous reserves. Density dependent populations experience random fluctuations in size and the risk of extinction rises with the degree of fragmentation. Migration can slow extinction, but as fragmentation increases, higher dispersal rates are needed to maximize survival. However, an analysis of a collection of data sets indicated that species richness was greater on a collection of small islands than on fewer larger islands.

Possible causes include habitat diversity, population dynamics, and historical effects. A collection of small isolated areas contain a wider range of habitat than fewer large ones. Colonization and extinction dynamics of smaller isolates enable them to support more species. In contrast, some species do require large tracts of unfragmented habitat to survive and successfully reproduce.

With the increase in fire frequency caused by the conversion of sagebrush-steppe to annual grassland, communities are becoming less structurally diverse and patches are becoming larger. A mosaic landscape will support a higher species diversity, but a large, species poor mosaic will have isolation of patches within that area. Arid systems may be more sensitive to factors creating patchy vegetation. Recovery from disturbances in arid systems tends to be slow, so these patches may last longer than ones in more mesic systems.

Fragmentation of shrubsteppe habitats and human-caused disturbance can significantly affect sagebrush obligate species, such as sage and Brewer's sparrows and sage thrashers. Many shrubsteppe bird species increase with high vertical heterogeneity but their responses vary in relation to horizontal patchiness. Overall, many species' abundances are correlated with habitat structure. When the heterogeneity of habitat structure is lost by, for example, sagebrush control and crested wheatgrass seedings or the invasion of exotic annuals, species diversity will decrease. As in fire, the effects of fragmentation may be very scale dependent. Large scale fragmentation may be more detrimental than small scale fragmentation.

Fragmentation is occurring on the INEEL every time a new road is put in, building developed, or fire takes place. With the continuation of development beyond the

boundaries of the INEEL, this sagebrush-steppe habitat is becoming more and more isolated. The negative impacts of this fragmentation and isolation could be detrimental to this fragile ecosystem. Information on how species respond to habitat fragmentation, patchiness in relation to natural ecosystems, and how these characterize entire ecosystems is very limited and needs to be expanded.

SUMMARY

Sagebrush-steppe habitat has been and always will be affected by various types of disturbance. These disturbances may temporarily or permanently alter this ecosystem in a variety of ways. For example, fire can increase grass and forbs available for wildlife forage, increase soil nutrients, and rejuvenate old shrub communities. However, it also opens up areas for exotic annual invasion and can be detrimental to sagebrush obligate bird species if the fire covers a large area. Most methods of sagebrush control have a negative effect on sagebrush obligates by decreasing nesting sites and insect fauna. The conversion of rangelands to crested wheatgrass for livestock grazing has significantly decreased plant and animal diversities in these areas. Overall, grazing has been found to also decrease plant and animal densities. Almost any type of disturbance opens up possible sites for exotic annual invasion. This invasion is increasing the fire frequency of the sagebrush-steppe habitat and converting shrublands into annual grasslands. Human presence and facilities can have an impact on raptors and bats, so any new development plans need to take these factors into account. The debate about effects of fragmentation and patchiness, many small or few large reserves, or island biogeography vs species/area relationships may be ongoing, but the fact remains that little

information is available and it is important that more research be conducted in this area. Management objectives need to take into account what resources are affected by a particular disturbance and if those effects are detrimental to these resources. Special consideration is needed for sagebrush obligate species if the goal is to preserve native communities.

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ANNOTATED BIBLIOGRAPHY OF STUDIES ON LAND USE DISTURBANCE^{1,2}

- 1 **Abdel-Magid, A. H., M. J. Trlica, and R. H. Hart.** 1987. Soil and vegetation responses to simulated trampling. *Journal of Range Management* 40:303-306.

This laboratory study assessed the plant material detached by simulated trampling and determined the effects on soil bulk density and infiltration rates. Soil bulk density increased under trampling, while infiltration rates decreased. Dead vegetation was removed more easily by hoof action than living vegetation. Biomass production aboveground was 7% greater under short-duration grazing.

- 2 **Abugov, R.** 1982. Species diversity and phasing of disturbance. *Ecology* 63:289-293.

Several studies have suggested that the diversity of a community is maximized at intermediate levels of disturbance. If there is no disturbance, only the competitively superior species can survive and dominate. Fugitive species can survive at high levels of disturbance. This study supports the idea that temporal patterning, in addition to rate of disturbance, may be an important factor in determining the effects of disturbance on species diversity.

A patch is "unphased" if its probability of being disturbed is independent of other patches, such as constant predation. If a patch is disturbed along with all other patches, it is considered "phased," for example, a storm or fire. Abugov used a Markovian projection matrix for his study. The results supported the intermediate disturbance hypothesis. At high disturbance

rates, fugitive species are dominant. At low disturbance rates, competitive species are dominant. This study suggests that the effects of increased phasing depend on the relative abundances of species and their sensitivities to changes in the disturbance rates due to phasing.

- 3 **Anderson, J. E. and G. M. Marlette.** ¹ 1986. Probabilities of seedling recruitment and the stability of crested wheatgrass stands. Pp. 97-105 in K. L. Johnson (ed), *Symposium Proceedings on Crested Wheatgrass: Its Values, Problems, and Myths*. Utah State University, Logan.

This study investigated the dispersal of native propagules into crested wheatgrass seedings and determined if competition from crested wheatgrass was inhibiting their colonization. The results showed that the seed bank was mostly dominated by crested wheatgrass with very few native propagules. Competition was not the main factor maintaining crested wheatgrass seedings. Adjacent native communities are not significant enough sources of seeds. If the management goal is to reestablish native vegetation, seeding with crested wheatgrass could slow down recovery or prevent it from happening.

- 4 **Anderson, J. E. and K. E. Holte.** ¹ 1981. Vegetation development over 25 years without grazing on sagebrush-dominated rangeland in southeastern Idaho. *Journal of Range Management* 34:25-29.

Long-term vegetation data was collected and used to compare trends for 1965-1975

¹Study conducted on INEEL.

²Study conducted in southern Idaho.

with data before 1965. Grazing had been excluded from the area since the 1950's. No disturbances such as fire or sagebrush removal treatments had been used since 1950. Big sagebrush cover increased by 54% from 1950 to 1975. Density of sagebrush did not increase, indicating the population of dominant shrubs had been stable during the 25-year period. Rabbitbrush cover and density also remained relatively stable. Because no seral replacement of rabbitbrush had taken place, shrub composition would likely not change much without a major disturbance. Perennial bunchgrass cover increased 20-fold during the 25-year period. This probably resulted from the availability of seeds increasing as the populations recovered. No evidence of seral replacement of grasses was found. This data tends to support the "relative stability/initial floristics" succession model more than the "classic" model of directional and predictable vegetation development into a climax community.

- 5 **Anderson, J. E. and R. Inouye.**¹ 1988. Long-term dynamics of vegetation in sagebrush steppe of southeastern Idaho. Idaho National Engineering Laboratory. 54 pp.

Anderson and Inouye described vegetation changes and invasion of cheatgrass over 35 years on ungrazed plots of the long-term vegetation transect at the INEEL. Shrub and perennial grass cover increased until 1975, after which their overall cover decreased significantly. Green rabbitbrush continually increased in cover. Shrub and perennial grass cover may significantly fluctuate even without a major disturbance. Density of perennial grasses and shrubs were not as affected by precipitation as perennial forbs. Species richness per plot increased, but remained relatively constant for the study area.

Cheatgrass increased in distribution until 1975. Occurrence of cheatgrass in 1985 decreased, supporting that its abundance may be contingent on precipitation patterns. Personal observation by Anderson suggests cheatgrass distribution is becoming more widespread than the data demonstrate. Increase in cheatgrass distribution could cause an increase in the probability of fires.

- 6 **Anderson, J. E. and R. Inouye.**¹ In press. Long-term vegetation dynamics in sagebrush steppe at the Idaho National Engineering and Environmental Laboratory. Environmental Science and Research Foundation ESRF-027.

This study examined changes in cover, density, and distribution of vegetation in relation to species richness, precipitation patterns, and the absence of major disturbances over a 45-year period. Permanent vegetation plots at the INEEL, protected from grazing since the 1950's, were used. Over the last 20 years, the number of plots in which cheatgrass (*Bromus tectorum*) occurred increased. Perennial grass cover on core plots varied almost 4-fold over the last 45 years, but increased from 0.3% in 1950 to 1.3-4.0% in recent samples. Shrub cover increased until 1975. After 1975, widespread die-off of *Artemisia tridentata* caused a decrease in overall shrub cover, although *Chrysothamnus visiciflorus* cover continued to increase. Precipitation patterns were positively correlated with shrub and perennial grass cover, with a probable delay in the response of vegetation.

Average species richness of the study area did not change significantly, however mean species richness per plot increased. The increase in richness per plot was likely due to small, isolated populations increasing in size and distribution. Heterogeneity in vegetative structure increased among plots and mean percent similarity of plots

decreased over the 45 years. These are, for the most part, the result of vegetation recovery from drought and extensive grazing. Anderson and Inouye were unable to find significant evidence of directional change among common shrub or perennial grass species composition. The only clear directional change was the increase in *C. viscidiflorus*.

Shrub and perennial grass cover were positively correlated with species richness. The magnitude of change in relative cover from year to year was negatively correlated with species richness. Cover tended to fluctuate less on plots with higher species richness. The greater the species richness, the higher the probability of a species being present that can excel in that year's predominate environmental conditions. Productivity on these sites should remain relatively constant. These results support the idea that higher species richness increases efficiency of using limited resources.

- 7 **Belnap, J.** 1994. Potential role of cryptobiotic soil crusts in semiarid rangelands. Pp. 179-185 in S. B. Monson and S. Kitchen (eds), Proceedings of the Symposium on Ecology, Management, and Restoration of Intermountain Annual Rangelands. USDA For. Serv. Gen. Tech. Rep. INT-GTR-313. 416 pp.

Cryptobiotic crusts are important in semiarid ecosystems. These cyanobacteria, mosses, and lichens help stabilize soil, reduce water runoff, improve nutrient cycling, and increase germination and establishment of some vascular plants. Cyanobacterial crust coverage and cohesion are damaged by trampling. Undisturbed sandy soils of the Colorado Plateau had cyanobacterial sheath material as deep as 10 cm below the surface. Disturbed areas that were heavily trampled had only a thin layer of cyanobacterial sheath. Trampling reduces soil stability, fertility, and moisture

retention. The rate of recovery depends on the type and extent of disturbance, temperature, moisture, and availability of inoculation material. Natural recovery estimates from disturbance range from a few years to 100 years.

- 8 **Belthoff, J. R. , L. R. Powers, and T. D. Reynolds.**¹ In press. Breeding birds at the Idaho National Engineering Laboratory, 1985-1991. Great Basin Naturalist.

Bird abundance and diversity was higher for routes near industrial facility complexes than for undisturbed remote routes. Species composition also differed between the two routes. Raptors tended to occur more on the remote routes, while facility routes supported more waterfowl and "human-associated" species. Human activity near major facility complexes affected the composition of avifauna compared to remote sites.

- 9 **Best, L. B.** 1972. First-year effects of sagebrush control on two sparrows. Journal of Wildlife Management 36:534-544.

This study examined the effects of chemical control of sagebrush using 2,4-D on Brewer's sparrows and vesper sparrows in central Montana. Of the sprayed plots, one plot was sprayed for total kill of sagebrush, one plot was sprayed for only partial kill of sagebrush, and one plot was sprayed for total kill of sagebrush in alternate strips. The 50% reduction of live sagebrush in the strip and partial kill areas had no noticeable effect on the number of breeding pairs of either sparrow. The total kill of sagebrush significantly reduced nesting pairs of Brewer's sparrow, but not the vesper sparrow. Partial kill of sagebrush did not sufficiently affect the nest habitat or food available to cause a population change in 1 year. However, total kill may have reduced nest cover or flora diversity with

possible effects on insect fauna. Vesper sparrows were not as affected by this reduction in cover due to less rigid requirements of nest cover than Brewer's sparrows. Grass probably provided enough cover to protect vesper sparrow nests.

