ENVIRONMENTAL SCIENCE AND RESEARCH FOUNDATION, INC.

ANNUAL TECHNICAL REPORT TO DOE-ID: CALENDAR YEAR 1997

Edited by
Timothy D. Reynolds and Ronald W. Warren

May 1998

O. Doyle Markham, Executive Director

INEEL
IDAHO NATIONAL ENGINEERING & ENVIRONMENTAL LABORATORY

Environmental SCIENCE & RESEARCH FOUNDATION
P.O. Box 51838 • Idaho Falls, ID 83405-1838

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ENVIRONMENTAL SCIENCE AND RESEARCH FOUNDATION REPORT SERIES, NUMBER 27

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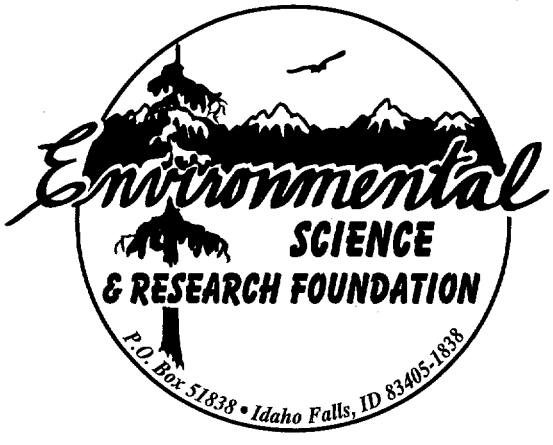

ENVIRONMENTAL SCIENCE AND RESEARCH FOUNDATION
ANNUAL TECHNICAL REPORT
JANUARY 1 - DECEMBER 31, 1997

EXECUTIVE SUMMARY

This Annual Technical Report describes work conducted for the Department of Energy, Idaho Operations Office (DOE-ID), by the Environmental Science and Research Foundation (Foundation) under contract DE-AC07-94ID13268. The Foundation's mission to DOE-ID provides support in several key areas. We conduct an environmental monitoring and surveillance program over an area covering much of the upper Snake River Plain, and provide environmental education and support services related to Idaho National Engineering and Environmental Laboratory (INEEL) natural resource issues. Also, the Foundation, with its University Affiliates, conducts ecological and radioecological research on the Idaho National Environmental Research Park. This research benefits major DOE-ID programs including Waste Management, Environmental Restoration, Spent Nuclear Fuels, and Land Management Issues. The major accomplishments of the Foundation and its University Affiliates during the calendar year 1997 can be divided into five major categories.

ENVIRONMENTAL SURVEILLANCE PROGRAM

In this category, the Foundation and its University Affiliates:

- Routinely sampled air, water, soils, environmental dosimeters and various foodstuffs throughout the upper Snake River Plain for contaminants originating from the INEEL. During 1997, we collected 2,514 samples as part of the surveillance program, and performed 4,204 analyses on these samples.
- Continued operations and collected data from two Community Monitoring Stations located at area schools.
- Prepared the *INEEL Site Environmental Report for Calendar Year 1996*. Also, we prepared and distributed a report that highlighted the significant data and conclusions from the annual site environmental report. This report was written for a more general audience than the full report and was titled, *In Summary: Idaho National Engineering Laboratory Site Environmental Report for Calendar Year 1996.*
- Developed radiological control plan and procedures for Foundation work at the INEEL.
- Continued to conduct routine quality assurance assessments of our internal programs as well as contractor analytical laboratories. These assessments ranged from informal "walkdowns" of selected field activities by the program manager to formal surveillances using a checklist by a designated quality assurance coordinator. A program to obtain and submit blind spiked samples (samples containing a known amount of radioactive material) to laboratories performing radiological analyses was also continued.
- Obtained analytical services from independent laboratories including laboratories at Idaho State University, University of California at Davis, University of Toronto, and a commercial laboratory.
- Upgraded the Sample and Environmental Analyses Management System (SEAMS). This system allows surveillance program users to schedule samples, generate

bar-code labels, and track samples from collection, through the analysis process, until final disposal. Analytical data received from the laboratories in electronic format can be loaded directly into the system.

ENVIRONMENTAL EDUCATION

In this category, the Foundation and its University Affiliates:

- Published four issues of *Foundation Focus*. Circulation remains over 1,000.
- Gave 75 presentations. The audiences included professional societies, INEEL tour groups, classrooms (from elementary through university graduate level), and others. Eighteen presentation were at annual meetings of regional or national scientific societies.
- Prepared and issued 25 news releases to approximately 212 media outlets. Each month, Foundation activities related to INEEL were mentioned by news media across Idaho, with additional coverage in Montana, South Dakota, and Utah.
- Continued to operate a Travelers' Information Radio Station for the INEEL. This station provides information on INEEL environmental topics to passengers in vehicles traveling through the INEEL. Fourteen messages were aired in 1997.
- Made a portable display describing the INEEL Offsite Environmental Surveillance Program available to libraries and other public institutions throughout Idaho. It appeared at 14 locations in 1997.
- Published 9 Foundation reports. In addition, Foundation researchers had 30 technical, peer-reviewed articles and reports published, accepted for publishing, or in press. Eight additional articles were submitted to journals and are in the review process.
- We established a World Wide Web site at http://esrf.org. At this site you can learn about the Foundation and the work that we do, including, information about the surveillance program , reports on various research projects, and general interest stories about the INEEL. Many of our reports are also available for download.

ENVIRONMENTAL SERVICES AND SUPPORT

In this category, the Foundation and its University Affiliates:

- Responded to more than 250 requests for information from the public, DOE, DOE contractor personnel, scientists, and stakeholders regarding the Foundation's programs or the environmental contamination, radioecology, ecology, surveillance activities and natural resources at the INEEL.
- Conducted 21 field evaluations in support of NEPA at the INEEL. The Foundation has taken a leading role in monitoring compliance with requirements of Environmental Checklists during the progress of projects at the INEEL.
- Responded to 19 requests regarding revegetation of disturbed areas. Eleven were for field inspections to determine the success of previous revegetation efforts; eight were to develop revegetation plans.
- Conducted two big-game surveys and one site-wide raptor count. We sent the results to appropriate agencies, including DOE, the Idaho Department of Fish and Game, and the U.S. National Biological Service. We published a Foundation Report describing the history and possible solutions of big game depredation near the INEEL.
- Maintained established working relationships with State and Federal resource management agencies on behalf of the INEEL. The Foundation continued as the INEEL interface with the U.S.

Department of Agriculture Wildlife Services (formerly Animal Damage Control) program and the U.S. Fish and Wildlife Service Threatened and Endangered Species program.

- Participated in INEEL meetings including several established group meetings, ad hoc committees, and singular meetings.
- Facilitated use of the Idaho National Environmental Research Park by University scientists, staff, and graduate students. We provided technical review of INEEL research plans and management documents.
- Participated in a DOE-HQ sponsored working group to review the INEEL site-wide risk assessment.
- Interacted regularly with other people involved in ecological risk assessment across the nation to discuss ideas and share solutions to ecological risk problems which are of interest across the DOE complex.
- We analyzed data from our 1996 surveys of sensitive species at the INEEL and prepared a series of draft reports for most Waste Area Groups.

Radioecology and Ecology Research Benefitting the DOE-ID Mission

In this category, the Foundation and its University Affiliates:

- Conducted 27 research projects. A total of 158 scientists, graduate students, and technicians from 13 universities and colleges participated in Foundation research projects at the INEEL. These projects supported DOE-ID programs for Waste Management, Environmental Restoration, Spent Nuclear Fuels, High-Level Waste, Land Management Issues, and other INEEL and DOE programs.
- Provided research data to DOE-ID for use in complying with various mandates and regulations including the National Environmental Policy Act; the Endangered Species Act; the Natural Resource Damage Assessment and Risk Assessment sections of the Comprehensive Environmental Response, Compensation, and Liability Act; and the Federal Noxious Weed Act.
- Foundation researchers submitted or published 22 manuscripts for peer-reviewed technical journals, two Foundation Technical Reports, one article in the popular literature, and coauthored one book.
- Presented research results at regional, national, and international scientific society meetings, as well as in university and other classroom environments. Other products of our research program included the validation and refinement of existing models to predict snowmelt runoff, testing of predictive models for soil moisture infiltration, and various computerized databases of plants and animals on the INEEL, including several geographic information system (GIS) layers.

Overall, the Foundation was productive and efficient while under contract to DOE-ID during 1997. Most of the goals of each individual program were accomplished, and the Foundation's responses to requests from DOE-ID and INEEL contractors were timely, complete, and cost effective.

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ENVIRONMENTAL SCIENCE AND RESEARCH FOUNDATION
ANNUAL TECHNICAL REPORT
JANUARY 1 - DECEMBER 31, 1997

INTRODUCTION

This Annual Technical Report is submitted to the Department of Energy, Idaho Operations Office (DOE-ID), by the Environmental Science and Research Foundation, Inc., in accordance with contract DE-AC07-94ID13268. This report summarizes the major activities conducted for DOE-ID by the Environmental Science and Research Foundation during the period January 1 through December 31, 1997. Because universities are involved in almost all Foundation activities, in this report the term "Foundation" collectively refers to Foundation staff and Foundation University Affiliates.

The Environmental Science and Research Foundation designed this annual technical report to be readable and meaningful to DOE-ID and interested citizens. We made efforts to reduce scientific terminology and overly-detailed descriptions of specific experimental and statistical design.

The Foundation manages, coordinates, and conducts ecological and environmental research, environmental surveillance, environmental services, and environmental education for DOE-ID at the Idaho National Engineering and Environmental Laboratory (INEEL). The Foundation's staff has more than 90 years combined experience in conducting these activities at the INEEL.

By using University Affiliates and university and commercial analytical laboratories, and by operating as a private, non-profit organization, the Foundation obtains facts independent from the management and operating contractors. This provides independent data analyses and reports which help to satisfy concerns expressed by the State of Idaho and its citizens. Additionally, this approach is consistent with DOE's commitment to public openness.

The Foundation work conducted for DOE-ID is reported in the four major sections of this report.

SECTION I: INEEL OFFSITE ENVIRONMENTAL SURVEILLANCE PROGRAM

The Foundation conducted surveillance to satisfy the environmental protection program requirements of DOE Order 5400.1 which assure compliance with environmental laws and regulations, executive orders, and DOE policies. Section I describes the offsite environmental surveillance program and summarizes the sampling effort. This summary indicates the types, frequency, and location of routine environmental samples, and the constituents for which each sample was analyzed. This section does not provide analysis or interpretation of the program data for 1997. Analysis and interpretation will be presented in a separate report, *The Idaho National Engineering Laboratory Annual Site Environmental Report for Calendar Year 1997*, available later in 1998.

SECTION II: ENVIRONMENTAL EDUCATION

Through its educational mission, the Foundation aims to improve public understanding of the environment of the INEEL. Section II of this report emphasizes the Foundation's support of DOE-ID's open and frank discussion of environmental issues with various individuals and stakeholder groups. The Foundation's Environmental Education program includes

an aggressive agenda of news releases, interpretive displays, newsletters, and presentations to both technical and non-technical audiences.

SECTION III: ENVIRONMENTAL SERVICES AND SUPPORT

Ecological and natural resource related information is vital not only for the completion of environmental compliance documentation, but also for the management at the INEEL. Section III summarizes the Foundation's activities regarding natural resource issues on the INEEL. The Foundation provided DOE-ID with information and recommendations for wildlife and other ecological concerns on the INEEL. We served as the technical point of contact for DOE-ID on natural resource issues with various agencies (e.g., Bureau of Land Management and the Idaho Department of Fish and Game). In addition, the Foundation responded to public and professional inquiries about the ecology of the INEEL and was involved in ecological risk assessment issues and efforts, both locally and nationally.

SECTION IV: ECOLOGY AND RADIOECOLOGY RESEARCH

At the INEEL, the Foundation develops scientific goals and conducts environmental research consistent with the needs of DOE-ID. Section IV summarizes the various radioecology and ecology research projects conducted by Foundation staff and University Affiliates on the INEEL. This research provided sound, scientifically-defensible answers to basic and applied ecological questions related to DOE-ID programs including Waste Management, Environmental Restoration, Spent Fuels, and Infrastructure. The knowledge gained from this research is the basis for the environmental education, services and support supplied by the Foundation to DOE-ID and the INEEL community.

CONTRIBUTORS

This annual technical report was a collective effort of Foundation staff and University Affiliates. Foundation contributors included R. D. Blew, R. W. Brooks, R. B. Evans, O. D. Markham, R. G. Mitchell, R. C. Morris, T. D. Reynolds, D. E. Roush, T. R. Saffle and R. W. Warren. The University Affiliates contributing to this report included principal investigators L. D. Flake (South Dakota State University); J. E. Anderson, J. W. Laundré, and C. R. Peterson (Idaho State University); W. H. Clark (Albertson College of Idaho); J. M. Peek (University of Idaho); S. A. Ibrahim (Colorado State University); L. C. Pearson (Ricks College); D. S. Rogers (Brigham Young University); W. P. MacKay (University of Texas at El Paso); J. R. Belthoff (Boise State University); and J. P. Dobrowolski (Utah State University); research assistants T. D. Ratzlaff and E. K. Duffin (Idaho State University), K. C. Jones (Idaho Falls School District 91), and M. D. Gaglio, E. A. Osorio, and S. I. Watts (University of Texas at El Paso); and graduate students S. L. Cooper, K. I. Gabler, L. T. Heady, M. Miller, A. Morris, D. Evans, and S. Patrick (Idaho State University); N. A. Fahler (South Dakota State University); S. Haymond (Brigham Young University); and D. E. Beaver (University of Idaho).

SECTION I

INEEL OFFSITE ENVIRONMENTAL SURVEILLANCE PROGRAM

Operations at the Idaho National Engineering and Environmental Laboratory (INEEL) have the potential to release both radioactive and non-radioactive contaminants into the air and water. To assess the effects of these contaminants, the Environmental Science and Research Foundation conducted the INEEL Offsite Environmental Surveillance Program for the Department of Energy, Idaho Operations Office (DOE-ID).

The program's primary purposes were to sample media representing pathways of contaminants from the INEEL to the public, to obtain radiological analyses for these samples, and to report and to interpret the results of these analyses for the public. The Foundation conducted surveillance to satisfy the environmental protection program requirements of DOE Order 5400.1 which assure compliance with environmental laws and regulations, executive orders, and DOE policies. We compared the data to derived concentration guides established for protection of members of the public and the environment in DOE Order 5400.5.

PROGRAM GOALS AND OBJECTIVES

The Foundation's major goals for the INEEL Offsite Environmental Surveillance Program were to:

- Sample and analyze media from all relevant contaminant radionuclide pathways to the offsite environment.
- Evaluate results of offsite environmental monitoring data and coordinate with other agencies performing environmental monitoring both on and offsite, including INEEL contractors, federal and state organizations.
- Collect the necessary data to verify that INEEL operations are in compliance with applicable environmental standards and assess the offsite impact of INEEL operations on humans and the environment.
- Report and interpret environmental monitoring results to DOE-ID and the public by using data collected by the Foundation, Lockheed-Martin Idaho Technologies Company (LMITCO), the National Oceanic and Atmospheric Administration, the United States Geological Survey, and other agencies.
- Promote public awareness of the surveillance program and its results.

In order to achieve these goals, we established the following objectives for 1997:

- Conduct a routine monitoring program to sample representative exposure pathways for contaminants from the INEEL.
- Prepare technical reports that present and interpret environmental surveillance data for the DOE and the public.
- Continue to develop and implement a quality assurance program to ensure data quality and to meet contractual requirements.
- Continue to evaluate the Offsite Environmental Surveillance Program through continuous review of data, procedures, and methodologies.
- Provide environmental monitoring data and interpretation to the public through periodic reports, news releases, the Foundation Focus newsletter, our webpage, travelers information radio, and public presentations.
- Complete upgrades of our computerized

sample/data management system and the training in the use of the system.

PROGRAM ACCOMPLISHMENTS

The Foundation conducted the INEEL Offsite Environmental Surveillance Program for DOE-ID during 1997. The objectives described above were satisfied by the surveillance program.

Routine Sampling Program

A total of 2514 samples of air, water, foodstuffs, and environmental dosimeters were collected during 1997, and 4204 analyses were performed on these samples. Of this total, quality control samples accounted for approximately 15% of the total analyses.

A network of 17 low-volume air samplers (Figure 1), including 14 at offsite locations and three on the INEEL, operated continuously throughout the year. Filters were changed weekly at all locations, and samples were screened for ^{131}I, gross alpha and gross beta presence and concentration.

Quarterly composites of the weekly filters were analyzed for gamma-emitting radionuclides. Filters from selected locations were also analyzed for ^{90}Sr and transuranic radionuclides. To monitor for tritium in the air, atmospheric moisture was collected at four offsite locations. Precipitation was collected at three locations (two onsite and one offsite) to further assess levels of tritium.

The Foundation funded the Interagency Monitoring of Protected Visual Environments (IMPROVE) sampler located at Craters of the Moon National Monument. The Foundation also operated an IMPROVE sampler at the INEEL, and sent semi-weekly samples to the University of California, Davis for analysis. The IMPROVE program is used nationwide to measure particulate air quality affecting visibility at national parks and wilderness areas.

As part of the Environmental Protection Agency (EPA) Environmental Radiation Ambient Monitoring System program, the Foundation collected biweekly air filters

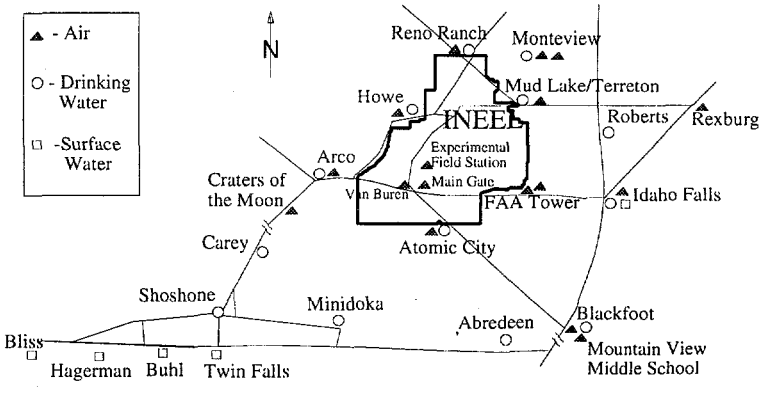

Figure 1. Air, drinking water, and surface water sampling locations for the INEEL Offsite Environmental Surveillance Program.

from a high-volume air sampler in Idaho Falls. These samples were sent to the EPA laboratory in Montgomery, AL for analysis. Monthly precipitation and quarterly drinking water samples were also collected for the program. The Foundation obtained semiannual water samples from 11 drinking-water locations and two surface-water locations. In addition, quarterly samples were collected at two drinking-water and three surface-water sites in the Magic Valley. All samples were analyzed for gross alpha, gross beta, and tritium.

We collected milk from one dairy weekly and from eight others monthly. Each milk sample was analyzed for ^{131}I, with one sample from each location also analyzed for tritium and ^{90}Sr during the year. ^{129}I analysis continued semiannually.

Annual samples of foodstuffs were collected. Lettuce, wheat, and potatoes were analyzed for gamma-emitting radionuclides and ^{90}Sr (Figure 2). The Foundation took muscle, liver, and thyroid samples from sheep grazing onsite and at a control location, and from game animals accidentally killed on INEEL roads.

Environmental dosimeters were collected from 13 sites semiannually to assess radiation exposure at distant and boundary sites (Figure 2).

Analytical Laboratories

For the radiological monitoring program, the Foundation obtained analytical services from three independent laboratories. The Environmental Monitoring Laboratory at Idaho State University performed most routine analyses, including gross alpha, gross beta, tritium, and most gamma spectrometry. Strontium-90, transuranic analyses, and some gamma spectrometry analyses were obtained from Quanterra Environmental Services, Inc. in Richland, WA. ^{129}I analyses were conducted by Isotrace Laboratory at the University of Toronto.

Crocker Nuclear Laboratory at the University of California, Davis, provided analytical support for the IMPROVE

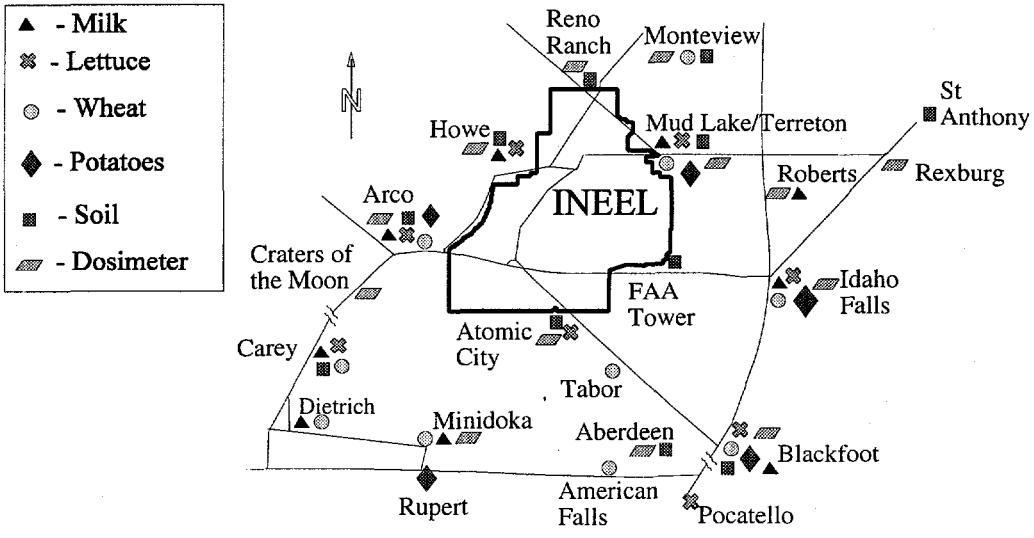

Figure 2. Soil and foodstuff sampling locations for the INEEL Offsite Environmental Surveillance Program.

program. Environmental dosimetry was provided by the Operational Dosimetry Unit of Lockheed-Martin Idaho Technologies Company.

Quality Assurance and Sample Management

The Foundation continued to revise standard operating procedures for sample collection and preparation, safety, and quality assurance incorporated into the controlled Environmental Science and Research Foundation Manual. Routine audits were continued on sample collection and preparation procedures by our independent quality assurance coordinator. In addition to field assessments, the coordinator also prepares quarterly reports of quality assurance data, and assists with evaluations of laboratory performance. Training and qualification for staff members continued to be upgraded.

The Foundation continued to use the Sample and Environmental Analyses Management System (SEAMS). Sample numbers, schedules and tracking labels are generated. Samples are tracked from analysis to disposal. The system was upgraded, and new features added, facilitating the transfer of analytical results from diskette to a secured system.

Public Information

One of the Foundation's major goals is to inform and educate the public about environmental surveillance at the INEEL. We used a variety of approaches to provide information on the environmental surveillance program to the general public including presentations, an educational display, media releases, articles in the Foundation Focus newsletter, and reports. Detailed information on these is provided in Section II of this document.

Community Monitoring Program

A major component of the public education program included the development of Community Monitoring Stations to inform stakeholders about, and involve them in, environmental surveillance at the INEEL. At each station, a public display area allows for the presentation of data on current weather conditions and gamma radiation levels. More importantly, the stations serve as an educational tool for the two schools. Data generated by the stations can be accessed through the school's computer systems, allowing this data to be incorporated into science classes.

PRODUCTS

The Foundation prepared the INEEL Site Environmental Report for Calendar Year 1996 as required by DOE Orders (Mitchell et al. 1997). The report contained environmental monitoring data collected by the Foundation, INEEL contractors, the U.S. Geological Survey, and the National Oceanic and Atmospheric Administration. In addition, the report summarized the INEEL's compliance status with respect to major environmental laws and regulations, and provided a summary of significant environmental restoration and waste management issues. The report also included an evaluation of the hypothetical dose to a member of the public resulting from operations at the INEEL. Following DOE-ID and INEEL contractor review, the report was printed and distributed to more than 400 individuals and published on the Internet. The Foundation will also prepare the INEEL Site Environmental Report for 1997.

We also completed a summary document (Mitchell et al. 1997) as a companion report to the Annual Site

Environmental Report. This report highlighted the significant data and conclusions from the Annual Site Environmental Report.

The Foundation prepared quarterly environmental surveillance reports for the second, third and fourth quarters of 1996 and the first two quarters of 1997 (Peterson et al. 1996, Brooks et al. 1997, Peterson et al. 1997). Following review by DOE-ID, each of these reports was printed and distributed.

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SECTION II

ENVIRONMENTAL EDUCATION AND COMMUNICATIONS

The Foundation aims to improve public understanding of the environment of the Idaho National Engineering and Environmental Laboratory through an aggressive program of information dissemination and educational activities. Communication strategies employed included news releases; presentations; interpretive signs, posters and displays; brochures, reports, flyers, papers and other documents; travelers' information radio messages; community monitoring stations; the Internet; and a newsletter. The Foundation's environmental education and communications program seeks to help increase awareness, foster understanding, and, ultimately, provide people with the best available information to use in their environmental decision-making.

PROGRAM OBJECTIVES

For 1997, the environmental education and communications program's objectives were to:

- Develop and distribute attractive and factual materials about the environment of the INEEL.
- Disseminate results from the INEEL Offsite Environmental Surveillance Program and provide opportunities for public involvement.
- Provide environmental education activities to schools.
- Distribute information about the INEEL ecological research findings to publics beyond traditional scientific audiences.

PROGRAM ACCOMPLISHMENTS

- News Releases: The Foundation issued 25 news releases. These resulted in editorial coverage in newspapers and magazines and on television and radio stations throughout Idaho and occasionally elsewhere.
- Presentations: Foundation staff and University Affiliates gave 75 presentations to professional peers, students, civic leaders, and others (Table 1; Appendix B). Several thousand people attended these presentations.
- Interpretive Signs, Posters, and Displays: Illustrative media–meaning signs, posters, and displays–are created and placed by the Foundation to help reveal the purposes and findings of INEEL ecological research and environmental monitoring (Table 2). Permanent interpretive signs are part of the community monitoring stations at Madison Middle School in Rexburg, ID, and Mountain View Middle School in Blackfoot, ID, as well as at the Protective Cap/Biobarrier Experiment at the Experimental Field Station on the INEEL. A traveling display describing the INEEL Offsite Environmental Surveillance Program appeared at 14 libraries and other public institutions. Foundation scientists displayed four peer-reviewed posters for presentation at scientific meetings.
- Publications: After passing peer review, scientific findings become accepted into a body of knowledge through publication. During 1997, nine reports were published by the Foundation (Table 3). In addition to Foundation-published reports, Foundation researchers had 29 technical, peer-reviewed articles and reports published, in press, or submitted (Appendix A).
- Travelers' Information Radio: The

Foundation operates the INEEL Travelers' Information Radio station, broadcasting a low-powered AM signal from a transmitter located at the intersection of U.S. Highways 20 and 26. A total of 14 messages discussing the environment, natural history, and cultural history of the INEEL and southeastern Idaho desert were broadcast.