Spraying sagebrush increased grass growth, which in turn, increased grass seed, a predominant food source. Spraying also reduced floral diversity which could negatively affect insect fauna. Because vesper sparrows consume more plant food versus animal foods during the summer than Brewer's sparrows, and sagebrush spraying increases plant food, spraying would likely be more beneficial to vesper sparrows.

- 10 Blaisdell, J. P.²** 1953. Ecological effects of planned burning of sagebrush-grass range on the upper Snake River Plains. USDA Tech. Bulletin No. 1075. 39 pp.

Blaisdell described the long-term effects (over 12 and 15-year periods) of planned burning and interpreted the effects on the vegetation and soil. All grasses were injured by fire but recovered within 3 years and had higher production rates than unburned areas. Prescribed burning can be beneficial to resprouting shrubs and rhizomatous grasses and forbs, but detrimental to nonsprouting shrubs, some forbs, and finer bunchgrasses. The grazing capacity of the burned sites were 40% and 100% greater than unburned sites. Organic matter, nitrogen, and soil moisture were significantly reduced in the upper soil surface on the heavily burned site.

- 11 Bosworth, W. R.¹** 1994. Characteristics of winter activity in *Plecotus townsendii* in southeastern Idaho. Unpublished M. S. Thesis. Idaho State University, Pocatello. 74 pp.

P. townsendii is a species of bat that is very susceptible to human disturbance,

especially during hibernation or during the formation of maternity colonies. Human presence in the cave can produce premature arousal of bats at the end of a torpor bout. The specific cause for the premature arousal is not known. Noise from moving around in the cave, light from flashlights, or microclimate change could be the cause of arousal. Even low levels of disturbance could have a negative impact on the bat's winter energy budget. Human disturbance by handling increased bat activity for at least 48 hours after the disturbance. Bosworth recommends surveillance when the least number of bats are near the end of a torpor bout.

- 12 Brown, J. C., R. A. Evans, and J. A. Young.** 1985. Effects of sagebrush control methods and seeding on runoff and erosion. Journal of Range Management 38:195-199.

This study investigated the effects on infiltration rates, surface runoff and soil erosion of different sagebrush control methods (plowing, spraying, and burning) and the changes within 2 years after treatment in hydrologic condition following crested wheatgrass seeding in central Nevada. Immediately following all three of the sagebrush control methods, terminal infiltration rates were reduced and sediment yields increased. Plowing and seeding caused the greatest impact. Burning and seeding had some impact. Spraying and seeding caused minimal impact. After a 2-year period, all treatments showed some recovery. Burning/seeding and spraying/seeding had greater impacts on runoff initiation frequency than did plowing/seeding. Overall, plowing/seeding improved rangeland. Burning/seeding was detrimental to rangeland.

- 13 Bunting, S. C.** 1985. Fire in sagebrush-grass ecosystems: successional changes. Pp. 7-11 in K. Sanders and J. Durham (eds),

Rangeland Fire Effects; A Symposium.
Bureau of Land Management. Boise, Idaho.
124 pp.

After a fire, the resources that were used by sagebrush (*Artemisia*) are utilized by the herbaceous plants present at the time of the fire. Total production of a burned sagebrush-grass habitat does not return to preburn levels until sagebrush is reestablished. Biomass production of perennial grasses increases after a fire because of reduced competition with sagebrush, but it could take more than 2 years to return to preburn levels. After recovery, grass production in the burned area could be over 100% higher than in unburned areas. This could last for over 20 years.

Annuals will quickly invade space released by disturbance if there is not abundant perennial herbaceous vegetation, and will increase on these sites for 2-5 years until sagebrush reestablishes. Shrub production after a fire is low unless there is a high amount of resprouting shrubs, such as rabbitbrush and spineless horsebrush on the site prior to the fire. Most sagebrush do not resprout after a fire, dramatically reducing shrub cover. High fire frequency will remove the seeds of nonsprouting plants and reduce productivity for many years. Total grass cover is reduced by fire. Perennial forbs generally respond to fire with increased productivity, but not increased density. They reproduce slowly until perennial grasses and shrubs dominate the site. Many results of a fire depend on the habitat type, conditions of the site, and severity of the fire.

- 14 Burgess, R. L. 1988. Community organization: effects of landscape fragmentation. *Canadian Journal of Botany* 66:2687-2690.

Most terrestrial ecosystems are fragments of what were once extensive communities. The theory of island biogeography was developed in the 1960's by MacArthur and Wilson. This theory suggested that the number of species present on an island was a function of island size, age, and distance from a source of replacement species. Terrestrial islands are very different from true islands. Terrestrial fragments have a more permeable boundary than saltwater around an island. These fragments also tend to support less species than islands because terrestrial fragments are usually quite small. Evidence from terrestrial studies support species/area curves (larger areas support more species than smaller ones) rather than island biogeography. Dispersal, pollination rates, and effectiveness of genetic recombination are all areas that need to be addressed to understand the effects of fragmentation.

- 15 Burkey, T. V. 1988. Extinction in nature reserves: the effect of fragmentation and the importance of migration between reserve fragments. *Oikos* 55:75-81.

Burkey developed a simulation model (with density dependent reproduction and survival) to determine if species are more prone to random extinction in continuous or patchy reserves. He also examined the function of fragmentation and the probability of extinction. This model only took into account stochastic birth, death, and migration. Fragmented reserves, according to Burkey's model, are more likely to become extinct than continuous reserves. Fragmentation would have no effect on a population without density dependence. Density dependent populations experience random fluctuations in size and the risk of extinction rises with the degree of fragmentation. Migration can slow extinction, but as fragmentation increases,

higher dispersal rates are needed to maximize survival.

- 16 **Castrale, J. S.** 1982. Effects of two sagebrush control methods on nongame birds. *Journal of Wildlife Management* 46:945-952.

Castrale investigated bird distribution and vegetation composition on three sites on the Wasatch National Forest in Utah. Sagebrush was the dominant form of vegetation with Utah juniper occurring at higher elevations. One site was plowed and seeded with grasses in 1963. One site had been chained and seeded to grasses in spring 1976. The other site was prescribed-burned in August 1976 after having been seeded beforehand. The plowed site had the least grass cover with high shrub cover. The burned site had the greatest grass cover with the least shrub cover. Bird species responses to sagebrush control varied and can be explained by the differences in requirements of shrubs for nesting.

Burning caused the most long-lasting changes in sagebrush habitat because shrubs were killed by fire and ground litter was reduced. Chaining was not as damaging to birds dependent on sagebrush because more rapid regeneration may occur. Sprayed sagebrush can still offer cover and acceptable nest sites for shrub dependent birds for a limited time. Management objectives should emphasize preserving native bird communities. Brewer's sparrows and sage thrashers should be paid close attention because they are sagebrush obligates. Patches of suitable habitat could be achieved by chaining, burning, or spraying in strips 100 m wide instead of large blocks.

- 17 **Connelly, J. W., W. J. Arthur, and O. D. Markham.**¹ 1981. Sage grouse leks on recently disturbed sites. *Journal of Range Management* 34:153-154.

Out of 51 located sage grouse leks on and near the INEEL, three occurred on recently disturbed sites. One occurred on a burned area. The remaining two occurred on and in gravel pits. These leks were located in a portion of INEEL that appeared to have fewer natural clearings. This suggests that sage grouse will use man-made clearings if no natural clearings are available. This could be used as a management tool where lek areas are destroyed by roads, mining, or other disturbances.

- 18 **Doerr, T. B., E. F. Redente, and F. B. Reeves.** 1984. Effects of soil disturbance on plant succession and levels of mycorrhizal fungi in a sagebrush-grassland community. *Journal of Range Management* 37:135-139.

This study examined the effects of weather and four levels of soil disturbance on mycorrhizal fungi and plant succession. Annual vegetation production was more sensitive to weather fluctuation than perennial grasses. There was a positive correlation between perennial grass cover and production and mycorrhizal inoculum potential (MIP). Annual forb cover and production were negatively correlated with MIP. Perennial grasses were negatively correlated with disturbance, while annuals were positively correlated with the level of soil disturbance. Levels of MIP seem to be good general indicators of plant succession after soil disturbance. Other modifying factors prevent it from being a precise predictor.

- 19 **Fielding, D. J. and M. A. Brusven.**² 1992. Food and habitat preferences of *Melanoplus sanguinipes* and *Aulocara elliotti* (Orthoptera: Acrididae) on disturbed rangeland in southern Idaho. *Journal of Economic Entomology* 85:783-788.

This study examined how the planting of annual grasslands with crested wheatgrass affected the food resources and abundance of the grasshoppers *Melanoplus sanguinipes* and *Aulocara ellioti*. Food preferences of the grasshoppers were consistent with habitat preferences. *M. sanguinipes* density was positively correlated with forbs and annual grasses. Density of *A. ellioti* was positively correlated with crested wheatgrass and percent of bareground. There was a negative correlation between both species and sagebrush biomass. Rehabilitation of annual grasslands with crested wheatgrass could change the species composition of grasshoppers.

- 20 Fielding, D. J. and M. A. Brusven.² 1994.** Grasshopper community responses to shrub loss, annual grasslands, and crested wheatgrass seedings: management implications. Pp. 162-166 in S. B. Monson and S. Kitchen (eds), Proceedings of the Symposium on Ecology, Management, and Restoration of Intermountain Annual Rangelands. USDA For. Serv. Gen. Tech. Rep. INT-GTR-313. 416 pp.

Increased fire frequency has promoted shrub loss and invasion of cheatgrass. This study identified patterns of grasshopper species composition among vegetation types, and determined if the conversion of native habitat to annual grasslands had an affect on the abundance of the major grasshopper pest species. *Melanoplus sanguinipes* is a pest species and migrates through a wide variety of crops. *Aulocara ellioti* feeds only on grasses and is not usually found in cultivated crops. Vegetation types with sagebrush had the lowest density and highest diversity of grasshoppers. Annual grasslands had high density and low diversity of grasshoppers. These grasslands were dominated by *M. sanguinipes*. Crested wheatgrass seedings were dominated by *A. ellioti*. Habitats with

shrub cover and an understory of perennial grasses supported the lowest densities of grasshoppers with a lower proportion of pest species. Outbreaks would be less common, less intense, and less extensive in areas with shrub cover than in cheatgrass-dominated habitats that frequently burn.

- 21 Fischer, R. A., K. P. Reese, and J. W. Connelly.² 1996.** An investigation on fire effects within xeric sage grouse brood habitat. Journal of Range Management 49:194-198.

This study investigated the impacts of fire on sage grouse foods, particularly insects. Wyoming big sagebrush communities support diverse insect fauna that provides an important food source for many vertebrates. This food source, in addition to forbs, is very important in sage grouse chick diets. Treatments to sagebrush that reduce the abundance and diversity of forbs are destructive to sage grouse brood habitat. The prescribed burn created a patchy mosaic of sagebrush with open areas of forbs and grasses. Fire had a negative impact on insects important in sage grouse diets for several years. Short-term effects of prescribed burns in xeric environments did not better brood-rearing habitat, and were possibly damaging to Hymenoptera which are important to sage grouse diets.

- 22 Fleischer, T. L. 1994.** Ecological costs of livestock grazing in western North America. Conservation Biology 8:629-644.

Three basic attributes of ecosystems have been affected by grazing: change in species composition of communities; disruption of ecosystem functioning; and alteration of ecosystem structure. A decrease in density and biomass of species, species richness, and the altering of community organization change the species composition of communities. Grazing has a negative effect

on all vertebrate classes. Density and diversity of small mammals, birds, raptors, lizards, snakes, and fish have all been decreased in grazed areas. The effect of grazing on insect populations is not clear. Factors that determine the effects on insect populations include the length of grazing, plant community structure, and seasonal differences in the plant and insect communities. Community organization is changed by the elimination of species and the invasion of exotic species. Grazing opens up habitat for species such as cheatgrass and reduces competition from native vegetation.

Grazing damages microbiotic crusts and decreases crust cover and species richness. Human footprints, vehicle tracks, and grazing can easily stop nitrogen fixation by microbiotic crusts. Long-term grazing can alter ecological succession by maintaining early seral vegetation. Grazing disrupts ecosystem functioning by interfering with nutrient cycling and ecological succession.

Vegetation stratification can be changed by grazing. Grazing also removes soil litter that may cause delayed plant phenology, affecting pollinators. Increases in soil erosion, soil compaction, and deterioration of soil stability and porosity are also results of grazing. This increases surface runoff and decreases water infiltration. Grazing is also detrimental to riparian areas.

- 23 Gates, R. J.¹** 1983. Sage grouse, lagomorph, and pronghorn use of a sagebrush grassland burn site on the INEL. Unpublished M. S. Thesis. Montana State University, Bozeman. 135 p.

There was no difference in use of the burn and control sites by sage grouse, pygmy rabbit, black-tailed jack rabbit, and pronghorn prior to treatment. One year later, relative use by sage grouse and jack rabbit of the burned area was greater than their use of the control site. Pronghorn use

was lower for the burned area. Pygmy rabbit use did not differ. Sage grouse and pronghorn concentrated near irrigated croplands and lawns of INEEL facilities during the summer because of damage to forbs in sagebrush habitats. Removal of sagebrush by the fire could have had a negative impact on sage grouse and pronghorn, but the burn area was smaller than their winter range sizes and not all sagebrush was removed. Since pygmy rabbits use sagebrush for food and cover, they could be negatively affected by fire. Jack rabbit use of the burn area could increase because of increased production of grasses and forbs.

- 24 Goff, B. F., G. C. Bent, and G. E. Hart.¹** 1993. Erosion response of a disturbed sagebrush steppe hillslope. *Journal of Environmental Quality* 22:698-709.

Shallow land burial practices dramatically disturb surrounding vegetation cover. This leads to increased runoff and erosion. This study examined erosion response of a sagebrush hillslope with natural, bare, and clipped cover treatments. Soil loss was generally 100-1000 times greater on the bare treatment than on the natural or clipped treatments. As simulated slope length increased, the soil loss from the bare treatment increased almost linearly. Rill erosion on the undisturbed and disturbed areas of the hillslope was insignificant.

- 25 Gurr, J. E. and M. Wicklow-Howard.²** 1994. VA mycorrhizal status of burned and unburned sagebrush habitat. Pp. 132-135 in S. B. Monson and S. Kitchen (eds), *Proceedings of the Symposium on Ecology, Management, and Restoration of Intermountain Annual Rangelands*. USDA For. Serv. Gen. Tech. Rep. INT-GTR-313. 416 pp.

Some studies have found that fire lowers the mycorrhizal inoculum potential (MIP) of the soil. Sagebrush is an obligate vesicular-arbuscular mycorrhizal plant. Therefore, after a fire it could take longer for sagebrush to reestablish. This study investigated the relationship of vesicular-arbuscular mycorrhizae (VAM) and Wyoming big sagebrush on burned and unburned soils. Sagebrush seedlings were inoculated with VAM and planted on burned and unburned sites. These inoculated seedlings did not have increased arbuscular or vesicular colonization, but did have increased hyphal colonization. Seedlings in the burned and unburned cheatgrass sites did not survive as well as the seedlings on the burned sagebrush site. MIP was not significantly lower after burning, but VAM infection of seedlings was low. VAM infection of wild sagebrush in the unburned site was significantly higher than on the burned site.

- 26 **Hansen, R. W.¹** 1994. Raptor use of the Idaho National Engineering Laboratory. Unpublished M. S. Thesis. South Dakota State University, Brookings. 141 pp.

Raptors did not appear to be affected by site facilities. There was a high frequency of raptors within 10 km of site facilities. This was probably due to the increased power pole densities in these areas, as power poles were often used as perches. Ferruginous hawks avoided human development when choosing nest sites. Early in the nesting cycle, these raptors tended to abandon their nests when exposed to increased human activity. Nest abandonment from increased human activity was the cause of 7 out of 13 nest failures.

- 27 **Harniss, R. O.¹** 1968. Vegetation changes following livestock exclusion on the National Reactor Testing station, southeastern Idaho. Unpublished M.S. Thesis. Utah State University, Logan.

76 pp.

This study examined vegetation changes after livestock exclusion on plots at the National Reactor Testing station, presently INEEL). Most plots were located on the long-term vegetation transects. Shrub cover and precipitation patterns tended to be similar. However, total grass cover did not correspond with precipitation patterns. Harniss thought this was a result of the presence of only a small quantity of grass on most plots. Grass cover increased during the years of the study, but the amount of increase was not statistically significant. Total grass cover was relatively small compared to shrub cover.

Harniss concluded most changes in vegetation could be attributed to precipitation patterns rather than livestock exclusion. Revegetation is extremely slow if the management goal is to increase grass. Long-term protection of this type of range would likely prevent further damage to its resources.

- 28 **Harniss, R. O. and R. B. Murray.²** 1973. 30 Years of vegetal change following burning of sagebrush-grass range. *Journal of Range Management* 26:322-325.

Harniss and Murray investigated vegetation changes 30 years after the burning of 640 acres of sagebrush-grass range in southern Idaho. They compared the results of Blaisdell's (1953) study on the burn in 1948 to their results of the same burn in 1966. Most of the important species of shrubs, grasses, and forbs decreased in yield from 1948 to 1966 while big sagebrush regained its dominance after the burn. The sagebrush was able to reinvade the dominant grass stand.

- 29 **Hedlund, J. D. and W. H. Rickard.** 1981. Wildfire and the short-term response of

small mammals inhabiting a sagebrush-bunchgrass community. *Murrelet* 62:10-14.

Hedlund and Rickard examined the response of Townsend's ground squirrels and Great Basin pocket mice populations to a summer wildfire in an *Artemisia/Agropyron* plant community in southeastern Washington. Fire did not damage small mammals that could escape to belowground burrows. Small mammal populations increased one year after the fire. It was suggested that the increase was due to precipitation rather than fire.

- 30 **Hobbs, R. J. and L. F. Huenneke.** 1992. Disturbance, diversity, and invasion: implications for conservation. *Conservation Biology* 6:324-337.

The "intermediate disturbance hypothesis" states that species richness will be highest at intermediate frequencies and intensities of disturbance. Disturbance in plant communities, however, can promote the invasion of exotic and weedy plant species. Therefore, conservation management can be difficult. Disturbance frequency and the characteristics of component species have an effect on the response of the community to disturbance. Fire increases light availability by removing plant canopy and increases nutrient availability for a short period of time. Fire, grazing, soil disturbances, and trampling can promote invasion of non-native, weedy species. Nutrient input, such as fertilizer, can be damaging to low-fertility sites by decreasing species richness. Grasses tend to dominate sites that have been nutrient enriched. Adding nutrients to nutrient-poor soils is a major disturbance and can also enhance non-native species invasion.

Fragmentation can alter the landscape matrix. Fragmentation influences edge effects and transfer of materials among adjacent patches. It will also lead to an

increase in edge species, which could be due to increased non-native, weedy species. Multiple disturbances are synergistic. Managing disturbance can be difficult. One technique may favor one species while hurting another. Hobbs and Huenneke recommend using a diversity of management strategies to favor different species in different parts of the habitat.

- 31 **Holechek, J.** 1980. Livestock grazing impacts on rangeland ecosystems. *Journal of Soil and Water Conservation* 35:162-164.

Overgrazing by livestock reduces palatable plants and vegetative cover. This decline in vegetative cover leaves soil unprotected, which increases erosion and sediment yields. Infiltration rates are reduced because of soil compaction. The response of wildlife to overgrazing is species specific, but usually the effect is negative. Ground-nesting birds are seriously affected by overgrazing because it reduces cover and increases predation. When grazing is controlled, it can be beneficial (e.g., loosening soil surface in dry years, removing excessive dead vegetation, reducing fire, insects, and rodents). There are several areas in range management and grazing that need more research.

- 32 **Holthuijzen, A. M. A.²** 1989. Behavior and productivity of nesting prairie falcons in relation to construction activities at Swan Falls Dam. Final Report. Idaho Power Company, Boise, Idaho. 77 pp.

This study examined the effects of construction and recreational activities at the Swan Falls Dam in southern Idaho on nesting prairie falcons. Relationships between changes in prairie falcon behavior and construction and recreation activities were not consistent, but were more associated with behavioral changes over the nesting season. Prairie falcon behavior

seemed to fluctuate according to biotic factors more than human activity. Prey delivery rates, copulation frequencies, productivity, and occupancy of nesting territories were not affected by human activities. Blasting had no significant effect on prairie falcon productivity, behavior, or occupancy of nesting territories. Prey population density seemed to be a more important factor than human activities in determining prairie falcon populations. If human activities, over a long period of time, interfere with feeding, there may be an increase in chick mortality. Overall, recreation and construction activities had no noticeable negative effects on prairie falcons.

- 33 **Hosten, P. E. and N. E. West.** 1994. Cheatgrass dynamics following wildfire on a sagebrush semidesert site in central Utah. Pp. 56-62 in S. B. Monson and S. Kitchen (eds), Proceedings of the Symposium on Ecology, Management, and Restoration of Intermountain Annual Rangelands. USDA For. Serv. Gen. Tech. Rep. INT-GTR-313. 416 pp.

This study examined community dynamics within burned/ungrazed, burned/grazed, and unburned/grazed treatments with 11 years of data from a fire in central Utah. All burned areas had a decrease in sagebrush cover and an increase in native perennial bunchgrasses. During the first 2 years after the fire, cheatgrass cover increased. The following 2 years had a sharp decrease in cheatgrass cover. For 3 years thereafter, cover had year to year fluctuations. During the last years of the study, cheatgrass cover was negligible. Cattle grazing did not have an impact on vegetation after a burn.

- 34 **Howard, R. P. and M. L. Wolfe.**² 1976. Range improvement practices and ferruginous hawks. *Journal of Range*

Management 29:33-37.

Habitat requirements and breeding biology of ferruginous hawks were studied in northern Utah and southeastern Idaho. The conversion of sagebrush-steppe to grasslands could have a negative effect on these hawks. This study did not specifically examine the effects of land management activities on ferruginous hawks, but the authors made some inferences. Habitat conversion to monotypic stands may reduce ferruginous hawk densities and reproductive success due to increased disturbance to nests, loss of nesting sites, and reduction in prey populations.

- 35 **Humphrey, L. D.**² 1984. Patterns and mechanisms of plant succession after fire on *Artemisia*-grass sites in southeastern Idaho. *Vegetatio* 57:91-101.

Perennial forbs and grasses were most abundant for a few years after the fire. Sprouting shrubs then became dominant a few years later. Nonsprouting shrubs and perennials, which have to generate from seeds dispersed to the area, became co-dominant in later years. At this time, some forbs and grasses were reduced. No trend of change in alpha diversity of the years was indicated by the Shannon-Weaver and Simpson diversity indices or species richness. This was a result of many species being present in early and later seral stages and as some species were becoming established, others were being eliminated. Succession patterns could have primarily been due to species traits.