- Community Monitoring Stations and Public Involvement in the INEEL Offsite Environmental Surveillance Program: Public awareness of results from the Foundation's environmental monitoring is integral to allaying fears, correcting misconceptions, and promoting support for the INEEL. Toward this end, the Foundation packages data, along with easy-to-follow interpretations and explanation of their underlying concepts, into reports, report summaries, fact sheets, multimedia presentations, and a portable display. Community monitoring stations at Rexburg and Blackfoot supplement these efforts. These stations monitor radioactivity and particulates in the air, environmental radiation levels, and weather conditions, providing real-time measurements and collecting samples for laboratory analyses. Information from the stations is being incorporated into science and mathematics curricula at Madison Middle School and Mountain View Middle School.
- Internet: The Foundation established a World Wide Web site, located on-line at http://esrf.org. Visitors can view quarterly monitoring summaries, executive summaries of recent INEEL site environmental reports, information about plants and animals of the high desert, *Foundation Focus* newsletters, lists of scientific papers by Foundation authors, and abstracts of current research projects. Full-length reports and dozens of photographs are available for downloading.
- *Foundation Focus* Newsletter: The Foundation's newsletter, circulated to more than 1,000 recipients, including selected individuals, requestors and libraries. Issues contain stories about Foundation surveillance and research activities as well as natural and cultural history of the INEEL. The first three issues of 1997 were significant in containing an in-depth series of articles entitled *The Site, the Plain, the Aquifer, and the Magic Valley*, which analyzed the effects of the INEEL on the aquifer beneath the Snake River Plain.

Table 1. Foundation Presentations During 1997.

Title	Audience
Wildlife of the Snake River Plain	Fourth Grade Classes at Westside Elementary School, Idaho Falls, ID
The Site, the Plain, the Aquifer, and the Magic Valley	Teachers in Shelley (ID) School District
Ecological Research and Environmental Monitoring at the INEEL	Environmental science students from Ricks College, Rexburg, ID
Environmental Monitoring and Ecological Research at the INEEL	French Atomic Energy Commission representatives
Environmental Science and Research Foundation Overview	Idaho Falls Chamber of Commerce Leadership Class
Surveying Public Perceptions about the Idaho National Engineering and Environmental Laboratory's Environment	Idaho Academy of Science Annual Meeting, Idaho Falls, ID
Environmental Science and Research Foundation Overview	Pocatello Chamber of Commerce Leadership Class
Thinking Like a Watershed	Blackfoot River Watershed Council, Blackfoot, ID
The Site, the Plain, the Aquifer, and the Magic Valley	Teachers from Madison and West Jefferson school districts
Protective Cap/Biobarrier Experiment and other Environmental Research	Science students from Sugar-Salem High School
Wildlife of the Snake River Plain	Young Women's Conference, West Minico Junior High School, Paul, ID
Biodiversity of the INEEL	Science Action Team, Skyline High School, Idaho Falls, ID
Magazines as a Medium for Environmental Communications	Conference on Communication and the Environment, Syracuse, NY
Environmental Monitoring and Ecological Research at the INEEL	Teaching Nuclear Topics teacher education class
Environmental Information	Barnes and Noble Bookstore
Protective Cap/Biobarrier Experiment	DOE Environmental Restoration Technology Information Exchange workshop
Environmental Monitoring and Ecological Research at the INEEL	Physics and environmental science students from Dietrich (ID) High School
Wildlife of the Snake River Plain	Students from Hansen (ID) Junior High School
Ecological Research and Environmental Monitoring at the INEEL	Environmental science students from Ricks College, Rexburg, ID
Ecological Research and Environmental Monitoring at the INEEL	Geology students from Ricks College, Rexburg, ID
Environmental Science as a Career	Chemistry, physics, and geology students at Ririe (ID) High School
Wildlife of the INEEL	Fourth grade students at Hillview Elementary School, Ammon, ID

Table 1 (Continued). Foundation Presentations During 1997.

Title	Audience
The Relationship between Soil Microbial Biomass and Climate	Department of Biological Sciences seminar, Idaho State University, Pocatello, ID
Rangeland Resource-related Research at the INEEL	Natural resources conservation class, Idaho State University, Pocatello, ID
Ecology of Watershed Uplands	Blackfoot Watershed Council, Blackfoot, ID
Foundation Overview	INEEL Citizens Advisory Board, Sun Valley, ID
INEEL Offsite Environmental Surveillance Program	INEEL Citizens Advisory Board, Sun Valley, ID
Idaho National Environmental Research Park and Ecological Research	INEEL Citizens Advisory Board, Sun Valley, ID
Protective Cap/Biobarrier Experiment and Long-Term Vegetation Dynamics	INEEL Citizens Advisory Board, Sun Valley, ID
The Foundation's INEEL Offsite Environmental Surveillance Program	INEEL Monitoring and Surveillance Committee
Effect of Ground Squirrel Burrows on Plant Productivity	International Theriological Congress, Acapulco, Mexico
Past Radioecological Research on the INEEL	INEEL Health Effects Advisory Subcommittee, Center for Disease Control and Prevention
INEEL Offsite Environmental Surveillance Program	INEEL Health Effects Advisory Subcommittee, Center for Disease Control and Prevention
Cave Ecology and Biotic Resources	Student interns and advisors, Shoshone-Bannock Tribes
Locations and Status of Sensitive and Other Species of Interest on the INEEL	DOE-HQ Peer Review Committee for INEEL Sitewide Ecological Risk Assessment
Ecological Resources of the INEEL	Shoshone-Bannock Tribes members
Being an Environmental Scientist	Eighth-grade class, Clair E. Gale Junior High School, Idaho Falls, ID
INEEL Environment and Foundation Research	Environmental science class, Skyline High School, Idaho Falls, ID
Bird Monitoring Programs on the INEEL	Upper Snake River Audubon Society
History of and Research on the Idaho National Environmental Research Park	DOE-ID Office of Program Execution representatives
Conducting Research on Wildland Fires on the INEEL	Science Action Team members and advisors
History of Ecological Research at the INEEL Leading to the Protective Cap/Biobarrier Experiment	National Risk Management Research Laboratory, U.S. Environmental Protection Agency
Evolution of the Protective Cap/Biobarrier Experiment	George Schneider, DOE-ID
Soil Dynamics at a Low-Level Radioactive Waste Management Site	Northwest Scientific Association Annual Meeting, Yakima, WA
Effects of Wildlife and Species of Concern and Wetlands on Environmental Restoration Planning and Activities	INEEL Environmental Restoration project managers
Ecology of the INEEL Site	Rutgers University researchers

Table 1 (Continued). Foundation Presentations During 1997.

Title	Audience
Sorption and Transport of Radionuclides by Tumbleweeds from Two Plastic Lined Evaporation Ponds	Health Physics Society Annual Meeting, San Antonio, TX
Environmental Science and Research Foundation Overview	Parsons Engineering staff
The Hydrologic Evaluation of Four Cover Designs for Hazardous Waste Landfills	Landfill Capping in the Semi-Arid West: Problems, Perspectives, and Solutions, Grand Teton National Park, WY
Potential Doses from Game Animals	Environmental monitoring class, Idaho State University, Pocatello, ID
Capping as an Alternative to Landfill Closures: Perspectives and Approaches	Landfill Capping in the Semi-Arid West: Problems, Perspectives, and Solutions, Grand Teton National Park, WY
Soil-plant Covers Systems for Final Closure of Solid Waste Landfills in Arid Regions	Landfill Capping in the Semi-Arid West: Problems, Perspectives, and Solutions, Grand Teton National Park, WY
Habitat use by summer populations of bats in sagebrush-steppe	Brigham Young University, Department of Zoology, Ecology and Systematics Division, Provo, UT
An ecological engineering approach for keeping water from reaching interred wastes in arid or semiarid regions.	International Containment Technology Conference, St. Petersburg, FL
A Soil-Plant Cover System for Keeping Water from Reaching Interred Hazardous Wastes	Conference on Hazardous Wastes and Materials, Pocatello, ID
Modeling the location of snake dens on the Idaho National Engineering Laboratory	Idaho Chapter of Wildlife Society Annual Meeting, Boise, ID
Modeling the location of snake dens on the Idaho National Engineering Laboratory. Platform Presentation	Society for Northwestern Vertebrate Biology/Washington Chapter of Wildlife Society Annual Meetings, Yakima, WA
Modeling Snake Dens on the Eastern Snake River Plain	Society for Study of Amphibians and Reptiles Annual Meeting, Seattle, WA
Reptiles of the Pacific Northwest Workshop	Society for Northwestern Vertebrate Biology/Washington Chapter of Wildlife Society Annual Meetings, Yakima, WA
Introduction to Snakes and Other Reptiles	Pint-sized Academy Program, Idaho Museum of Natural History, Pocatello, ID
Snake Safety on the INEEL	Radioactive Waste Management Complex personnel, INEEL
Snake Safety on the INEEL	Willow Creek Building employees, INEEL
Snake Safety on the INEEL	Custer County Elementary School Teachers, Challis, ID
Snake Safety on the INEEL	Test Area North personnel, INEEL
Snake Safety on the INEEL	Woodruff Avenue Complex employees, INEEL
Snake Safety on the INEEL	Idaho Chemical Processing Plant personnel, INEEL
Snake Safety on the INEEL	Science Action Team members and Foundation summer hires and staff

Table 2. Foundation Signs, Posters, and Displays During 1997.

Title	Location
INEEL Offsite Environmental Surveillance Display	Snake River School/Community Library (Moreland, ID)
INEEL Offsite Environmental Surveillance Display	American Falls (ID) District Library
INEEL Offsite Environmental Surveillance Display	Clark County (ID) District Library
INEEL Offsite Environmental Surveillance Display	Earth Day Fair, Ricks College, Rexburg, ID
INEEL Offsite Environmental Surveillance Display	Idaho Academy of Science Annual Meeting, Idaho Falls, ID
INEEL Offsite Environmental Surveillance Display	Eco Fair, Idaho Museum of Natural History/Idaho State University, Pocatello
INEEL Offsite Environmental Surveillance Display	Ririe (ID) Public Library
INEEL Offsite Environmental Surveillance Display	INEEL Citizens Advisory Board Meeting, Sun Valley, ID
INEEL Offsite Environmental Surveillance Display	St. Anthony (ID) Public Library
INEEL Offsite Environmental Surveillance Display	Lost River Visitor Center (Arco, ID)
INEEL Offsite Environmental Surveillance Display	Mackay (ID) District Library
INEEL Offsite Environmental Surveillance Display	Sugar Salem School/District Library (Sugar City, ID)
INEEL Offsite Environmental Surveillance Display	North Bingham District Library (Shelley, ID)
INEEL Offsite Environmental Surveillance Display	Hamer Branch, Jefferson County District Library
DOE's National Environmental Research Parks	North American Association for Environmental Education Annual Conference, Vancouver, British Columbia, Canada
Protective Cap/Biobarrier Experiment: A Replicated, Field-scale Comparison of Barrier Performance	Landfill Capping in the Semi-Arid West: Problems, Perspectives, and Solutions, Grand Teton National Park, Wyoming
Protective Cap/Biobarrier Experiment A Replicated, Field-scale Comparison of Barrier Performance	INEEL Citizens Advisory Board Meeting, Sun Valley, ID
Help the INEEL Conquer Noxious Weeds	Central Facilities Area Cafeteria, INEEL
Madison Middle School Community Monitoring Station	Madison Middle School, Rexburg, ID
Mountain View Middle School Community Monitoring Station	Mountain View Middle School, Blackfoot, ID
The Protective Cap/Biobarrier Experiment: Assessing Natural Materials and Ecological Processes to Isolate Hazardous Waste	Protective Cap/Biobarrier Experiment visitors, Experimental Field Station, INEEL
Recreation Rates, Risk Perception and Future Land Use Preferences of People Living Near the Idaho National Engineering and Environmental Laboratory	Consortium for Risk Evaluation with Stakeholder Participation Annual Meeting, Seattle, WA

Table 3. Foundation Reports Published During 1997.