- 36 **Johnson, M. K.**¹ 1982. Response of small mammals to livestock grazing in southcentral Idaho. *Journal of Range Management* 35:51-53.

This study compared small mammal abundances from 25 sites, grazed (by cattle

and sheep) and ungrazed, on the INEEL. There was no significant difference between plant composition of areas grazed by cattle, grazed by sheep, or ungrazed. The number of burrows did not significantly differ between grazed and ungrazed areas. Livestock grazing did not appear to limit important small mammal distribution. The variation in abundance of small mammals is highly site specific and is not affected by grazing.

- 37 Klebenow, D. A.² 1970. Sage grouse versus sagebrush control in Idaho. *Journal of Range Management* 23:396-400.

Evidence from studies indicate large areas treated with herbicide show a decrease in sage grouse numbers. Habitat where only portions of sagebrush were sprayed did not result in a decrease in grouse. This study examined the effects of sagebrush spraying and burning on sage grouse. Nesting stopped on an area sprayed in 1964 and almost completely stopped on other sprayed areas. The decrease of grouse in sprayed areas was most likely due to the lack of shrub cover and food. Sprayed areas recovered faster for brooding than for nesting. Klebenow believes it would take at least 10 years for a sprayed area to recover its original carrying capacity. This length of time would depend on the degree of original kill, the amount of remaining shrubs, and the speed of sagebrush recovery. Results from the burning treatment were inconclusive.

- 38 Klebenow, D. A. 1985. Big game response to fire in sagebrush-grass rangelands. Pp. 53-57 in K. Sanders and J. Durham (eds), *Rangeland Fire Effects; A Symposium*. Bureau of Land Management. Boise, ID. 124 pp.

Fire does have an effect on game animals. Fire may improve forage for mule

deer and mountain sheep by increasing grass production. The lack of fire in Nevada and California has resulted in an increase of shrubs, decreasing forage for mountain sheep. Fire can also be used to improve pronghorn habitat.

In sagebrush-grassland habitat, the role of fire in mule deer habitat is less clear. Fire in summer ranges could remove critical cover for mule deer, negatively affecting the population. In winter ranges, sagebrush and antelope bitterbrush are the only hiding and thermal cover available. These are usually removed by fire. Deer avoid large burned areas in the winter, but may forage on burned areas in early spring or late winter.

The long-term effects of fire can be beneficial. Fires maintain the diversity of vegetation, and rejuvenate old bitterbrush-sagebrush stands, increasing winter forage. Some effects are negative. Fire may favor establishment of exotic annuals species, such as cheatgrass, consequently increasing fire frequency and ultimately replacing perennial shrublands with grasslands dominated by annual species.

- 39 Knick, S. T. and J. T. Rotenberry.² 1995. Landscape characteristics of fragmented shrubsteppe habitats and breeding passerine birds. *Conservation Biology* 9:1059-1071.

This study tested the null hypothesis that the distribution of breeding passerine birds was independent of local habitat and large-scale landscape characteristics in shrubsteppe habitat. The authors found cover values of shrub species were not as important as landscape features in predicting the presence of sage sparrows. Shrub cover and patch size were important in predicting the presence of Brewer's sparrow. As both shrub cover and patch size values increased, the probability of occupancy was greater. Sage thrasher occupancy was positively related to sagebrush cover and similarity of the

habitat. Landscape features did not affect the probability of occupancy by horned larks or western meadowlarks. Horned lark habitat selection decreased with sagebrush cover. Horned larks and western meadowlarks were not sensitive to landscape characteristics at the scale measured in this study. These species were more influenced by grasslands or lack of shrub cover.

Sage and Brewer's sparrows and sage thrashers, sensitive to landscape characteristics, had a higher probability of returning to sites that had high shrub cover, low disturbance, large patch size, and high similarity within the site. Habitat disturbance and fragmentation were also associated with probability of occurrence between years. Fragmentation of shrubsteppe habitats and human-caused disturbance can significantly affect sagebrush obligate species, such as sage and Brewer's sparrows and sage thrashers.

- 40 Koehler, D. K. and S. H. Anderson.¹**
1991. Habitat use and food selection of small mammals near a sagebrush/crested wheatgrass interface in southeastern Idaho. *Great Basin Naturalist* 51:249-255.

This study evaluated the habitat use and food selection of small mammals near a sagebrush/crested wheatgrass interface on the Subsurface Disposal Area (SDA) at the INEEL. Small mammals frequently utilized the crested wheatgrass habitat. Slightly more small mammals occurred in native sagebrush vegetation. Crested wheatgrass stands were the least used out of native, crested wheatgrass, and disturbed habitats. However, over 30% of the total small mammals captured were found in crested wheatgrass seedings. Montane voles, Ord's kangaroo rats, and Townsend's ground squirrels, uncommon in the native vegetation, were early colonizers of the disturbed area. Montane voles are more

dependent on the crested wheatgrass habitat than any other species, because crested wheatgrass is their dominant food source. Crested wheatgrass was also used by kangaroo rats for seeds. Deer mice, whose diet reflects food availability, also utilized crested wheatgrass as a food source. For Townsend's ground squirrels, crested wheatgrass was the most heavily used food item. The SDA and presence of crested wheatgrass influenced the species of small mammals and their densities.

- 41 Marlette, G. M. and J. E. Anderson.¹**
1986. Seed banks and propagule dispersal in crested-wheatgrass stands. *Journal of Applied Ecology* 23:161-175.

The authors examined the seed banks of crested wheatgrass stands and adjacent native sagebrush vegetation and dispersal of wind-dispersed species into these stands. Dispersal of propagules into crested wheatgrass stands was very limited. The seed banks in these stands had little diversity and were dominated by crested wheatgrass propagules. Sagebrush was co-dominant in the seed banks in areas where natives were becoming reestablished. These results indicate that dispersal from adjacent native communities into crested wheatgrass stands will not likely recolonize the stands. In addition, planting rangeland with crested wheatgrass may slow or prevent recovery to a native diverse community.

- 42 McAdoo, J. K., W. S. Longland, and R. A. Evans.** 1989. Nongame bird community responses to sagebrush invasion of crested wheatgrass seedings. *Journal of Wildlife Management* 53:494-502.

This study investigated bird community responses to shrub- and grass-dominated communities in three central Nevada valleys. Shrub-nesting birds were positively related to the amount of sagebrush. Grass-

nesting species were negatively related to shrub cover. Sagebrush-invaded crested wheatgrass had a higher bird species richness than monoculture crested wheatgrass or unconverted sagebrush. Sagebrush-invaded seedlings were suitable habitat for both types of species. Shrub-nesting species were displaced and grass-nesting species were favored following the conversion to crested wheatgrass. As succession continued and sagebrush invaded, shrub-nesting bird species were restored.

- 43 Moloney, K. A. and S. A. Levin.** 1996. The effects of disturbance architecture on landscape-level population dynamics. *Ecology* 77:375-394.

Moloney and Levin used a simulation model (JASPER) of a serpentine grassland to examine interactions between species life history traits and spatial and temporal structures controlling their distribution. They varied disturbance rate, size and temporal and spatial autocorrelation. The impact of disturbance depended on the species' life history and the spatial and temporal structure of the disturbance regime. A change in temporal autocorrelation structure had the biggest impact on species abundance after disturbance rate. Intermediate levels of disturbance resulted in the highest species richness.

- 44 Parmenter, R. R. and J. A. MacMahon.** 1983. Factors determining the abundance and distribution of rodents in a shrub-steppe ecosystem: the role of shrubs. *Oecologia* 59:145-156.

This study investigated the relative importance of food (leaves, seed, arthropods) and cover provided by shrubs to rodents in a shrub-steppe ecosystem in southwestern Wyoming. Deer mice, Great

Basin pocket mice, northern grasshopper mice, and Uinta ground squirrels were not affected by the removal of shrubs. No changes in their population sizes, home range sizes, sex ratios, or age structure were found. Montane voles increased after shrub removal. Least chipmunks emigrated from plots with shrub removal to adjacent plots with shrubs. Shrub removal did not change major food resources used by the rodents. Therefore, any changes in rodent populations would be the result of the loss of food or cover provided by sagebrush. Sagebrush removal probably affected diurnal rodents more than nocturnal rodents because of increased exposure to direct solar radiation. This may have affected heat loading and the amount of time spent above ground by diurnal rodents. Long-term rodent distribution may be indirectly affected by shrubs. Herbaceous vegetation, a major food source for rodents can be affected by shrub removal. Shrubs provide litter accumulation for seed germination, shading, nutrients, higher soil moisture, and microhabitats for arthropods.

- 45 Petersen, K. L. and L. B. Best.¹** 1987. Effects of prescribed burning on nongame birds in a sagebrush community. *Wildlife Society Bulletin* 15:317-329.

This study investigated the effect of a prescribed burn on nongame birds in southeastern Idaho sagebrush range. As a result of the burn, sagebrush coverage decreased, and coverage of forbs and bare ground increased. The burn (45% complete) resulted in a mosaic of habitats that tended to support more species than control plots. No species present before burning was eliminated by fire. Two new species were attracted to the burned areas. Fire had no significant negative effects on the two dominant species' breeding biology. If the burn had been more complete the avian community composition may have

been altered. Burned plots consistently supported one more bird species than unburned control plots. Total bird densities on the burned plots were greater than those on unburned plots. Incomplete burns are least damaging to nongame bird populations and the breeding biology of sage and Brewer's sparrows. Petersen and Best recommend mosaic-pattern, narrow-strip, or small block burns and monitoring of controls and treated sites over a long period of time.

- 46 Quinn, J. F. and S. P. Harrison. 1988. Effects of habitat fragmentation and isolation on species richness: evidence from biogeographic patterns. *Oecologia* 75:132-140.

This study examined the effects of size versus number of islands on species richness within archipelagoes. Analysis of 30 data sets collected from the literature indicated species richness was greater on a collection of small islands than on fewer larger islands. Possible causes include habitat diversity, population dynamics, and historical effects. A collection of small isolated areas contain a wider range of habitat than fewer large ones. Colonization and extinction dynamics of smaller isolates support more species. Conservation strategies should include increasing the number of reserves.

- 47 Ratzlaff, T. D. and J. E. Anderson.² 1995. Vegetal recovery following wildfire in seeded and unseeded sagebrush steppe. *Journal of Range Management* 48:386-391.

Ratzlaff and Anderson compared vegetation development in seeded areas and unseeded controls during two growing seasons following a fire in a sagebrush/grass/juniper community near Pocatello, Idaho. They found seeding the burn was unnecessary and may have slowed postfire recovery of vegetation. Unseeded

areas were homogeneously vegetated. Sparsely vegetated, disturbed patches in the seeded areas provided favorable habitat for cheatgrass and other annual species establishment. Rangeland drilling resulted in reduced vegetative cover and plant density and increased bare ground. The seeding efforts obstructed postfire recovery of vegetation and possibly increased erosion by increasing the area of bare soil.

- 48 Ream, C. H. 1981. The effects of fire and other disturbances on small mammals and their predators: an annotated bibliography. USDA For. Serv. Gen. Tech. Rep. INT-106. 55 pp.

Any disturbance that removes the dominant vegetation from a habitat increases temperature ranges and air movements at ground level. The amount of precipitation that reaches the ground, dew, evaporation, and transpiration rates are also changed by major disturbance. The long-term response to fire is increased densities of small mammals due to the surge in plant growth and seed-producing plan.

Shrew (*Sorex* spp.): Are insectivores and depend less on vegetation. Usually require a mat of ground vegetation. Temporarily vacate areas where ground vegetation is removed and return when the ground vegetation recovers.