Report Number	Report Name	Author(s)
ESRF-016(2QT96)	INEEL Offsite Environmental Surveillance Program Report: Second Quarter of 1996	Don Peterson, Russell Mitchell, Donny Roush
ESRF-016(3QT96)	INEEL Offsite Environmental Surveillance Program Report: Third Quarter of 1996	Don Peterson, Russell Mitchell, Donny Roush
ESRF-016(4QT96)	INEEL Offsite Environmental Surveillance Program Report: Fourth Quarter of 1996	Ron Brooks, Russell Mitchell, Donny Roush, Don Peterson
ESRF-017	Environmental Science and Research Foundation Annual Technical Report to DOE-ID, Calendar Year 1996	Randall C. Morris and Roger D. Blew (eds.)
ESRF-018 and DOE/ID-12082(96)	Idaho National Engineering and Environmental Laboratory Site Environmental Report for Calendar Year 1996	Russell G. Mitchell, Ron W. Brooks, Don Peterson, Luke R. Paulus, Donny Roush, Don B. Martin, B. Sue Lantz
ESRF-019	Conference Proceedings of "Landfill Capping in the Semi-Arid West: Problems, Perspectives, and Solutions"	Timothy D. Reynolds and Randall C. Morris (eds.)
ESRF-021(1QT97)	INEEL Offsite Environmental Surveillance Program Report: First Quarter of 1997	Ron Brooks, Don Peterson, Donny Roush
ESRF-022	In Summary: Idaho National Engineering and Environmental Laboratory Site Environmental Report for Calendar Year 1996	Russell G. Mitchell, Donald E. Roush, Jr., and Donald S. Peterson
ESRF-024	INEEL Elk Related Depredation Problems; Information and Potential Solutions	Ronald W. Warren and O. Doyle Markham

SECTION III

ENVIRONMENTAL SERVICES AND SUPPORT

Ecological and natural resource related information is vital not only for the completion of environmental compliance documentation (e.g. Environmental Checklists, Environmental Assessments, and Environmental Impact Statements) but is important for the day-to-day management at the INEEL. For example, knowing the habits of rattlesnakes and the location of den sites can improve worker safety. Foundation staff members have more than 90 years collective experience collecting and interpreting ecological and environmental information at the INEEL. This knowledge resource is valuable to the entire INEEL family. The Foundation makes this information available to DOE-ID, Lockheed Martin Idaho Technologies Company (LMITCO), subcontractors, INEEL stakeholders, and the general public. Responding to requests for information and expertise is a growing segment of the Foundation's activities. Valuable as it is, past experience is insufficient to assure competent decision making. Past experience with the ecological resources of the site must be supplemented with current knowledge about the constantly changing plant and animal populations on the INEEL. For this reason, the Foundation regularly conducts plant and wildlife surveys and interprets the results of these surveys for INEEL decision makers.

The Foundation's role in performing and interpreting plant and animal surveys complements its role in transferring information to the public, state and federal agencies, and legislators. Being aware of the current condition of the population of plants and animals enables us to respond quickly and accurately to public concerns about environmental issues involving the INEEL. For example, past wildlife depredation on agricultural areas near the INEEL prompted criticism of DOE by the Idaho Department of Fish and Game (IDF&G) and local legislators. Knowledge of the current status and trends in the populations of elk and pronghorn helps the Foundation anticipate depredation problems work with IDF&G and DOE to proactively address depredation issues and explore reasonable resolutions. The quality of the environment on and near the INEEL is important to most local residents because it is one of the last large, undisturbed areas of sagebrush steppe remaining in the western United States, and is an important habitat for game and nongame animals. The scientific community also recognizes the inherent ecological benefits of such a large tract of protected and relatively undisturbed habitat. Such was the consensus of scientists participating in a workshop to develop the scientific basis for long-term land use management at the INEEL. In addition, because of the vast tracts of sagebrush-steppe, and the long-term history of research on birds, the INEEL was designated a National Important Bird Area in 1997.

OBJECTIVES

The Foundation's specific environmental services and support objectives are to:

- Respond to requests from DOE-ID, other DOE sites, other State and Federal agencies, and members of the public for assistance, advice, and information on a wide range of issues, including wildlife and environmental surveillance.

INEEL managers as well as resource managers at other DOE facilities, or with other State and Federal Agencies, often require information about the INEEL environment to effectively manage the resources in their care. The Foundation is the primary repository of such information. In addition, responding promptly and accurately to these requests is an important part of the INEEL initiative to be open and honest about environmental issues. Because the environmental picture at the INEEL is generally positive, this also provides positive public relations for DOE.

- Conduct field investigations and offer ecological recommendations for the National Environmental Policy Act (NEPA) process.

Most Environmental Checklists require biological evaluations and many require field investigations. The Foundation performs these evaluations and investigations. The Foundation also provides current information about the plant and animal species inhabiting the INEEL, including threatened, endangered, or other species of special concern, for use in Environmental Assessments and Environmental Impact Statements.

- Coordinate and participate in studies to determine the status of Threatened and Endangered, or otherwise important species on the INEEL.

There is one Endangered Species (gray wolf), two Threatened Species (bald eagle and Ute's ladies tresses), and 16 species of concern that may occur on, or may be impacted by, the INEEL. Monitoring these species is necessary to ensure DOE-ID is able to meet its legal obligations with regard to the Endangered Species Act. Monitoring these species and their habitats also simplifies and expedites NEPA field evaluations for activities at the INEEL. In addition, depredating species (e.g. pronghorn, elk and mule deer) and other game species (e.g. sage grouse and jackrabbits) are of interest to the local public and other State and Federal agencies. Elk and pronghorn have caused extensive damage to crops in agriculture lands adjacent to the INEEL in the past decade. Monitoring these species provides information with which to develop management strategies for animals that use the INEEL for part or all of the year. It also allows DOE to have informed dialog with game management agencies and stakeholder groups.

Breeding Bird Surveys have proven to be an effective method of monitoring ecological and environmental change and effects of WAGS. For this reason, the Foundation continues to conduct annual Breeding Bird Surveys. For more information on this effort, see the research report titled *1997 Breeding Bird Surveys at the INEEL* in Section IV of this report.

Similarly, birds of prey are at the top of the food chain and are important indicators of ecological and environmental change. For this reason, the Foundation participates in the annual midwinter eagle count sponsored by the Biological Resources Division of the U.S. Geological Survey. On the INEEL, the Foundation expands this count to include all raptors. This count enables us to track population trends and to compare trends on the INEEL with those in similar locations. These data help the biological evaluation of construction and other activities on the INEEL to prevent further decreases in sensitive species. Two raptors (ferruginous hawk and burrowing owl) inhabiting the INEEL are former C2 candidates for listing as threatened or endangered under the Endangered Species Act. We periodically monitor nesting success of these species to:

- Serve as a point of contact for environmental expertise and information exchange with the USDA Forest Service, USDA Animal and Plant Health Inspection Service (Wildlife services, formerly Animal Damage Control [ADC]), USDA Dubois Sheep Experiment Station, USGS Biological Resource Division Raptor Research Center, USDI Bureau of Land Management (BLM), USDI National Park Service, USDI Fish and Wildlife Service and the Idaho Department of Fish and Game in matters involving natural resource management.

Sharing information with these agencies is important for enhancing and maintaining DOE's credibility with them. The Foundation has specific responsibilities with respect to some of these agencies. For example, as part of the DOE Memorandum of Understanding with BLM that established the grazing zones on the INEEL, DOE agreed to fund predator control in the grazing areas. The Foundation funded and administered that program for DOE in 1997. During some years the INEEL is winter range for one third of all the pronghorn in Idaho and hundreds of elk. Besides being game species, these animals have a history of depredation on the agricultural fields surrounding the site. The IDF&G is responsible for managing this depredation problem. Because these animals spend time on the INEEL, an area mostly closed to hunting, IDF&G looks to DOE-ID for assistance. The Foundation contributes to the dialogue between DOE and IDF&G on this and other issues. For example, the Foundation provides current information about animal population trends to IDF&G and has assisted in the coordination of elk removal operations.

- Correspond with USF&WS to satisfy the requirements of Section 7 of the Endangered Species Act and exercise local authority to determine whether proposed developments on the INEEL require formal Biological Assessment consultation with that agency.

Compliance with the Endangered Species act requires DOE-ID to semiannually ask the USF&WS for an updated list of threatened and endangered species likely to occur on the INEEL. The Foundation makes this request on behalf of DOE-ID. Moreover, the Foundation advises DOE-ID and contractors when it is appropriate to enter into a formal Section 7 Consultation with the USF&WS.

- Coordinate and encourage use of the Idaho National Environmental Research Park by ecologists, environmental scientists, and other natural resource scientists.

The boundaries of the INEEL enclose a large expanse of undeveloped and relatively undisturbed sagebrush steppe habitat. This unique environment provides an excellent opportunity for environmental scientists and ecologists to study natural processes and, in particular, the impact of human energy development on such systems. For this reason, DOE designated the INEEL as a National Environmental Research Park in 1975. As coordinator of the Research Park, the Foundation encourages scientists to perform research on the INEEL, coordinates their work, and assists them with logistics. DOE-ID obtains valuable data about the INEEL environment from the studies performed by these scientists. In addition, by supporting this research DOE demonstrates its concern for the environment to the public. Finally, because much of the research is conducted by students seeking graduate degrees, DOE demonstrates its support for science education.

- Review and contribute to documents describing the ecology and radioecology of the INEEL whether generated at the

INEEL, by other DOE sites, or by outside agencies.

Foundation staff are recognized as experts on the ecology and environment of the INEEL as well as in individual speciality disciplines. We review manuscripts for technical accuracy and often author the ecological sections of various INEEL documents.

PROGRAM ACCOMPLISHMENTS

Following is a brief summary of the variety and scope of the environmental services and support provided by the Foundation staff. During the calendar year of 1997, the Foundation:

- Responded to more than 250 requests for information about our environmental surveillance and research programs, or the environmental contamination, radioecology, and ecology of the INEEL.

These requests came from DOE-ID, its contractors, interest groups, the scientific community, and the general public. Responses to these requests included short, informal telephone conversations, preparation of written responses (sometimes extensive documents) and formal presentations such as the four invited talks to the INEEL Citizens Advisory Board.

- Conducted 21 field evaluations in support of NEPA at the INEEL (Table 4). The Foundation has taken a leading role in monitoring compliance with requirements of Environmental Checklists during the progress of projects at the INEEL.
- Provided ecological surveys to support the NEPA Environmental Assessment for the Partnership for Natural Disaster Reduction.
- Provided assistance in developing revegetation plans and assisted the INEEL Stormwater Pollution Prevention Plan Coordinator in monitoring the success of revegetation efforts (Table 5).
- Corresponded with the USF&WS to satisfy the requirements of Section 7 of the Endangered Species Act. The list of listed and proposed endangered and threatened species and species of concern (Table 6) was distributed to the DOE-ID NEPA Compliance Officer, LMITCO NEPA Environmental Affairs, several INEEL subcontractors and various individuals.
- Coordinated the annual national mid-winter eagle count sponsored by the USGS Biological Resources Division Raptor Research Field Station.

The zone surveyed covered the INEEL and all of Butte and Clark Counties. Several staff members participated in this count. For the INEEL, this was an expanded effort to count not only eagles, but all raptors.

- Conducted two big game surveys (midwinter and midsummer) and supplied the resulting data to DOE-ID and the IDF&G.
- Participated in INEEL meetings including several established group meetings [e.g., Ecological Risk Assessment Working Group, Natural Resource Damage Assessment Trustees meetings, NEPA Planning Board], ad hoc committees (e.g., Emergency Preparedness for Flood Response, Wildland Fire Lessons Learned, Wildland Fire Management, Birch Creek Wetland, Service Wastewater Disposal at ICPP) and singular meetings (e.g. Environmental Issues for Mission Management Group, Noxious Weed Management)
- Provided funding to USDA APHIS Wildlife Services to conduct predator control on the INEEL. During 1997, 23 lambs were killed by predators on the

Table 4. NEPA Field Evaluations conducted by the Environmental Science & Research Foundation during 1997.

Date	Contractor	NEPA Number	Project
1-14	LMITCO	INEL-97-001	TRA Sewer Upgrade
3-18	LMITCO	INEL-97-005	ICPP Shallow Perched Water Investigation
3-26	LMITCO	PBF-97-002	Comprehensive Remedial Investigation/Feasibility Study
3-26	LMITCO		Advanced Combined Environments Testing Station
4-9	ESRF	INEL-97-010	Monitoring Effects of Dust Suppression Activities on Vegetation Recovery Following Fire
4-9	LMITCO	PBF-97-003	WAG 5 Operable Unit 5-01 ARA 16 Tank Sampling
4-22	LMITCO		Status of Cold Test Pit Cultural, Historical, or Biological Clearances for FY-97 Stabilization Studies
4-28	LMITCO	CPP-97-005	ICPP Radionuclide Contaminated Soils Removal
5-5	LMITCO	CFA-97-006	WAG-4 Miscellaneous Sites Non-Time Critical Removal Action CFA-08, -13, -17/47, and -42
5-7	LMITCO	INEL-97-013	Unexploded Ordnance Removal Action
5-13	LMITCO	INEL-97-015	Chaotic Dynamic-Conceptual Model of Fluid Flow in Fractured Vadose Zone Project
5-15	LMITCO	INEL-97-014	1997 INEEL Groundwater Monitoring at TRA
5-19	LMITCO	INEL-97-016	Big Lost River Dike Rip-Rap
6-5	ESRF	INEL-97-018	Water Infiltration Into and Through Ant Nests
6-5	LMITCO	CPP-97-019	Contaminated Soils Removal Action at the ICPP
6-6	LMITCO	PBF-97-004	WAG 5 Comprehensive Remedial Investigation/Feasibility Study at OU 5-10 ARA-01 Chemical Evaporation Pond, OU 5-07 ARA-02 Sanitary Waste Leach Field and Seepage Pit, and OU 5-12 ARA-23 and -24 Surface Soils Around ARAI, II, and III, and ARA-10 Septic Tank
6-16	LMITCO	CPP-96-009	Revision of CPP Spent Nuclear Fuel Dry Storage
6-17	LMITCO	INEL-97-007	Operable Unit 10-04 Comprehensive Remedial Investigation Feasibility Study FY97 Field Sampling
7-15	LMITCO	INEL-96-	FY-98 Road Rehabilitation
7-31	LMITCO	INEL-97-017	INEEL - TRU Waste Transportation from RWMC to ANL-W
7-31	LMITCO	CPP-97-021	1997 TMI-2 ISFSI Drilling at ICPP

Table 5. Revegetation planning and inspection projects assisted by the Environmental Science and Research Foundation.