Rabbits (*Sylvilagus* spp.): Usually associated with shrubs. Habitat where fire has removed shrubs is unsuitable. Rabbits will not return until cover is restored.

Ground Squirrels (*Spermophilus* spp.): Prefer open habitat and feed on the plant species that grow there. Disturbances that remove cover improve habitat for ground squirrels.

Pocket Gophers (*Thomomys* spp.): Disturbances that remove cover and increase herbaceous vegetation improve gopher habitat. Grazing also improves their habitat.

Deer Mice (*Peromyscus maniculatus*):

These are the most abundant small mammals in seriously disturbed areas. This is due to their food habits, nocturnal habits, avoidance of predators, and lack of competition.

- 49 Reynolds, T. D.¹ 1979. Response of reptile populations to different land management practices on the Idaho National Engineering Laboratory Site. Great Basin Naturalist 39:255-262.

Plant diversity of sagebrush habitat was significantly reduced by sheep grazing. This diversity was further reduced by planting of crested wheatgrass. However, invertebrate fauna relative density was increased in crested wheatgrass plantings, but lizard populations were below densities found in the sagebrush habitats. Ants, primary prey items for lizards, were found in equal abundance in all of the four habitats studied. The altering of sagebrush habitat to crested wheatgrass resulted in the decrease of populations of the short-horned and sagebrush lizards. Grazing did not significantly affect the lizard populations.

- 50 Reynolds, T. D.¹ 1980. Effects of some different land management practices on small mammal populations. Journal of Mammalogy 61:558-561.

This study compared the relative densities and species diversities of small mammals in two areas dominated by sagebrush and two areas planted with crested wheatgrass. One area of each vegetation type was grazed. Sagebrush habitat supported larger densities of deer mice, least chipmunks, and grasshopper mice than crested wheatgrass planting. Grasshopper mice population levels were lower on grazed areas. All species' abundances, except the deer mouse, were reduced on the grazed sagebrush habitat. This decreased the species diversity in this

area. The only small mammal to increase in numbers in crested wheatgrass plantings was the western harvest mouse, all other species decreased; reducing species diversity. Grazing crested wheatgrass habitat reduced the relative density of small mammals. The planting of crested wheatgrass and sheep grazing in sagebrush habitat changed the distribution of small mammal species. The effects of both crested wheatgrass and grazing were damaging to small mammal populations.

- 51 Reynolds, T. D. and C. H. Trost.¹ 1979. The effect of crested wheatgrass plantings on wildlife on the Idaho National Engineering Laboratory Site. Pp. 665-666 in G. A. Swanson (technical coordinator), The Mitigation Symposium: A National Workshop on Mitigating Losses of Fish and Wildlife Habitats. USDA For. Ser. Gen. Tech. Rep. RM-65. 684 pp.

Changing native sagebrush rangeland to a crested wheatgrass monoculture results in a reduction of plant, nesting bird, and large mammal species diversity. In crested wheatgrass areas, relative density of the groups of vertebrates were significantly lower implying these habitats are inferior to native sagebrush habitat.

- 52 Reynolds, T. D. and C. H. Trost.¹ 1980. The response of native vertebrate populations to crested wheatgrass planting and grazing by sheep. Journal of Range Management 33:122-125.

This study examined the responses of native vertebrate populations to different land use practices on the INEEL. Plant species diversity was significantly decreased by 2/3 from grazing and crested wheatgrass planting. However, relative density and diversity of large mammals, lizards, and nesting birds were not affected by grazing and crested wheatgrass planting. Ant

mounds were equally as common in grazed and ungrazed habitats. Reduction of forbs and grasses (rodent forage) was responsible for the decreased diversity and density of small mammals in the grazed sage area.

Both grazed and ungrazed crested wheatgrass plantings had fewer nesting bird species and a lower density of birds, mammals, and reptiles than did native sagebrush habitats. Crested wheatgrass plantings had a larger impact on vertebrate populations than did sheep grazing. Physical disturbances and vegetation changes caused by different land use practices have an effect on vertebrate populations.

- 53 Reynolds, T. D. and C. H. Trost.¹ 1981.** Grazing, crested wheatgrass, and bird populations in southeastern Idaho. *Northwest Science* 55:225-234.

This study compared bird species diversity and relative density in four areas of different land management practices. Sheep-grazed sagebrush habitat had a lowered plant species density, but the bird species density and diversity remained unchanged. Areas of crested wheatgrass also had a significant decrease in plant species diversity, in addition to a reduction in nesting bird diversity and density. Grazing by sheep further reduced the diversity and density of nesting birds in these areas. Migrant birds and birds nesting off the study areas used sagebrush dominated habitats more than crested wheatgrass plantings. Spring grazing in sagebrush habitats was not severely detrimental to bird populations. Crested wheatgrass plantings greatly changed the plant community structure and affected the bird populations.

- 54 Rosentreter, R. 1994.** Displacement of rare plants by exotic grasses. Pp. 171-175 in S. B. Monsen and S. G. Kitchen (eds),

Proceedings-Ecology and Management of Annual Rangelands. USDA For. Serv. Gen. Tech. Rep. INT-GTR-313. 416 pp.

Shrub-steppe can be converted to nonshrub annual grasslands by the increased fire frequency caused by invasion of annuals. The fire frequency of sagebrush-steppe before annual invasion averaged 60-110 years. In much of the region, this frequency is now down to less than 5 years. Disturbed sites are rapidly dominated by exotic annual species. The shortened fire frequency cycle, caused by exotic annuals, is detrimental to most native plants and shrubs. Perennials do not have time to become reestablished. This results in a loss of genetic, species, and structural diversity.

Annual grasses burn more uniformly reducing landscape patchiness, species richness, and altering successional patterns. Loss of dominant species, such as sagebrush, can have a detrimental effect on shrub-dependent species. Losing shrubs reduces forage production, soil stability, diversity, consistent biomass production, mineral cycling, thermal and escape cover for wildlife, and esthetic values.

Many annual grasses are able to spread to sites adjacent to the disturbed area. The change of a community to exotic annuals is not temporary, "but rather a shift in successional patterns to a self-perpetuating annual community." This change in the community increases fire frequency that reduces shrub cover, structural diversity, and patchiness of the landscape.

- 55 Rotenberry, J. T. In press.** Avian conservation research needs in western shrublands: exotic invaders and the alteration of ecosystem processes. In J. M. Marzluff and R. Sallabanks (eds). *Avian Conservation: Research and Management.* Island Press, Covelo, CA.

Fire, grazing, and agriculture in western shrublands have contributed to loss and fragmentation of native habitat for many bird species. Species that are most affected by this fragmentation are shrubsteppe obligates such as, Brewer's, sage, and black-throated sparrows (*Amphispiza bilineata*). Livestock grazing disturbs the soil, provides sites for germination of annual plants, and may increase unpalatable plant species. Agricultural lands are continuous sources of exotic plants that threaten native habitat. Cheatgrass invasion has significantly decreased the fire return interval for shrublands. Fire frequency is too high to allow regeneration of nonsprouting shrubs, such as sagebrush. This is converting shrubsteppe landscapes to exotic annual grasslands. An effort needs to be put forth in finding ways to eliminate exotic annuals, specifically cheatgrass, and developing methods to speed the recovery of shrublands. Rotenberry also discusses some management and conservation techniques that may be helpful in restoring shrublands. The importance of information transfer between researchers and land managers is also mentioned.

- 56 Rotenberry, J. T. and J. A. Wiens.** 1980. Habitat structure, patchiness, and avian communities in North American steppe vegetation: a multivariate analysis. *Ecology* 6:1228-1250.

The effects of horizontal and vertical patchiness in vegetation distribution on bird abundance and distribution were examined using Principal Component Analysis (PCA). Brewer's and sage sparrows, sage thrashers, and loggerhead shrikes abundances were positively correlated with woody plant and bare ground cover. Their abundance decreased as grass cover increased.

Horizontal patchiness was mostly independent of the degree of vertical patchiness. Many shrubsteppe species

increased with high vertical heterogeneity but their responses varied in relation to horizontal patchiness. Niche width of habitat-typical birds were independent. Independent bird species had little interactions with co-occurring species. They had their own distributions but were associated with similar habitat. Overall, many species abundances were correlated with habitat structure. This was not habitat selection, but association with the variable measured or other variables closely associated with them.

- 57 Schroeder, M. H. and D. L. Sturges.** 1975. The effect on the Brewer's sparrow of spraying big sagebrush. *Journal of Range Management* 28:294-297.

This study investigated the effects of spraying big sagebrush with the herbicide 2,4-D on the Brewer's sparrow in Wyoming. Nest success of Brewer's sparrow nests sprayed with 2,4-D was not affected by the spray or the plants' death. For two years after spraying, Brewer's sparrows were seldom seen on the sprayed area and were relatively numerous on the unsprayed area. After the leaves had dropped off the dead sagebrush, use by Brewer's sparrows greatly decreased. No nests or singing Brewer's sparrows were found in the dead sagebrush. Bird densities were 67% lower on sprayed areas than on unsprayed areas 1 year after the treatment and 99% lower than on two unsprayed areas after 2 years. Any birds seen on the sprayed areas were near small patches of live sagebrush that had survived the treatment.

- 58 Sime, C. A.¹** 1991. Sage grouse use of burned, non-burned, and seeded vegetation communities on the INEL, Idaho. Unpublished M. S. Thesis. Montana State University, Bozeman. 72 pp.

Sage grouse seasonal distributions are largely determined by vegetation patterns and food availability. Alteration of sagebrush habitat may either benefit or harm sage grouse populations depending on the type, severity, and location of the disturbance in relation to seasonal ranges. Sage grouse may use crested wheatgrass stands for strutting grounds, but these stands do not meet the winter needs of sage grouse. Sagebrush cover of Tractor Flats winter range on the INEEL had not been reduced enough by fire and crested wheatgrass planting to cause damage. The area naturally revegetated was more favorable for brood-rearing because overhead canopy and understory vegetation diversity were higher than in the crested wheatgrass area.

- 59 Stamps, J. A., M. Buechner, and V. V. Krishnan.** 1987. The effects of edge permeability and habitat geometry on emigration from patches of habitat. *American Naturalist* 129:533-52.

Habitat patches may be bounded by hard, impermeable edges or soft, permeable edges. This study used simulation models to investigate the effects of edge permeability and habitat shape and size on emigration. Edge permeability is the tendency of a disperser at the edge of a habitat to cross the boundary and emigrate from that patch. Emigration is positively related to edge permeability. Edge-to-size ratio (ESR) is the proportion of home ranges at the edge of a habitat patch and is positively related to emigration when edge permeability is greater than zero. Edge permeability is more important than ESR in determining emigration when the habitats have hard edges. ESR is more important than edge permeability when habitat edges are soft. Researchers should be careful when comparing habitats with soft and hard edges because patch size and shape may not be important in hard-edged habitats, but

may be important in soft-edged habitats.

- 60 Starkey, E. E.** 1985. Impact of fire on nongame wildlife. Pp. 48-51 in K. Sanders and J. Durham (eds), *Rangeland Fire Effects; A Symposium*. Bureau of Land Management. Boise, ID. 124 pp.

The most significant impact of fire on wildlife is the alteration of habitat, not mortality. Bird species diversity can increase following prescribed burns. These burns often result in a mosaic of burned and unburned areas, increasing the habitat diversity and, in turn, species diversity. Fires do have some effect on wildlife species composition, but population densities are mostly stable after a fire. Game and nongame animals can benefit from prescribed burning and suppression of catastrophic wildfires.

- 61 Sturges, D. L.** 1975. Hydrologic relations on undisturbed and converted big sagebrush lands: the status of our knowledge. USDA For. Serv. Research Paper RM-140. 23 pp.

The removal of sagebrush creates vegetation that is dominated by herbaceous species. Spraying favors grasses over forbs. Burning, disking, and plowing do not alter herbaceous composition. Spraying greatly reduces forb growth. This should be taken into account for management purposes. Organisms, such as sage grouse chicks, are dependent upon forbs. Forb loss after spraying can be to the extent that grass-forb production does not equal unsprayed vegetation until 2 years after treatment. Above-ground biomass declines after spraying even with increased grass-forb production. Sagebrush canopy coverage is severely reduced by treatment. This, however, is offset by increased basal area of herbaceous species.

Conversion to herbaceous species reduces soil moisture withdrawal by about

15%. Spraying is the best technique for watershed rehabilitation because it minimizes soil disturbance. Total annual watershed streamflow was increased 13% by sagebrush conversion because of the lower soil moisture withdrawal by herbaceous vegetation.

- 62 Swenson, J. E., C. A. Simmons, and C. D. Eustace.** 1987. Decrease of sage grouse (*Centrocercus urophasianus*) after plowing of sagebrush steppe. *Biological Conservation* 41:125-132.

This study examined the effects of plowing sagebrush steppe on sage grouse populations and compared the effectiveness of plowing and spraying. The study area was in south central Montana where the dominant vegetation is big sagebrush and bluebunch wheatgrass. Plowing of sagebrush steppe was detrimental to sage grouse. The plowing of 16% of the study area resulted in at least a 73% decline in sage grouse. Sage grouse declined to a lower level than other populations relative to the loss of sagebrush. This was a result of plowing 30% of sage grouse wintering area. Sage grouse depend on wintering ranges of sagebrush for food 7-8 months of the year.

Plowing was more harmful to sage grouse than spraying because some sage grouse populations have partially recovered after spraying. In addition, sagebrush cannot recover on plowed land because this land is generally cultivated annually. The largest long-term declines in sage grouse populations occurred on where sagebrush was plowed.

- 63 Tabler, R. D.** 1968. Soil moisture response to spraying big sagebrush with 2,4-D. *Journal of Range Management* 21:12-15.

Spraying killed about 90% of the sagebrush and severely decreased forb

production for 2 years after treatment. Grass production greatly increased after spraying. Total production of the treated plots was below control plot levels until 2 years after treatment. Sagebrush did not reinvade the sprayed sites during this study.

Soil moisture depletion was higher on control plots than on sprayed plots. There were differences in root distributions within a six foot profile. A majority of the differences occurred between three and six feet. Within the second foot, the treated plot had more root activity as a result of increased grass production. Unsprayed plots generally had a greater soil moisture recharge than sprayed plots.

- 64 Warren, S. D., T. L. Thurow, W. H. Blackburn, and N. E. Garza.** 1986. The influence of livestock trampling under intensive rotation grazing on soil hydrologic characteristics. *Journal of Range Management* 39:491-495.

This study evaluated the effects of livestock trampling on infiltration rates and sediment production of bare soil subjected to intensive rotation grazing. The impact of trampling increased as stocking rate increased. Moist soils were more susceptible to compaction than dry soils. It took more than 30 days of rest for hydrologic recovery. Soil recovery may be very important in arid, semiarid, and disturbed or overgrazed areas where there is sparse vegetation. Rate of trampling, soil surface microrelief, aggregate stability and size distribution were significantly correlated with infiltration rate and sediment production. Heavy stocking rates with continuous grazing increased bulk density, reduced infiltration rates, and increased sediment production.

- 65 Whisenant, S. G.²** 1990. Changing fire frequencies on Idaho's Snake River Plains: ecological and management implications.

Pp. 4-10 in E. D. McArthur, E. M. Romney, S. D. Smith, and P. T. Tueller (eds), *Proceedings of a Symposium on Cheatgrass Invasion, Shrub Die-Off, and Other Aspects of Shrub Biology and Management*. Intermountain Research Station, Ogden, Utah INT-276. 315 pp.

Sagebrush-steppe in the Idaho Snake River Plain used to have fire return intervals of 35 to 100 years. Now with the invasion of cheatgrass and grazing, this return interval has decreased to 2 to 4 years. The relative frequency of cheatgrass and fire frequency were significantly correlated. The more cheatgrass the higher the fire frequency. Cheatgrass carries fire continuously between shrubs, changing the fire regime and causing a more uniform burn. Areas with higher fire frequencies had lower species richness than areas with lower fire frequency. Annuals in communities with high fire frequencies increase while other species such as perennial grasses and forbs and shrubs decrease. Cryptogam ground cover also decreases with higher fire frequency. As sagebrush-steppe is converted to annual grasslands by fire, larger areas are being burned more often, and these fires are burning more uniformly with fewer patches of unburned vegetation remaining. A mosaic landscape supports a higher species diversity, but a large, species poor mosaic would have isolation of patches within that area.

- 66 White, C. M. and T. L. Thurow.² 1985. Reproduction of ferruginous hawks exposed to controlled disturbance. *Condor* 87:14-22.

This study investigated the effects of disturbance on ferruginous hawks, the levels at which they will tolerate disturbance, and the buffer zones needed. Disturbances were simulated to be associated with land development on western rangelands. The

hawks did not increase their tolerance over time, but became more sensitized to the disturbances. In response, adults were less attentive to their young, which could explain their reduced fledging success. Disturbed nests fledged significantly fewer young than undisturbed control nests. In addition, disturbed adults showed less defensive behavior. A decrease in fragmentation of habitat and an adequate buffer zone of at least 250 m in years of optimal food and prime hawk health would decrease disturbance to ferruginous hawk nests.

- 67 Wicklow-Howard, M. C. 1994. Mycorrhizal ecology of shrub-steppe habitat. Pp. 207-210 in S. B. Monson and S. Kitchen (eds), *Proceedings of the Symposium on Ecology, Management, and Restoration of Intermountain Annual Rangelands*. USDA For. Serv. Gen. Tech. Rep. INT-GTR-313. 416 pp.

Ninety-five percent of dominant plant species in semiarid grasslands have mycorrhizae. Disturbances such as fire, overgrazing, and vehicle use can reduce the mycorrhizal inoculum potential of the soil. On a disturbed site only about one percent of the colonizing plants are mycorrhizal compared to about 99% on undisturbed sites. *Salsola kali* and *Halogeton glomeratus*, nonmycotrophic weeds, can invade disturbed sites and compete with desired species. Many desired plants require vesicular-arbuscular mycorrhizal infection to colonize disturbed areas. Some disturbed sites have had no vesicular-arbuscular mycorrhizae for up to 10 years. Land disturbance can lower mycorrhizal inoculum potential, creates a nutrient pulse available to plants, allow nonmycorrhizal species to dominate the site, reduce mycorrhizal fungi propagules, and slow succession.

- 68 Wiens, J. A. 1976. Population responses to patchy environments. *Annual Review of Ecology and Systematics* 7:81-120.

Wiens reviewed some important features of population responses to patchy environments. The most obvious patchiness in terrestrial ecosystems is vegetation patterns. Vegetation patterns are strongly influenced by seed germination, establishment, and survival. Soil characteristics and microclimate are also very important. Arid systems may be more sensitive to factors creating vegetation patchiness. Recovery from disturbances in arid systems tends to be slow so patches may last longer than in more mesic systems.

Dispersion of animals in a population may be nonrandom due to patch or habitat selection. Gene flow can be enhanced by dispersal of individuals. In a patchy environment, this would depend on individuals finding suitable habitat. Social organization, such as territoriality, social grouping, and mating can vary in relation to patchy environments. Patchiness can affect predation on prey population distributions and stabilization of population interactions.

There is little good information on patchiness in natural ecosystems, responses to these gaps, and how these characterize entire ecosystems.

- 69 Wiens, J. A. 1994. Habitat fragmentation: island v landscape perspectives on bird conservation. *Ibis* 137:S97-S104.

Wiens discussed characteristics of fragmentation and its effects. Fragmentation is important because it results in loss of habitat and jeopardizes species dependent upon that habitat. Views of fragmentation are biased by what we view as "habitat" and "matrix." The scale of fragmentation will be different depending on if the scope is on individuals or populations. Habitat fragments are not

islands. They are vulnerable to influences of the surrounding areas. These effects on populations and communities are not always the same.

Corridors between fragments are believed to improve recolonization of empty patches and reduce the risk of extinction. Attention should be paid to the probability of movement among habitat types in a landscape. Landscapes change because of disturbances. The effects of habitat changes may not be immediately apparent. Habitat selection and movement are very important in determining responses to fragmentation. A habitat that is isolated for one species may not be for another species. Information on how species respond to habitat fragmentation is very limited. Integration of a mosaic theory with a specific domain of application and studies on target species that model a group of species are needed.

- 70 Wiens, J. A., C. S. Crawford, and J. R. Gosz. 1985. Boundary dynamics: a conceptual framework for studying landscape ecosystems. *Oikos* 45:421-427.

Landscape patterns, other things being equal, are determined by edaphic factors. Variation in climate also has an impact on landscape patterns. These factors determine spatial patterns mainly by their effects on vegetation. Boundary locations can be affected by edaphic patterns or disturbances. Disturbances can alter vegetation, soil characteristics, or the structure of the habitat. The frequency of disturbances can affect the heterogeneity of the system as well. Patches can be closed or open systems depending on the permeability of the boundary and the characteristics of the vectors transporting materials or information. Density of the population in the patch and patch features on the opposite side of the boundary also influence boundary openness. The more impermeable a boundary is, the more localized the

activities within the patch become and the system closes. Destabilizing influences, such as the spread of disturbances from a patch to the surrounding area, produce a net imbalance between inputs and outputs of the system.

- 71 Wiens, J. A. and J. T. Rotenberry. 1981.** Habitat associations and community structure of birds in shrubsteppe environments. *Ecological Monographs* 51:21-41.

This study investigated the relationships between bird species distribution and abundance and habitat characteristics in the north-western Great Basin. Bird species abundance and densities in the locations studied were independent of each other. Few pairs of bird species were associated. Widespread bird species did not have strong associations with habitat structure, but were more closely associated with plant species coverage. Species that had smaller distributions did have associations with habitat structure. Species richness decreased with increasing horizontal heterogeneity, but increased with increasing vertical heterogeneity of the habitat. Analysis of continental-scale showed a correlation between shrubsteppe bird species and habitat structure. In this regional-scale study, bird species were correlated with vegetative species. Birds may occupy certain habitat structure configurations and then further adjust their distribution to vegetation composition.

- 72 Wiens, J. A. and J. T. Rotenberry. 1985.** Response of breeding passerine birds to rangeland alteration in a North American shrubsteppe locality. *Journal of Applied Ecology* 22:655-668.

Wiens and Rotenberry documented changes in habitat characteristics and in breeding bird populations in south-central

Oregon in response to the spraying of sagebrush habitat with the herbicide 2,4-D and then planting with crested wheatgrass using a rangeland drill. After the treatment, there were immediate changes in habitat structure and floristics. Sage sparrows decreased in abundance, horned larks increased, and Brewer's sparrows fluctuated in numbers from year to year. There was a time lag in the response of these species to the habitat change possibly caused by site fidelity. Adult sage and Brewer's sparrows that have successfully bred at a certain location often return to that same location to breed in following years. This site fidelity, in some species, may outweigh habitat selection responses and lead individuals to remain in areas where the habitat has been significantly altered.

- 73 Winter, B. M.¹ 1984.** Effects of prescribed burning on avian foraging ecology and arthropod abundance in sagebrush-grassland. Unpublished M. S. Thesis. Iowa State University, Ames. 82 pp.