Date	Contractor	Action	Project
4-16	LMITCO	inspection	Monitoring Wells Northeast of ICPP Seeding
4-16	LMITCO	inspection	NODA Road Reclamation
4-16	LMITCO	inspection	TRA Sewage Lagoon Seeding
4-16	LMITCO	inspection	Van Buren Boulevard Roadside Seeding
4-24	LMITCO	planning	ICPP Well Pad Re-seeding
5-13	LMITCO	inspection	SDA Buried Cable Trench Seeding
5-13	ESRF	inspection	Uptake Research Project Seeding
5-13	ESRF	inspection	Travelers Radio Transmitter Seeding
7-24	LMITCO	inspection	CFA Fire and Medical Complex Seeding
7-31	LMITCO	inspection	ICPP Electrical Substation Seeding
9-24	LMITCO	planning	Spreading Area B Seeding
9-24	LMITCO	planning	Well Pad Seeding
10-6	LMITCO	planning	Aquifer Pump and Infiltration Test Basin Reclamation
10-7	LMITCO	inspection	CFA Landfills II and III Cover Seeding
10-7	LMITCO	planning	CFA Fire and Medical Complex Seeding
10-8	LMITCO	planning	Old Fire Training Area Reclamation Seeding
11-4	LMITCO	planning	BORAX V Reclamation Seeding
12-23	LMITCO	planning	ICPP Substation Haul Road Re-seeding

INEEL. In response to complaints by livestock operators, 73 coyotes were taken by APHIS personnel.

- Facilitated the use of the Idaho National Environmental Research Park by 29 scientists from 13 universities. A total of 158 university personnel participated in Foundation programs on the INEEL. The activities of these scientists, their students, and their staff are described in Section IV of this document.
- Helped organize and participated in a workshop to develop the scientific basis for long-term land management of the INEEL, edited and published the workshop proceedings.
- Wrote a section about the INEEL's annual environmental reporting requirements for the INEEL Integrated Safety Management System Program report.
- We hosted a national workshop on landfill capping in the semi arid west, which attracted over 130 participants from agencies, DOE contractors, municipalities, Indian tribes, and the private sector.
- Continued to be active in professional societies (e.g. Idaho Academy of Science, Northwest Scientific Association, Health Physics Society, Ecological Society of America, Society

Table 6. Listed Threatened and Endangered Species and Other Species of Concern Possibly Occupying the INEEL (from USF&WS July 1997).

Species	Classification	Occurrence on the INEEL
Bald Eagle (*Haliaeetus leucocephalus*)	Listed: Threatened	Winter visitor most years
Gray Wolf (*Canis lupus*)	Listed: Endangered, Experimental Population	Several unconfirmed sightings on the INEEL since 1993.
Ute's Ladies Tresses (*Spiranthes diluvialis*)	Listed: Threatened	Unknown on the INEEL
Long-eared Myotis (*Myotis evotis*)	Former C2 species	Limited distribution on INEEL
Small-footed Myotis (*Myotis subulatus*)	Former C2 species	Relatively common over much of INEEL
Townsend's Big-eared Bat (*Plecotus townsendii*)	Former C2 species	Year round resident on INEEL
Pygmy Rabbit (*Brachylagus idahoensis*)	Former C2 species	Limited distribution on INEEL
Merriam's Shrew (*Sorex merriami*)	State protected species	Limited distribution on INEEL
Ferruginous Hawk (*Buteo regalis*)	Former C2 species	Summer resident; widespread distribution on INEEL
Long-billed Curlew (*Numenius americanus*)	Former C2 species	Summer resident; limited distribution on INEEL
Northern Sagebrush Lizard (*Sceloporous graciosus graciosus*)	Former C2 species	Widespread distribution on INEEL
Painted Milkvetch (*Astragalus ceramicus* var. *apus*)	Former C2 species	Common in sandy areas dominated by sagebrush on the north end of the INEEL
King's Bladderpod (*Lesquerella kingii* var. *cobrensis*)	Idaho Native Plant Society monitor list	Uncommon on East Butte
Nipple Cactus (*Coryphantha missouriensis*)	Idaho Native Plant Society monitor list	Uncommon on Reno Point
Sepal-tooth Dodder (*Cuscuta denticulata*)	Idaho Native Plant Society Category 1	Not known on INEEL
Lemhi Milkvetch (*Astragalus aquilonius*)	Idaho Native Plant Society Sensitive Species	Limited to western foothills on INEEL
Winged-seed Evening Primrose (*Camissonia pterosperma*)	Idaho Native Plant Society Sensitive Species	Rare in northwest foothills on INEEL
Spreading Gila (*Ipomopsis* [=*Gilia*] *polycladon*)	Idaho Native Plant Society Category 2	Limited to western foothills on INEEL
Tree-like Oxytheca (*Oxytheca dendroidea*)	Idaho Native Plant Society Sensitive Species	Uncommon; wide spread in sandy soils on INEEL

for Range Management, American Society of Mammalogists, Soil Science Society of America and others).

The Foundation supported ecological risk assessment on the INEEL during 1997 through field surveys, document reviews, and presentations. Specific accomplishments included:

- Provided input to the Field Sampling Plan for the WAG 10-04 Ecological Risk Assessment. This was done in cooperation with LMITCO staff members and our University Affiliates.
- A Foundation staff member made a presentation to members of the Shoshone-Bannock Tribes about the ecological resources of the INEEL. This presentation was part of a larger presentation on the Site-wide Ecological Risk Assessment.
- Attended a DOE-HQ Peer Review of the INEEL's Sitewide Ecological Risk Assessment.

A Foundation staff member addressed the group about locations and status of sensitive and other species of interest on the INEEL and the quality of the INEEL environment. Subsequently, the draft report of the Peer Review Committee indicated there is "large body of existing information which indicates no ecological impacts to threatened and endangered (T/E) species, Category 2 (C2), or other species have occurred due to on-site activities." This is substantially different from the claim we did make, to the effect we have found no evidence of such impacts to the populations of interest.

- In cooperation with LMITCO, we planned and conducted surveys for sensitive species and habitats on and near facilities on the INEEL.
- At the request of DOE-ID, we responded to comments from the US Fish and Wildlife Service on the Field Sampling Plan for the Site-wide Ecological Risk Assessment. They were primarily concerned about use of ponds by migratory waterfowl and whether the currently planned sampling will adequately address their risks.
- One Foundation staff member collaborated with two LMITCO employees to prepare two peer-reviewed publications describing the innovative methodologies they developed for screening level ecological risk assessments at the INEEL.

As of the end of 1997, those manuscripts were in galley proofs with publication planned for early 1998.

Important Results

The mid-winter raptor survey and the two big game surveys provided results important for understanding the potential impacts of INEEL activities on wildlife species of concern.

The results of the mid-winter raptor survey are reported in Table 7. Two bald eagles were observed within the INEEL boundary. Also noteworthy was the occurrence of a gyrfalcon on the INEEL, the first recorded during a mid-winter raptor survey. As usual, the most common raptor observed on the site during the survey was the rough-legged hawk. Numbers of these birds were above the long-term average. Due to natural year-to-year variability in populations and wintering conditions, changes in numbers of raptors observed were not considered significant when compared to the long-term averages.

A record 6,365 birds, representing 61 species, were recorded during the annual breeding bird survey (BBS). Three species were added to the BBS survey records, although they had been previously

Table 7. Number of birds of prey observed on the INEEL during the 1997 winter raptor survey

Species	1997 tally	Long-term average
Bald eagle	2	1.6
Golden eagle	10	9.6
Merlin	1	0.1
Prairie falcon	1	1.7
Peregrine falcon	0	0.1
Gyrfalcon	1	0.1
American kestrel	4	0.9
Rough-legged hawk	91	60.1
Red-tailed hawk	0	0.6
Ferruginous hawk	0	0.3
Swainson's hawk	0	0.1
Northern harrier	0	0.9
Great-horned owl	0	0.6
Short-eared owl	0	1.6
Common raven	89	25.9
Northern shrike	5	2.7

documented on the INEEL outside the BBS time period.

The midwinter big game survey was conducted February 8-9, 1997. Using standard line-transect techniques, we observed 353 elk and estimated a population of 3,286 ± 692 pronghorn. The number of elk observed was about 60% higher and the pronghorn population was about 3.5 times higher than in the winter of 1996 survey. Deep snows in higher elevations likely resulted in this observed increased.

The midsummer survey was conducted on July 14-16, 1997, again using standard line transect techniques. Sixty elk were observed and 200-400 pronghorn were estimated on the INEEL. The number of pronghorn estimated on the INEEL is lower than that of 1996 but compares well with numbers estimated for 1994 and 1995. The number of elk observed in the summer of 1997 was slightly higher than the 53 elk observed during the summer survey of 1995.

Also completed in 1997 was a white paper to DOE-ID describing the history of elk on the INEEL, current depredation problems, and the pros and cons of various methods for the control of site elk populations.

SECTION IV

RESEARCH BENEFITTING THE DOE-ID MISSION

PROGRAM DESCRIPTION AND SUMMARY

At the Idaho National Engineering and Environmental Laboratory (INEEL), the Foundation sets scientific goals and conducts environmental research consistent with the needs of the Department of Energy, Idaho Operations Office (DOE-ID). DOE-Chicago Operations Office and Pittsburgh Naval Reactors Office also benefit from Foundation research through the needs of their facilities on the INEEL, Argonne National Laboratory-West and the Naval Reactors Facility. Because the INEEL is a National Environmental Research Park, the Foundation also coordinates ecological research on the INEEL that is not directly supported by funds from DOE-ID. Foundation research supports decision-making and regulatory compliance for Waste Management, Environmental Restoration, Spent Nuclear Fuels, and DOE Infrastructure Programs. DOE uses these data for complying with various mandates and regulations including, but not limited to, the National Environmental Policy Act, the Endangered Species Act, the Migratory Bird Treaty Act, the Federal Noxious Weed Act, and the Natural Resource Damage Assessment and Risk Assessment sections of the Comprehensive Environmental Response, Compensation, and Liability Act. Moreover, Foundation research is consistent with statements by the Secretary of Energy regarding land stewardship responsibilities and environmental protection, and promotes the mission statement of the National Environmental Research Park.

Some Foundation research projects are INEEL-wide in scope. They are not tied specifically to any particular DOE-ID program, but generally benefit all programs. For example, the Townsend's big-eared bat is a former Category 2 species under the Endangered Species Act, and is considered a species of concern by the U.S. Fish and Wildlife Service and the Idaho Department of Fish and Game. Surveys conducted for this species indirectly benefits all site activities and programs by providing the population and distribution information needed to maintain compliance with the National Environmental Policy Act. Big game surveys (pronghorn, deer, and elk) are also not tied to a particular INEEL program, but provide information that allows DOE to work effectively with stakeholders (e.g. adjacent land-owners, sportsmen, legislators, and the Idaho Department of Fish and Game) on issues related to crop depredation and hunting.

Other projects, such as research into the effect of plastic liners on radionuclide cycling and transport in evaporation ponds, and determining uptake parameters of selected radionuclides, are more program specific. Although an individual project may have a single funding source, the research often benefits more than one major INEEL program. Table 8 summarizes which major INEEL programs benefit most from particular research projects.

In 1997, the Foundation conducted 27 research projects on the INEEL. We developed technical publications from three projects for which field work was previously completed. Many individual research projects were related, providing a more comprehensive approach to a particular goal. Projects could be organized into three general categories: (1) contaminant transport, detection, and effects; (2) stewardship of natural resources; and (3) ecology of waste covers. Results

Table 8. DOE-ID Program Beneficiaries of Specific Environmental Science and Research Foundation Research Projects.

Research Project	DOE Program[1]			
	IS	WM	ER	SF
Wildlife Use of Man-Made Ponds on the INEEL		■	■	■
Breeding and Wintering Populations of Raptors on the INEEL	■	■	■	■
Comparison of Four Protective Cap Designs		■	■	
Mitigating Long-Term Impacts of Small Mammal Burrowing		■	■	
Effectiveness of Ant Biobarriers: Establishing Colonies on PC/BE		■	■	
Soil Subsidence and Snowmelt Erosion on Waste Disposal Sites	■	■	■	
Distribution and Abundance of the Pygmy Rabbit	■	■	■	■
Concentrations of Heavy Metals in Populations of Small Mammals		■	■	
Long-Term Vegetation Dynamics	■	■	■	
Habitat Use and Movement Patterns of Mule Deer	■			
Plutonium Distribution Among Soil Phases at the INEEL		■	■	
Lichens as Biomonitors of Air Pollution		■	■	
Breeding Bird Surveys and Long-term Data Analyses	■	■	■	■
Distribution and Status of Reptiles and Amphibians on the INEEL	■	■	■	■
Diversity of the Ant Fauna over the INEEL	■	■	■	■
Radioactivity Cycling in Plastic Lined Evaporation Ponds		■		
Radioecology of ^{129}I in the Sagebrush Steppe		■	■	■
Surface Water Penetration at the Subsurface Disposal Area		■	■	
Occurrence of Small Owls Species on the INEEL	■	■	■	■
Fire Ecology of the INEEL	■		■	
Movement of radionuclides by barn swallows		■	■	
Contaminant uptake on decommissioned radioactive waste ponds		■	■	
Effects of Wastewater Irrigation on Sagebrush Steppe		■		
Noxious Weeds on the INEEL	■	■	■	■
Bats on the INEEL	■	■	■	■
Trace Elements & Organics in SDA Soils		■		
Uptake Parameters Important to INEEL Ecological Risk Assessment			■	

[1] DOE Program abbreviations: IS = Infrastructure, WM = Waste Management, ER = Environmental Restoration, SF = Spent Fuels.

from some projects, such as the suite of experiments associated with the Protective Cap/Biobarrier Experiment, can potentially make significant contributions to municipal and industrial landfill practices, including low-level radioactive waste management. These contributions can result in a considerable future cost savings to DOE.

Fundamental to the Foundation's research program is the active participation of universities from Idaho and other states. This association is mutually beneficial. Universities provide specialized expertise at a reasonable cost to complement the skills available within the Foundation staff. University faculty and students benefit from

educational and research opportunities offered by the Foundation. Five Foundation staff members and 18 University Affiliates served as principal investigators on research projects at the INEEL. University personnel included 62 university researchers, graduate students, and research assistants and represented 13 universities. Additional Foundation staff members and university personnel supported other phases of the research. A total of 158 university personnel participated in Foundation programs during 1997.

The most important product of research is information. For the Foundation that information is generally made available in the form of reports and publications. These provide factual and citable sources of information for various INEEL documents (e.g., the *Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement, Comprehensive Facilities and Land Use Plan*, and the *Environmental Assessment for New Silt/clay Borrow Source*). These products provide the credible, defensible, scientific information base needed to support decision making regarding INEEL operations, land and natural resource stewardship, and many other issues.

Because the process of scientific research is not complete without the scrutiny of other scientists, Foundation researchers are strongly encouraged to publish their findings in peer reviewed science journals. In order for the benefits of Foundation research to reach a broader audience, the Foundation also strongly encourages its researchers to recast the information for less technical outlets, including the *Foundation Focus* newsletter. In 1997, Foundation research appeared in print in eight technical articles and one book. Twelve more manuscripts were accepted for publication in the technical literature, and another nine were submitted to journals and are at various stages in the review process. Eight Foundation technical reports were published. Other tangible products of our research program include designs (e.g., low-level waste covers), scientific equipment development, new research techniques, novel data analysis procedures, and creative application of existing technologies in new areas.

A product common to all Foundation research projects, and deserving special recognition, is new scientists with advanced degrees. Generally, one or more graduate students work under the direction of a principal investigator on each of the research projects. These students receive training in research principles, field experience, and report writing while conducting research for the Foundation. The research provides substance for a Master's thesis or Ph.D. dissertation and satisfies the research requirements for an advanced degree. Fifteen Master of Science students and three Ph.D. students were supported by their participation in Foundation research.

Following are summaries of the individual research projects detailing the scope, significance, major accomplishments, important results, and products produced during 1997. Some of these projects are in their infancy and their summaries focus on preliminary accomplishments, such as locating a suitable study area or installing equipment, rather than on scientific results or products. For more mature projects, field work may be complete and products such as technical publications and presentations are highlighted.

COMPARISON OF FOUR PROTECTIVE CAP DESIGNS FOR BURIAL OF HAZARDOUS WASTE AT THE IDAHO NATIONAL ENGINEERING AND ENVIRONMENTAL LABORATORY

Jay E. Anderson[1], Teresa D. Ratzlaff[1], Eric Duffin[1], and Amy Morris[1]

The Protective Cap/Biobarrier Experiment (PC/BE) was designed to test the efficacy of four variations of a soil-plant cover system for precluding water from reaching buried waste. Our previous research confirms the postulate that in a semiarid climate, where potential evapotranspiration (ET) far exceeds actual ET, a 2-m soil cap covered with perennial vegetation will adequately protect interred waste from moisture. The PC/BE includes a gravel/cobble layer to investigate the effects of a soil profile interrupted by a biological intrusion barrier on the movement of water, the plant root growth, and the burrowing depth of rodents and ants. We are comparing caps having biobarriers at 0.5 m or 1 m with caps having 2 m of uninterrupted soil and with caps designed to Environmental Protection Agency (EPA) specifications. The EPA cap includes 1 m of soil, an impermeable plastic liner, and 0.6 m of compacted clay soil. These caps are treated with either supplemental summer irrigation, fall/spring irrigation, or receive ambient precipitation only. We are testing these variables under two vegetation treatments: a crested wheatgrass monoculture, and a suite of native species.

OBJECTIVES

The ultimate objective of the Protective Cap/Biobarrier Experiment is to confidently recommend an effective, economical soil-plant cover system for interred wastes at the INEEL and climatically similar repositories. The specific objectives for 1997 were to:

- Compare water percolation, extraction, and drainage in soil profiles of four soil-cap configurations under three irrigation treatments and two vegetation types.
- Compare water storage in soil above biobarriers with that in soil-only plots at the same depth.
- Compare native plant cover among cap types and irrigation treatments.
- Determine whether plant roots bridge biobarriers.
- Establish complementary study plots in a native species area at the Experimental Field Station (EFS) to test the effects of simulated climate change on species composition and availability of soil nitrogen. Compare plant cover, species composition, and nitrogen availability between summer and fall irrigation treatments on the complementary study plots. Analyze soil samples from the complementary study plots to estimate nitrogen mineralization through the season.
- Establish a meteorological station at the PC/BE for collecting local data.
- Use local meteorological data to model rates of potential evapotranspiration.
- Estimate evapotranspiration for each subplot and compare means to those derived from models.

PROJECT ACCOMPLISHMENTS

The PC/BE was constructed in 1993-94. We sampled plant cover, soil moisture, and plant physiological parameters in successive years. Despite record precipitation during the summer of 1995, drainage was observed

[1]Department of Biological Sciences, Idaho State University, Pocatello, ID 83209-8007

only in two subplots in fall/spring irrigation treatments. No drainage was observed from any plots in 1996. Extraction of water beneath the biobarriers in both shallow and deep barrier plots implied that plant roots had bridged the biobarriers in 1996. For 1997:

- We estimated soil water content biweekly during the growing season and compared percolation, soil water extraction, and drainage among four cap designs under ambient precipitation and two supplemental irrigation treatments.
- Soil water content above biobarriers was compared to that of soil-only caps at the same depth.
- Plant cover was estimated by point interception on five transects per native species subplot.
- We examined graphs created from soil moisture data to determine if roots are bridging the biobarriers.
- Eighteen plots were established in a natural sagebrush community at the Environmental Field Station to investigate effects of precipitation patterns on species composition. Plant cover was estimated by point interception on these plots before irrigation treatments were initiated. Supplemental irrigation was applied during the summer on six plots, in the fall on six plots, and six plots received only ambient precipitation. Mineralization tubes and resin bags were used to estimate rates of nitrogen mineralization of soils.
- We installed a meteorological station at the PC/BE site. Weather data were collected from instrumentation and included in mathematical models to estimate potential ET.
- We estimated ET for each subplot and compared results among caps, vegetation types and irrigation treatments. ET, estimated by water balance, was compared to potential ET derived from models.

Important Results

Interpretation of data and other results for 1997 included:

- Under ambient precipitation and summer irrigation treatments, all caps were effective at precluding drainage. In 22 of 24 subplots, water did not percolate through biobarriers, and by the end of the season, soil water content was equal to that of fall 1996 in all subplots. In soil-only plots, water percolated nearly to the bottom in 5 of 12 subplots, but all precipitation and irrigation received was extracted by the end of the season. There were no differences between vegetation types for all parameters tested.

- Performance under fall/spring irrigation treatments varied. Percolation to the bottom 0.2 m of soil was observed in all soil-only subplots under fall/spring irrigation treatments, and soil water was depleted throughout the profile to about 15% by the end of the season. Percolation through the biobarriers was observed in all 0.5 barrier subplots, and extraction below the 0.5 m biobarriers was observed in five of six subplots. In contrast, water percolation through the 1 m biobarriers was observed in only two of six subplots, but extraction below the biobarriers was observed in four of six subplots, under both vegetation treatments. Drainage from the top of the liner occurred in most EPA plots, but drainage from the bottom of plots was not observed.
- Storage of water in soils above biobarriers was greater than that in the soil-only caps at the same depths.
- Mean plant cover was higher on all caps and treatments than typically observed in native communities of the area.

Mean cover was 69% on soil-only caps, 55% on 0.5-m barrier caps, 64% on 1-m barrier caps, and 52% on EPA caps. Mean plant cover was 73% in fall/spring irrigation subplots, 59% in summer irrigation subplots, and 49% in ambient precipitation subplots.

- Apparent extraction of water by plant roots occurred in all subplots in shallow barrier plots, and three of six plots in the deep biobarrier caps under fall/spring irrigation, indicating that plant roots do bridge the biobarriers, given sufficient soil water.
- On the complementary study plots, summer irrigation caused an increase in the growth of grasses and extended the period of mineralization of nitrogen.
- We tested six models for predicting potential ET (PET) for the PC/BE by incorporating meteorological data collected at the PC/BE site (Figure 3). PET is estimated for a complete cover of grass, 1.5 m high, drawing from an unlimited water supply (Shuttleworth 1993). Model predictions ranged from 483 to 792 mm for the period of April 18 through September 23, 1997; predictions for the period after September 23 indicate that energy was available for ET throughout the month of October at the PC/BE site. To predict actual ET levels at the PC/BE site, these results must be calibrated in a way that will reflect the dynamics of moisture flow exhibited by the sagebrush-steppe vegetation and dry soils found at the INEEL.
- Variation in predicted levels of PET is a reflection of model structure and input parameters. The Thornthwaite and Turc models estimated potential ET to be approximately 200 mm greater than actual ET for both irrigation treatments. These models utilize air temperature as a single input parameter. The Penman Monteith (PM) and FAO modified Penman (FAO-P) models incorporate relative humidity and windspeed into their calculations. These two parameters reflect the influence of advection produced by dry winds typically found in semi-arid environments. As a result, the PM and FAO-P models may be more representative of climatic conditions influencing ET at the INEEL.

PRODUCTS

The following publications and presentations relating to the above research were produced in 1997.

Publications:

- Anderson, J. E. 1997. An ecological engineering approach for keeping water from reaching interred wastes in arid or semiarid regions. Pp. 243-251 *In* Conference Proceedings at the International Containment Technology Conference, St. Petersburg, Florida.
- Anderson, J. E. 1997. Soil-plant cover systems for final closure of solid waste landfills in arid regions. Pp 27-37 *In* Reynolds T. D. and R. C. Morris (eds.) Landfill Capping in the Semi-Arid West: Problems, Perspectives, and Solutions. Environmental Science and Research Foundation, ESRF-010. Idaho Falls, Idaho.

Presentations

- Anderson, J. E. 1997. An ecological engineering approach for keeping water from reaching interred wastes in arid or semiarid regions. The International Containment Technology Conference, St. Petersburg, Florida. February 9-12, 1997.
- Anderson, J. E. 1997. Soil-plant cover systems for final closure of solid waste landfills in arid regions. DOE/ESRF Conference: Landfill Capping in the

Semi-Arid West--Problems, Perspectives, and Solutions. Jackson Lake Lodge, WY. May 21-22, 1997.

- Anderson, J. E. 1997. A soil-plant cover system for keeping water from reaching interred hazardous wastes. 1997 Conference on Hazardous Wastes and Materials. Pocatello, ID. April 8-9, 1997.

In addition, Dr. Jay Anderson presented results from the PC/BE and Long-term Vegetation studies to the INEEL State Advisory Board in Sun Valley, Idaho.

Dr. Jay Anderson received the 1997 Earth Day Environmental Award for New Environmental Technology Development, which was on presented on April 22. The award was sponsored by the Idaho Division of Environmental Quality, the Idaho Museum of Natural History, Idaho Department of Fish and Game, Greater Pocatello Chamber of Commerce, and the ISU Institute for Business and Environment. Dr. Anderson was recognized for his work and that of colleagues at the Environmental Science and Research Foundation on the Protective Cap/Biobarrier Experiment.