The foraging rates of sage sparrows decreased after burning. They spent more time shading and brooding their young. Males spent more time singing and defending their territories. Brewer's sparrows' activity budgets did not change after fire, but preferred areas with more sagebrush cover. Sage grouse and Brewer's sparrows can continue to breed in burned areas with a mosaic of burned and unburned patches. Fires that burn large patches would be damaging for both species because of their feeding requirements. Prescribed burning reduced sufficient sagebrush cover and appropriate microclimate conditions for nesting. Herbivorous arthropods, except lepidopteraus, were more abundant in burned patches. Predatory arthropods were more abundant in unburned areas.

- 74 Winter, B. M. and L. B. Best.¹ 1985. Effect of prescribed burning on placement of sage sparrow nests. *Condor* 87:294-295.

The sage sparrow breeds and nests in sagebrush dominated rangelands. Nests are usually placed within sagebrush canopies; however, some may be placed on the ground in depressions beneath plants. This study examined the effects of prescribed burning, near the western boundary of the INEEL, on the breeding ecology of the sage sparrow. The prescribed burn created a mosaic of burned and unburned patches of variable sizes that were interspersed. The burn significantly reduced sagebrush coverage, did not change the coverage of green rabbitbrush or grasses, and significantly increased forb coverage. There was a significant difference in nest placement between preburn and postburn nesting seasons. Before the burn, all the nests found were placed within sagebrush canopies with adequate cover above the nests. After the prescribed burn, only 79% were located within sagebrush canopies. All but one of the other nests were found on the ground in depressions.

- 75 Wright, H. A. 1972. Shrub response to fire. Pp. 204-217 in C. M. McKell, J. P. Blaisdell, and J. R. Goodin (eds), *Wildland Shrubs--Their Biology and Utilization*. USDA For. Ser. Gen. Tech. Rep. INT-1. 494 pp.

Sprouting shrub species, such as rabbitbrush and horsebrush, are not usually seriously harmed by fire. Nonsprouting species, such as big sagebrush and antelope bitterbrush, that have to generate from seed can be severely damaged by fire. If fires are not too frequent, these species can be enhanced by fire.

- 76 Wright, H. A. 1974. Range burning. *Journal of Range Management* 27:5-11.

Fires affect population densities of animals by altering the habitat. Habitat determines the species and their densities. A patchy burn (about 80% complete) is the best for wildlife. This leaves adequate cover and winter food supply. Prescribed fires generally increase wildlife and vegetation diversity.

- 77 Wright, H. A. and J. O. Klemmedson.² 1965. Effect of fire on bunchgrasses of the sagebrush-grass region in southern Idaho. *Ecology* 46:680-688.

Fire resistance of four species of bunchgrass as a function of season burning was determined by burning samples in a combustion chamber. *Poa secunda* was not injured by fire. *Sitanion hystrix* was only damaged in July. *Stipa comata* was the most susceptible to fire. *Stipa thurberiana* damage was less severe. Air temperature, relative humidity, season of burn, and size of the plant were some determining factors of the effect of burning.

- 78 Yensen, D. L.² 1981. The 1900 invasion of alien plants into southern Idaho. *Great Basin Naturalist* 41:176-183.

Vegetation before settlement of southern Idaho consisted of an overstory of shrubs with an understory of perennial bunch grasses. If vegetation was disturbed, native species would colonize the area. Continual disturbance by fire, overgrazing, agriculture, and construction of roads, towns, railroads, and canals changed secondary succession. After this continual disturbance, sites were usually invaded by exotic species. Some of the main plant species that invaded southern Idaho were Russian thistle, cheatgrass, and a variety of mustards.

- 79 Yensen, E., D. L. Quinney, K. Johnson, K. Timmerman, and K. Steenhof.² 1992. Fire, vegetation changes, and population

fluctuations of Townsend's ground squirrels. *American Midland Naturalist* 128:299-312.

Any fluctuations in Townsend's ground squirrel can have a major influence on the food supply of several birds of prey, badgers, and snakes. Vegetation in the Snake River Birds of Prey Area has been altered by several factors including exotic plant species and wildfires. Exotic annuals have changed the severity and frequency of wildfires. These annuals replace native shrubs and bunchgrasses after a fire and are prone to burn again, shortening and intensifying the burn cycle. Therefore, preventing the return of native species.

Yensen, et al. found strong relationships between vegetation type and ground squirrel abundance and annual variability. High Townsend's ground squirrel populations were found in winterfat communities. Negative correlations between ground squirrel densities and cheatgrass were found. Cheatgrass and other exotic annuals are not reliable food sources because their biomass fluctuate erratically from year to year. Fires affected Townsend's ground squirrels by reducing the food available to squirrels the following spring and replacing native vegetation with annual species. Squirrels that live in burned areas are vulnerable to erratic fluctuations in food biomass and low food plant diversity, which result in high amplitude population fluctuations. This could threaten the populations of predators that depend upon these squirrels in southwestern Idaho.

80 Young, J. A. and R. A. Evans. 1974. Population dynamics of green rabbitbrush in disturbed big sagebrush communities. *Journal of Range Management* 27:127-132.

The dynamics of green rabbitbrush communities were examined in response to grazing, burning, and chemical shrub-control in western Nevada. Green rabbitbrush resprouts after fire, providing a source of achenes and seedling establishment potential. Application of 2,4-D, a herbicide, partially decreases big sagebrush and rabbitbrush populations. However, seedling establishment of these species is largely increased. No seedlings establish when there is an absence of disturbance or when there is total shrub removal.

81 Young, J. A. and R. A. Evans. 1978. Population dynamics after wildfires in sagebrush grasslands. *Journal of Range Management* 31:283-289.

Young and Evans examined the population dynamics after wildfire of big sagebrush/Thurber needlegrass communities north of Reno, Nevada. For the first season after the fire, cheatgrass was the most frequent herbaceous species. Cheatgrass prevented the establishment of native perennial bunchgrasses. No shrub seedlings established in this first season. Big sagebrush was killed by fire, but rabbitbrush and horsebrush were able to resprout. The increase in cheatgrass increases fire frequency and the ultimate degradation of the ecosystem.

TOPICAL INDEX

This index presents studies dealing with land use disturbance at the Idaho National Engineering and Environmental Laboratory, in southern Idaho, and in similar sagebrush steppe habitat. Some theoretical writings have also been included. The numbers listed refer to numbered references in the accompanying annotated bibliography beginning on page A-19.

Crested Wheatgrass Planting

4, 12, 19, 20, 34, 40, 41, 42, 44, 49, 50, 51, 52, 53, 58, 72

Exotic Plants

5, 6, 13, 18, 19, 20, 22, 30, 33, 38, 39, 47, 54, 55, 65, 67, 78, 79, 81

Facilities/Human Presence

8, 11, 26, 32, 34, 66

Fire

5, 10, 12, 13, 16, 21, 23, 25, 28, 29, 30, 33, 35, 37, 38, 39, 45, 47, 48, 54, 58, 60, 61, 65, 67, 73, 74, 75, 76, 77, 79, 80, 81

Fragmentation/Patchiness

2, 14, 15, 30, 39, 46, 54, 55, 56, 59, 65, 68, 69, 70, 71

Grazing

1, 4, 6, 22, 27, 30, 31, 33, 36, 48, 49, 50, 52, 53, 55, 64, 67, 80

Miscellaneous

4, 5, 7, 17, 18, 24, 30, 40, 43, 44, 47, 48, 56, 67, 78

Sagebrush Control

General: 44

Burning: 12, 16, 37, 61, 80

Chaining: 16

Plowing: 12, 16, 61, 62

Spraying: 9, 12, 37, 57, 61, 62, 63, 72, 80

Table 1. Classification of studies on land disturbance factors and impacts to ecosystem components on the INEEL, southern Idaho, or similar sagebrush steppe habitat. Selected citations regarding ecological theory and general management strategies are included. Numbers correspond to citations in the Annotated Bibliography.

DISTURBANCE EVENT	IMPACTED RESOURCES							
	VEGETATION	BIRDS/ RAPTORS	SMALL MAMMALS	LARGE MAMMALS	HERPTILES	INSECTS	SOIL	EXOTIC PLANTS
FIRE	10 [†] , 13, 16, 21 [†] , 25 [†] , 28 [†] , 29, 30, 33, 35 [†] , 37, 38 [†] , 39 [†] , 45 [†] , 47 [†] , 54, 58*, 61, 65 [†] , 73*, 74*, 75, 76, 77 [†] , 79 [†] , 80, 81	16, 21 [†] , 23*, 37 [†] , 45 [†] , 58*, 60, 73*, 74*, 76, 79 [†]	23*, 29, 48, 60, 76, 79 [†]	23*, 38, 76		21 [†] , 73*	10 [†] , 12, 25 [†] , 65 [†] , 67	5*, 13, 30, 33, 38, 39 [†] , 47 [†] , 54, 65 [†] , 79 [†] , 81
SAGEBRUSH CONTROL	9, 16, 44, 61, 62, 63, 72, 80	9, 16, 37 [†] , 57, 62, 72	44			9	12, 61, 63	
CRESTED WHEATGRASS PLANTING	3*, 41*, 42, 49*, 51*, 52*, 53*, 72	34 [†] , 42*, 51*, 52*, 53*, 58*, 72	40*, 44, 50*, 52*	51*, 52*	49*, 52*	19 [†] , 20 [†] , 44, 49*, 52*	12	
GRAZING	1, 4*, 6*, 22, 27*, 31, 33, 36*, 49*, 52*, 53*, 55, 80	22, 31, 52*, 53*	22, 31, 36*, 48, 50*, 52*	22, 31, 52*	22, 49*, 52*	22, 31, 49*, 52*	1, 22, 31, 55, 64, 67	22, 30, 33, 55
EXOTIC PLANTS	6*, 54, 55, 78 [†] , 79 [†] , 81		79 [†]	54		19 [†] , 20 [†]	54	
FACILITIES & HUMAN PRESENCE		8*, 11*, 26*, 32 [†] , 34 [†] , 66 [†]						
OTHER (GENERAL)	4*, 5*, 18, 24*, 30, 43, 47 [†] , 67, 78 [†]	17*, 56	40*, 44, 48				7, 18, 24*, 30, 47 [†] , 67	18, 67, 78 [†]
FRAGMENTATION & PATCHINESS	2, 14, 15, 30, 39 [†] , 46, 54, 55, 56, 59, 65 [†] , 68, 69, 70, 71							

* Study conducted at INEEL

[†] Study conducted in southern Idaho

Location of other studies are mentioned in the bibliography.

APPENDIX B—LEGAL DRIVERS

This appendix lists many of the Federal mandates and Executive Orders regarding land management activities and ecological and heritage resources on the INEEL. The number of acts and other legislation is compounded because DOE and the Bureau of Land Management each have some management responsibilities for the INEEL

BIOTIC RESOURCES

- National Environmental Policy Act
- Endangered Species Act
- Comprehensive Response, Compensation, and Liability Act (CERCLA) of 1980
- Clean Water Act
- Bald and Golden Eagle Protection Act
- Migratory Bird Treaty Act
- Fish and Wildlife Coordination Act (50 CFR 410)
- Wild and Scenic Rivers Act (16 USC 1271-287)
- Floodplains Management (EO 11988)
- Protection of Wetlands (EO 11990)
- Taylor Grazing Act (BLM)
- Federal Land Policy and Management Act (BLM)
- Public Rangelands Improvement Act (BLM)
- Land and Water Conservation Fund Act (BLM)
- Federal Water Project Recreation Act (USF&WS)
- Food Security Act (USDA & USF&WS)
- Emergency Wetland Resources Act (USF&WS)
- North American Wetlands Conservation Act (USF&WS)
- Sikes Act
- Noxious Weed Act
- Surface Mining Control and Reclamation Act of 1977.
- Off-Road Vehicles on Public Land (EO 11644, 11989)
- Exotic Organisms (EO 11987)
- Federal Cave Resources Protection Act
- Federal Wildlife Restoration Act

HISTORIC RESOURCES

- National Environmental Policy Act
- American Indian Religious Freedom Act of 1978
- Archaeological Resource Protection Act (as amended)
- National Historic Preservation Act
- Native Grave Protection and Repatriation Act of 1990
- Religious Freedom Restoration Act of 1993
- Federal Cave Resources Protection Act
- Antiquities Act
- Protection and Enhancement of the Cultural Environment (EO 11593)

APPENDIX C--LIST OF 15 ASSUMPTIONS AND COMMENTS

Assumption 1—The INEEL will remain under government management and control for at least the next 100 years. The implementation of this management and control becomes increasingly uncertain over this time period. Regardless of the future use of the land now occupied by the INEEL, the federal government has an obligation to provide adequate institutional controls (i.e., limited access) to areas that pose a significant health and/or safety risk to the public and workers until that risk diminishes to an acceptable level for the intended purpose. Achievement of this obligation hinges on the Congress appropriating sufficient funds to the responsible government entity charged to maintain the institutional controls for as long as necessary and as long as the federal government of the United States remains viable.

Comments—Government control—what government (local, state, or federal)? The INEEL's importance as a natural resource needs to be stressed. Long-term issues for areas contaminated for over 100 years need to be addressed. The question and result of privatization needs to be considered. Ecosystem conservation should be one of the drivers used in considering whether or not to dispose of certain lands at the INEEL. Should it be stated that "portions of the INEEL will remain under government management..." given that there is a question regarding boundary changes? Might there be additional reasons to restrict access to certain areas besides health and safety, such as cultural resource protection, ecological research areas/preserves? Redefining the boundary would change clean-up and operational criteria. Would there be a potential for local governments (counties/cities) to attempt to obtain/develop areas being released? This is in contrast to apparently active options

such as offering facilities for privatization and reducing the land area of the INEEL. These active options will require major cultural resource assessments and may transfer significant historic preservation obligations to other entities; these actions, their drivers, and consequences have not been fully defined.

Assumption 2—Advances in DOE and private-sector research will result in the obsolescence of existing facilities. It is further assumed that new facilities will need to be constructed in response to the need to provide state-of-the-art research facilities. Other programs, however, will be discontinued entirely after the facilities become obsolete.

Comments—Plan research opportunities to reuse/recycle obsolescent sites, facilities and materials for integration into new facilities. Cultural resource statute and regulations require that all INEEL facilities be inventoried and described, primarily toward evaluation for eligibility to the National Historic Register and preservation and documentation of the historic record—a process that must precede any decisions about disposition of the facilities and their components. At the same time historic preservation law does not require preservation of buildings and components in every case nor does it prohibit activities such as decontamination and decommissioning (D&D) where necessary, but does encourage building/facility rehabilitation and re-use. (Culture resource inventory is also required, in coordination with the NEPA process, for the siting of new facilities.)

Assumption 3—New construction may include structures in existing facility areas; other new construction may require the development of new facility areas. New

development should be restricted to core areas already developed.

Comments—This assumption needs a discussion of buffer areas, in addition to the need to define "already developed." Does it mean no intrusion or conversion of existing native vegetation/plant communities? New development should be evaluated on a case-by-case basis, not restricted to core. Flood plain analysis and contaminant transport need to be considered. Geothermal, geotechnical, and seismologic research areas may require siting in places outside core development areas. Better sites (e.g., in terms of aquifer protection) may be identified for hazardous facilities. What are the boundaries for the current core areas? Existing facilities or entire identified development corridor? Are there areas within this corridor that should be considered further? What ecological considerations went into the proposed development corridor?

Assumption 4—As contaminated facilities become obsolete, D&D will be required. Similarly, contaminated areas will require remediation. The decontamination and decommissioning process will commence following closure of a facility once it has been determined that the facility is no longer needed and sufficient funds are appropriated to safely accomplish the work.

Comments—"Contaminated areas that show risk" rather than "contaminated facilities." Replace the last sentence in the assumption with: "The decontamination and decommissioning process will commence following closure of a facility once it has been determined that the facility is no longer needed or cannot be reused, and historic records/documentation, consultation, and significance evaluation has been incorporated into the decision-making process, and sufficient funds are appropriated to safely accomplish

the work."

Assumption 5—To the extent practical, new development will be encouraged in developed facility areas to take advantage of existing infrastructures. Such redevelopment will reduce environmental degradation associated with construction activities in previously undeveloped areas.

Comments—Combine with Assumption 3. Current ACETS or PNDR planning does not use existing infrastructures, rather, proposes to build facilities in an undisturbed area. This also impacts part of a large unfragmented block of undeveloped area.

Assumption 6—The Central Facilities area will remain the focal area for support and infrastructure activities, assuming continuity of existing or similar INEEL missions.

Comments—Okay as is.

Assumption 7—Environmental restoration and waste management activities will continue. Cleanup of hazardous, mixed, and low-level waste sites is expected to be completed within ten (10) years following completion of a Record of Decision for the cleanup mandated by the Comprehensive Environmental Response, Compensation, and Liability Act.

Comments—What is the reality of the 10-year goal? Is this reasonable? What are the contingencies? How do clean-up criteria reflect proposed land use for the areas? Doesn't land use need to be determined prior to establishing the extent of restoration required? Won't this affect ROD requirements? There needs to be risk-based cleanup.

Assumption 8—Research and development facilities will be expanded to accommodate "new frontier research." To support such efforts, cooperative partnerships between

the public and private sectors may be developed to achieve mutual goals. This could result in the re-use of INEEL facilities by private-sector interests, supplemented with technology support by INEEL personnel.

Comments—This could be combined with Assumption 1. Change "will" to "may." "New frontier research" should include ecological/environmental research. Impacts to ecological systems from a site level scale, to INEEL scale, to regional scale from defense activities, energy development, and industry should be examined.

Assumption 9—INEEL may be called upon to support defense-related operations.

Comments—Change to "address national needs."

Assumption 10—Regional development trends will be closely related to activities at the INEEL. The weight of INEEL's influence on the region may increase or decrease over time depending on the diversity and strength of the regional economy.

Comments—INEEL's influence is tied more to Congressional funding than regional economy.

Assumption 11—No residential development (i.e., housing) will occur within INEEL boundaries. Grazing will be allowed to continue in the buffer area.

Comments—Change to "compatible uses" rather than just grazing. If INEEL boundary changes, residents may eventually exist within current boundaries. How will this impact current operations and restoration plans? Who manages/regulates the grazing? How will grazing be monitored? Is existing monitoring adequate? How does grazing integrate with the mission of the National

Environmental Research Park?

Assumption 12—No new major, private developments (residential or non-residential) on public lands are expected in areas adjacent to the site. There is uncertainty about the applicability of this assumption to privately held land. Beyond 25 to 50 years, there is less certainty about this assumption.

Comments—This needs to be completely reworded. There is a high likelihood of development of privately held land. This assumption does not seem to hold true for even a 10-year planning cycle. Private developments generally do not occur on public lands. Private development can only happen on private land; the uncertainty with this assumption is already noted. The irrigated agricultural land adjacent to the site boundary could be subdivided. What is the purpose of this assumption? What is the uncertainty associated with development adjacent to INEEL boundary on private lands? If development occurs, how does this impact operations or change clean-up requirements?

Assumption 13—An 890 mi² site dedicated to nuclear research, development, testing, evaluation, and environmental management is irreplaceable. It was therefore assumed that it is unlikely that the siting of a similar DOE facility and land withdrawal would occur in the future at any other location in the contiguous 48 states.

Comments—Add NERP status. Add ecological research to mission. This is particularly true if a part of the strategic plan involves ecological research associated with natural resources extraction or development of "green" industries and associated impacts to resources.

Assumption 14—New locations for low-level waste disposal may need to be sited. If new

locations are needed, they will be subject to regulatory approval processes.

Comments—Take into account Brownfield sites and address the Batt agreement.

Assumption 15—In accordance with DOE Order 1230.2, DOE recognizes that a trust relationship exists between federally recognized Tribes and the DOE. DOE will consult with Tribal governments to assure that Tribal rights and concerns are considered prior to DOE taking actions, making decisions, or implementing programs that may affect the Tribes.

Comments—Refer to Executive Order rather than DOE order. Other interest groups will/should also have increased involvement with INEEL's future. DOE should actively solicit their input in land management planning and decision-making.

Proposed New Assumption and Rationale—Because of the recognized unique ecological resource contained within the INEEL borders, the biotic group agreed additional emphasis should be placed on its value and

protection. As a result, an additional assumption was recommended to ensure this resource is recognized and appropriate planning and studies occur to protect and understand its value. The general concept of this assumption was stated in two different ways:

(1) The unique nature and status of the INEEL ecosystem deserves recognition as an important biological resource and preserve. Unique opportunities exist for long-term ecological studies that can address local, regional, and global environmental issues. Due to its local and regional importance, construction and facility development activities will be away from, to the extent practicable, undeveloped areas of the INEEL; large undeveloped blocks of land will remain intact.

(2) Increases in INEEL activities may further fragment a relatively intact ecosystem resulting in long-term consequences including: an increase in exotic species, reduction in native species, and eventual degradation or loss of an ecosystem considered at risk.

**APPENDIX D--LIST OF CONTRIBUTORS AND PARTICIPANTS FROM INEEL LAND USE
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APPENDIX E-FINAL AGENDA FROM INEEL LAND USE WORKSHOP

Tuesday, September 9, 1997

- 9:00 am Welcome: Bob Breckenridge, LMITCO; Clay Nichols, DOE-ID; Bob Snelling, LMITCO
- 9:15 am Purpose and Logistics: Bob Breckenridge
- 10:00 am Keynote Addresses: Technical Issues and Long-Term Land Management Strategies
Biological Aspects of Disturbance in Arid Ecosystems: Dr. James MacMahon,
Dean, College of Science, Utah State University, President, Ecological Society of
America

Abiotic: Dr. Amrita DeSoyza, USDA ARS Jornada Experimental Range, Las
Cruces, NM

Heritage Resources - Sue Miller, Heritage Resources, INEEL

Institutional Issues & Current Planning Status: INEEL Facility Planning,
Tom Moriarty, INEEL
- 12:00 noon Lunch - working lunch presentation - INEEL Land Use Plan & GIS coverages
1:15 Regulatory Drivers and Constraints - Roger Twitchell, DOE-ID
Status of INEEL Ecorisk Assessments - Robin VanHorn
- 2:00 - 4:45 Breakout Sessions on Available Analyses and Data

Flora/Fauna - Ron Rope/Jim Glennon (Marilynne Manguba -recorder)
Abiotic and Landscape Level - Bob Breckenridge (Dena Tomchak - recorder)
Heritage Resources - Sue Miller (Sandi Thompson - recorder)
- 4:45 - 5:15 Summary of data needs from Breakout Sessions

Wednesday, September 10, 1997

- 8:00 Integration of information and assessment techniques to support decision making
Examples: Biotic Resource Management Plan - Larry Cadwell - PNNL
Oak Ridge Draft Land Use Plan - Pat Parr
Techniques for Integrated Habitat Mapping - Mike Scott
Landscape Level Habitat Mapping - Neil West
- 9:45 Discussion on Integration and Prioritization of Data and Research Needs
- 1:30 - 4:30 Discussion of Recommendations for how to proceed with INEEL Long-Term Land
Management Plan

1. How can available information and GIS be used to standardize siting of new facilities?
2. What data is needed to standardize responses to NEPA?
3. What parts of information management can be shared with collaborators?
4. What processes can we alter?
5. What processes don't we have any control over?
- 5:00 Wrap-up and path forward