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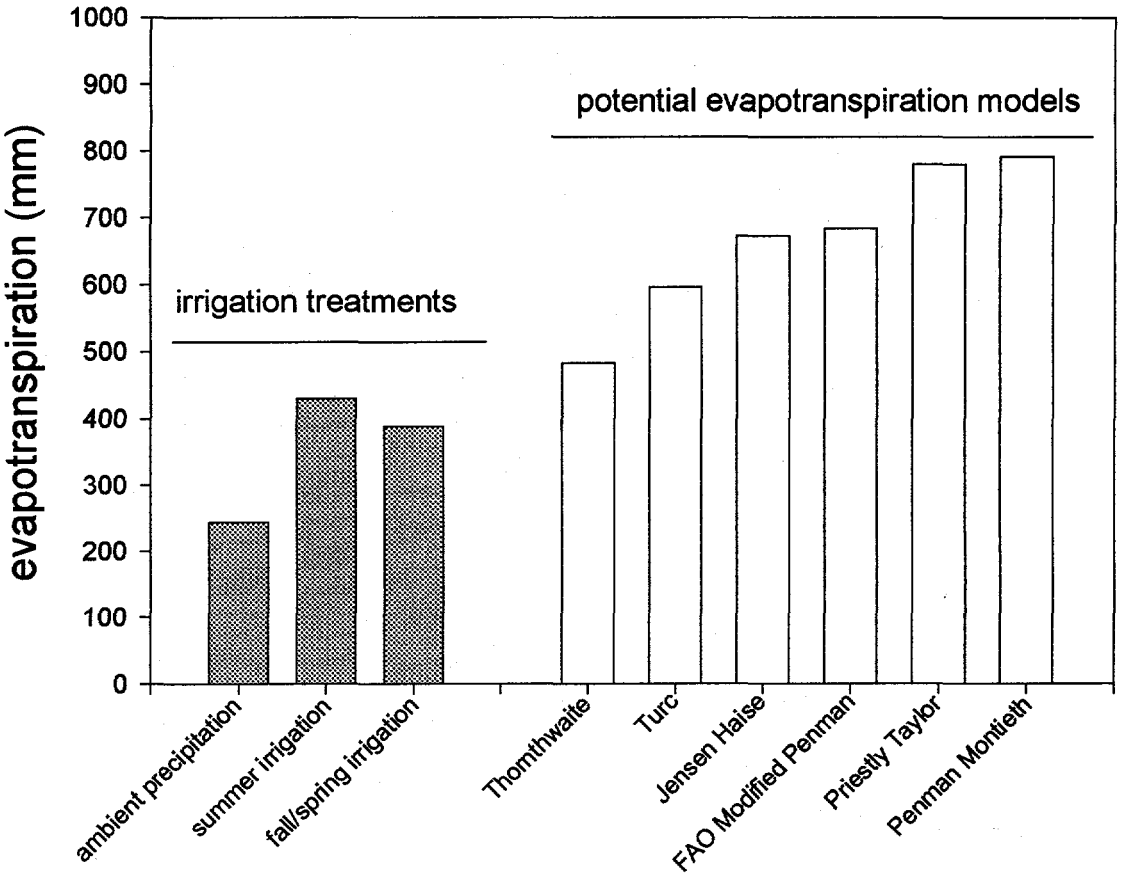

Figure 3. Evapotranspiration during the period from 18 April through 23 September 1997 from three irrigation treatments in the PC/BE and potential evapotranspiration calculated from six mathematical models (Thornthwaite 1948, Turc 1961, Saxton 1982, Smith 1988, Jensen 1990, Shuttleworth 1993). All models utilized data collected from the PC/BE site during the 1997 field season.

IMPACTS OF SMALL MAMMAL BURROWING ON THE CLOSURE OF HAZARDOUS WASTE AREAS

John W. Laundré[2]

The intrusion of burrowing mammals into hazardous waste areas (biointrusion) and the subsequent transport of waste off the burial area has been shown to be a problem on older areas and continues to be a concern regarding future closure of current waste areas. Consequently considerable effort is being expended on ways to mitigate the transport of waste by burrowing mammals.

In 1993 the Protective Cap/Biobarrier Experiment was begun on the INEEL. The project's goal is to test the effectiveness of several possible hazardous waste disposal site covers in preventing small mammals from burrowing into waste areas. The results will help determine the feasibility of using biobarriers to prevent small mammals from burrowing into waste areas.

OBJECTIVES

The overall objective of this project is to test the feasibility of using biobarriers to prevent small mammals from burrowing into hazardous waste areas. This objective will be accomplished by:

- Testing the effectiveness of three potential biobarrier layers to small mammal burrowing: (1) 5-10 cm cobble, (2) chipped roofing gravel, and (3) a mixture of gravel and cobble. Two small mammal species were used in the experiment: the kangaroo rat (*Dipodomys ordii*) and Townsend's ground squirrel (*Spermophilus townsendii*). These two species represent the deepest burrowing mammals on the INEEL (Reynolds and Wakkinen 1987 , Laundré and Reynolds 1993). The hypothesis tested for each species is that each biobarrier layer is equally effective in preventing animals from burrowing beyond the barrier layers.
- Testing the impact of small mammal burrowing on the effectiveness of these biobarrier layers as capillary breaks to water movement into the soil: The hypothesis being tested is that moisture movement beyond the capillary break during spring recharge is similar for enclosures containing small mammals and the controls.

Specific objectives for calendar year 1997 were to:

- Continue sampling soil moisture in the experimental enclosures.
- Begin excavating the burrows in the enclosures to determine their depth.

PROJECT ACCOMPLISHMENTS

Prior to 1997, experimental enclosures were constructed to simulate four proposed biobarriers. Small mammals were introduced into the enclosures and their burrowing activity has been monitored. Soil moisture has also been monitored to determine impacts of the mammals and the biobarriers themselves on soil water behavior.

Project accomplishments for the calendar year 1997 include:

- Sampling of soil moisture above and below the biobarriers during the spring

[2]Department of Biological Sciences, Idaho State University, Pocatello, ID 83209

recharge.
- Excavation of burrows in enclosures
- Planning of the release of ground squirrels into the PC/BE area during 1998.

Important Results

Soil moisture data from 1997 were combined with previous years. Analyses indicate:

- Soil moisture in the 50 cm of soil above biobarriers was significantly greater that for soil controls.
- When water did penetrate the biobarrier, it was able to penetrate deeper into the profile than that found in the controls.
- In all the enclosures excavated, there is no evidence that ground squirrels or kangaroo rats penetrated the biobarrier material.

Products

Three manuscripts were submitted in calender year 1997. One was published, one accepted, and the other is currently in press:

- Laundré, J. W. 1997. The impact of a shallow biobarrier on water recharge patterns in a semi-arid environment. Pp. 270-274 *In* Proceedings of 1997 International Containment Technology Conference and Exhibition. St. Petersburg, Florida, USA.
- Laundré, J. W. In Press. Effect of ground squirrel burrows on plant productivity in a cool desert environment. Journal of Range Management.
- Laundré, J. W. Accepted. The relationship between carbon isotope ratios and sagebrush productivity. Oecologia..

A paper titled *The impact of a shallow biobarrier on water recharge patterns in a semi-arid environment* was presented at the 1997 International Containment Technology Conference and Exhibition held in St. Petersburg, Florida, February, 1997.

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EFFECTIVENESS OF BIOBARRIERS IN PREVENTING HARVESTER ANTS FROM ENTERING WASTE SITES

Michael D. Gaglio[3], Erick A. Osorio[3], William P. MacKay[3], and Susan I. Watts[3]

Research continued on the effectiveness of biobarriers in preventing harvester ants from entering waste sites. Ant nest established on the Protective Cap Biobarrier Experiment (PC/BE) were monitored for viability and new nests were added to increase the density on the experimental plots. Additionally, research was conducted to determine the effect of ant nests on water infiltration rates and drying cycles in soil.

The harvester ant *Pogonomyrmex salinus* has been shown to excavate nests that can reach depths greater than 1.5 m and a radius of over 1 m away from their center (MacKay 1981). These tunnels form macropores in the soil that may increase the rate of infiltration of water into the soil profile, allow more water to reach deeper depths and, affect the drying cycle of the soil (Wang et al. 1996). It is conceivable that in the event of a flood or massive rain or rapid snowmelt, large volumes of water could move rapidly through the soil column by way of macropores such as ant tunnels. This poses a potential threat to ground water under low level nuclear waste sites (Blom 1990).

OBJECTIVES

Because ants established on the PC/BE require at least two years to undergo adequate nest formation, more time is needed before the extent of these burrow systems can be examined and the effectiveness of the biobarriers can be evaluated. Therefore, the primary focus of the work during CY-97 was to determine the infiltration rates of water into nests and control soils and to monitor the drying cycle of treated soils. With these data we intend to determine the extent of water infiltration and the time required for soils in both conditions to return to ambient moisture levels. Specific objectives for CY-97 were to:

- Monitor harvester ant, *P. salinus*, nests previously established on the PC/BE plots.
- Re-establish nests that may have moved or perished and evaluate the health and positions of all of the nests.
- Establish new nests on the PC/BE, bringing the total nest count up to, or slightly above, mean nest densities in natural areas.
- Compare water infiltration rates and soil drying patterns in soils with ant nests versus soils without ant nests.

PROJECT ACCOMPLISHMENTS

All objectives set for CY-97 were met. A density of ant nests now exists on the PC/BE plots that meets, or slightly exceeds, average natural densities for the area surrounding the PC/BE. Data on the ant populations transplanted in 1996 have been summarized and a draft manuscript written, and data has been collected on water infiltration into ant nests and soil drying patterns. Specific accomplishments for CY-97 included:

- We replaced six nests that were no longer viable and established 12 new nests, bringing the total nest count on the PC/BE plots to 27. This is higher than mean nest densities in natural areas

[3] University of Texas at El Paso, El Paso, TX 79968

similar to the PC/BE plots (Blom et al. 1991) and will therefore test the PC/BE plots for integrity and colony carrying capacity well.

- To calculate infiltration rates we used 20-cm diameter PVC infiltrometers to observe the infiltration rates of 10 L of water into 13 *P. salinus* nests and similar control soils. This method simulates the application of 31.8 cm of precipitation to a concentrated area. Nests were chosen at random within the area on the west side of the Experimental Field Station (EFS) at the Idaho National Engineering and Environmental Laboratory (INEEL). Control sites were located 1 m from the edge of the disc of a nest that was being treated.
- Following the infiltration event, we waited 24 hours, then installed 4-cm diameter aluminum neutron probe access tubes in the center of the infiltrometers. A dry control access tube and a dry nest access tube were installed in a nearby nest to monitor ambient soil moisture. Soil samples were obtained at 20, 60, and 100 cm to determine initial soil moisture. Every 24 hours thereafter, we took neutron probe readings at intervals of 20 cm in depth, for at least nine days.

IMPORTANT RESULTS

Three nests have been successfully transplanted to each of the 12 PC/BE plots. Plots containing biobarriers contained colored aquarium gravel placed in a 1-m^2 (10.9 ft^2) area above and below the biobarrier layer. Within three days, colored tracer gravel was noted on the surface of the first nest, indicating ants had excavated down to the top of the biobarrier at 0.5 m (1.7 ft). Colored gravel was subsequently seen on the surface of five more nests within one week of establishment.

Nests of *P. salinus* increase infiltration rates of water by at least 10 fold, and in some cases, the rate increased over 110 times (Figure 4). Neutron probe data suggest that soils disturbed by ant activity allow water to penetrate deeper, but also dry more quickly than undisturbed soils (Figure 5).

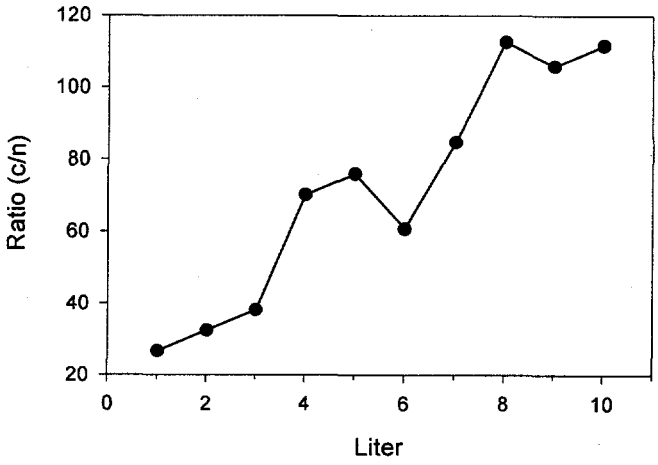

Figure 4. Mean ratio of infiltration rates (control/nest) for each liter.

- Increased infiltration- An important element in the design of any protective cap is its ability to prevent water from permeating through buried waste and contaminating ground water. The presence of *P. salinus* nests presents a challenge to the integrity of a protective cap because the nests allow more water to penetrate much more quickly than it would in conditions of undisturbed soil.
- Rapid drying cycle- Though the nests allow water to penetrate more quickly and to deeper depths, the soil also dries more rapidly. This is likely the result of the combination of ant activity and the increased surface area of soil exposed to air as a result of the tunnels. This may reduce the likelihood of water becoming contaminated and returning to the water table because it is cycled out of the soil quickly.

- Given the normal precipitation and history of the area in which the INEEL is located, it is not likely that nests under natural conditions should ever be subjected to the stress of nearly 32 cm of precipitation in approximately a 24 hour period. Therefore, we believe that nests of *P. salinus* do not pose an immediate threat to the ground water under low level nuclear waste buried under a 2-m protective cap. The next step in testing the PC/BE would be to reproduce this experiment on the PC/BE plots. This would be necessary in order to determine effects of nests on moisture penetration of the various plots.
- The nests that remained on the PC/BE plots from the 1996 field season appeared to be well established and productive.

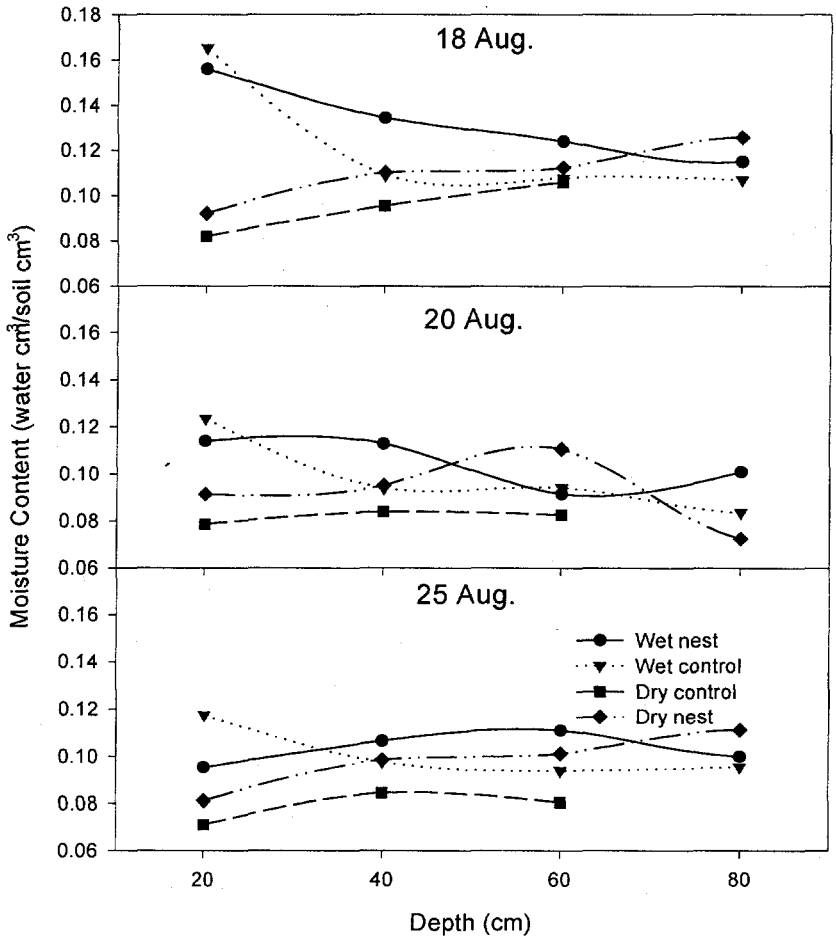

Figure 5. Mean soil moisture content of soil at several depths over time. Wet nest and wet control were treated with 10 L of water; dry nest and dry control were ambient levels.

PRODUCTS

Currently, we have a manuscript entitled, *Populations of POGONOMYRMEX SALINUS Harvester Ants (Hymenoptera: Formicidae)*, going through peer review and revision. It will be submitted for publication in the spring of 1998. We will also present those and other data discussed here at the Southwestern Association of Naturalists annual symposium in 1998. These data will form the basis of a masters thesis by Michael Gaglio.

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DISTRIBUTION, ABUNDANCE, AND HABITAT USE OF THE PYGMY RABBIT ON THE IDAHO NATIONAL ENGINEERING AND ENVIRONMENTAL LABORATORY

John W. Laundré[4], Laura T. Heady[4], and Kate I. Gabler[4]

The pygmy rabbit is the smallest North American rabbit species (Dobler and Dixon 1990). It is considered a sagebrush obligate but this relationship and other aspects of this species have been little studied. Currently, the western United States is experiencing annual losses of native sagebrush habitat. The INEEL represents one of the last large protected areas for pygmy rabbits. However, little is known of the suitability of the diverse habitat on the INEEL for pygmy rabbits. This study was initiated to learn more of the distribution, abundance, habitat use, and behavior of this species on the INEEL. Ultimately, by learning more about this unique species, the INEEL can assist in the preservation of biodiversity in the Great Basin desert ecosystem.

Providing mitigation for pygmy rabbits could have major, costly implications for current operations and future development at the INEEL. To comply with NEPA regulations, INEEL personnel need information on the pygmy rabbit's distribution, abundance, and habitat needs. Access to this information will enable rapid and inexpensive assessment of the potential suitability for pygmy rabbits of areas considered for development.

OBJECTIVES

This research is designed to assess pygmy rabbit distribution, abundance, and habitat needs on the INEEL and develop a habitat suitability index (HSI) as a valid predictor of possible pygmy rabbit occurrence on the Site. Objectives for CY-97 were to:

- Assess habitat characteristics of burrowing and foraging areas: Measure habitat characteristics including density and height of tall and short shrubs, topographic characteristics, and soil texture.
- Calculate a habitat suitability index HSI: calculate the index as the first principal component of vegetation height, soil composition, and topographic complexity.
- Combine habitat information with Geographical Information System (GIS) vegetation files of the INEEL to develop a predictive index of possible pygmy rabbit locations.
- Determine the reliability of the HSI. By analyzing data from 30 sites predicted to have rabbits to determine the accuracy of HSI predictions.
- Based on the above analyses, produce a map of likely rabbit locations on the INEEL.

PROJECT ACCOMPLISHMENTS

During the calendar year 1997, the following were accomplished:

- A map of potential pygmy rabbit habitat on the INEEL was created (Figure 6).
- Sampling of all predicted sites and non-predicted sites was completed.
- Calculation of an HSI was completed.
- Calculation and testing of the predictive GIS model was completed.

[4] Department of Biological Sciences, Idaho State University, Pocatello, ID 83209-8007

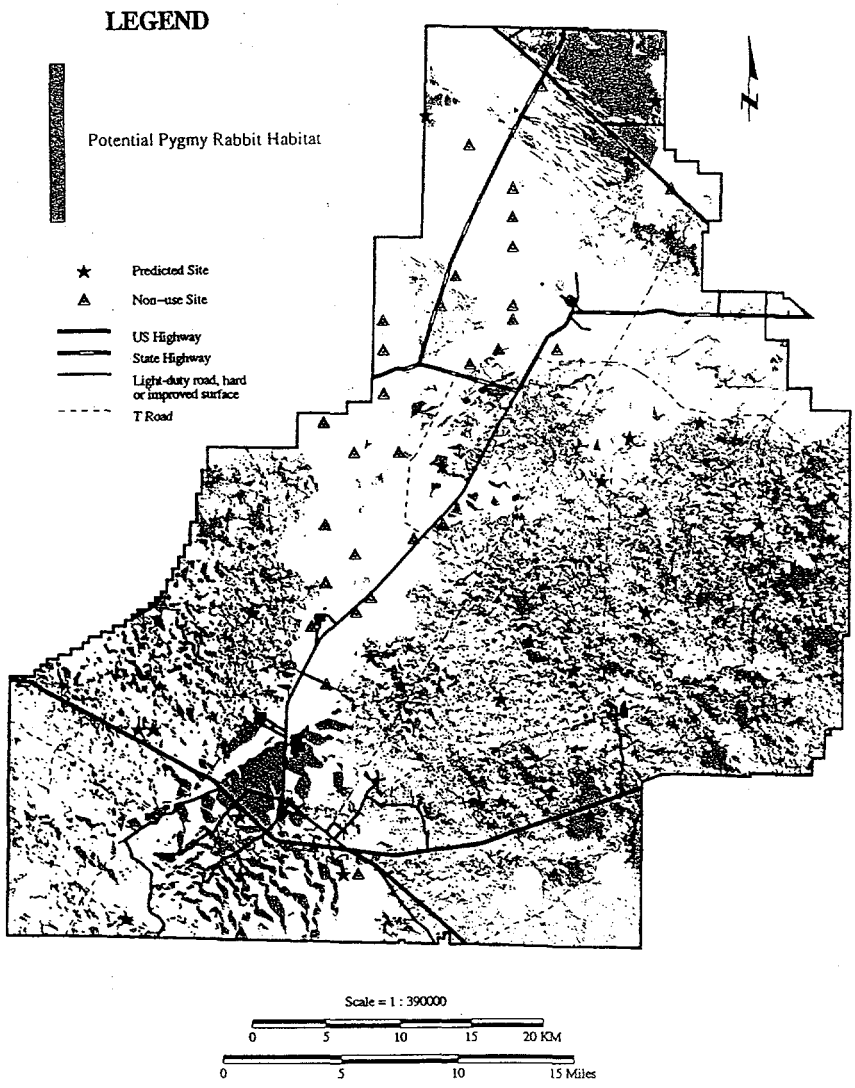

Figure 6. Potential pygmy rabbit habitat on the INEEL. Predicted use sites and predicted non-use sites searched in this study are displayed.

- Analysis of individual pygmy rabbit home range patterns was completed for eight individuals.
- Point quarter sampling of vegetation, measurements of topographic features, and soil samples were completed at 12 burrow sites.
- Data from approximately 500 camera trap nights were analyzed.
- Activity pulse data collected during radiotelemetry sessions were analyzed.

IMPORTANT RESULTS

The survey of the INEEL for pygmy rabbits indicated that the population is

significantly lower than that reported by Wilde (1978). Most burrow sites found had been abandoned within the last few years. Active sites only contained a few animals.

- The predictability of the GIS model for correctly identifying pygmy rabbit sites was 57%. The model had a 100% predictability of identifying non pygmy rabbit sites.
- Approximately 77% of the Site can be considered potentially appropriate habitat for pygmy rabbits. However only 23% of the site was classified as suitable for potential burrow sites.
- Analysis of location data suggests that males utilize a larger home range area than females. Pygmy rabbits do not use their home range uniformly; rather, there are areas of high, medium, and low use. The distribution of movements are clumped in the burrow area, along with approximately 10 additional 30-m^2 cells within the home range. The remainder of home range appears to receive low use.
- Within 40 x 40 m point-quarter sampling grids around the burrow sites, short shrub density was significantly higher in peripheral sampling cells (approximately 15 m from the burrow entrance) than in cells adjacent to the burrow (P=0.001). No trends were observed for tall shrub density. Height of tall shrubs was significantly higher in adjacent sampling cells than in peripheral cells (P=0.018). No trends were observed for height of short shrubs.
- Completed analysis of data indicate that daily summer activity peaks were observed at sunrise and early morning, between approximately 0600 and 0800, and at sunset, between 2000 and 2200. These data suggest that pygmy rabbits are not entirely crepuscular; they persist in a relatively high level of activity throughout the morning hours.

PRODUCTS

Products produced from this research include a map of potential pygmy rabbit habitat on the INEEL (Figure 6), development of a Habitat Suitability Index for pygmy rabbits, and a tested GIS model for pygmy rabbit habitat. One Masters thesis was completed during CY 97:

- Gabler, K. I. 1997. Distribution and habitat requirements of the pygmy rabbit (*Brachylagus idahoensis*) on the Idaho National Engineering and Environmental Laboratory. Unpublished M. S. Thesis, Idaho State University, Pocatello. 117 pp.
- A manuscript entitled *Using a geographic information system analysis to predict pygmy rabbit distribution* is in review.

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LONG-TERM VEGETATION DYNAMICS AT THE IDAHO NATIONAL ENGINEERING AND ENVIRONMENTAL LABORATORY

Jay E. Anderson[5]

The Idaho National Engineering and Environmental Laboratory occupies 2,315 km^2 of the temperate sagebrush-steppe region (West 1983) on the upper Snake River Plain in southeastern Idaho. The majority of the central portion of the INEEL has been protected from livestock grazing and other human-caused disturbances since 1950. The existence of a relatively pristine cold-desert community, coupled with a vegetation database that spans nearly half a century, provides an unparalleled opportunity to study the vegetation dynamics of sagebrush steppe. Vegetation studies were initiated at the INEEL in 1950 with the establishment of 94 permanent sample plots at 1.6-km intervals along two perpendicular lines that transect the entire INEEL from the southwest to the northeast and from the southeast to the northwest (Anderson et al. 1978).

OBJECTIVES

The major objectives of this project were to document and analyze changes in vegetation at the INEL that have taken place over the past 45 years, and to relate such changes to variation in climate or other factors such as invasions by exotic species (e.g., cheatgrass, *Bromus tectorum*). Specific objectives for FY 1997 were to:

- Update the long-term vegetation database for the INEEL.
- Analyze the 1995 vegetation data.
- Prepare a manuscript on long-term vegetation dynamics at the INEEL.

PROJECT ACCOMPLISHMENTS

In calendar year 1997 we:

- Analyzed the 1995 vegetation data in the context of the entire database.
- Completed a draft of a comprehensive manuscript on long-term vegetation dynamics at the INEEL entitled, *Long-term vegetation dynamics in sagebrush steppe at the Idaho National Engineering and Environmental Laboratory.*

IMPORTANT RESULTS

- Over the 45-year period of record, cover of perennial grasses and shrubs was correlated with the amount of precipitation received 2 to 5 years prior to the year of the census.

The response of shrubs differed from that of perennial grasses. Cover of grasses was best correlated with a 4-year lag in precipitation, whereas the lag time was shorter, 2 - 3 years, for shrubs. We postulate that these patterns reflect differences in life histories, rates of growth, and patterns of recruitment among the different species.

- The proportion of total plant cover contributed by big sagebrush (*Artemisia tridentata*) has declined significantly since 1950. This change has been accompanied by modest increases in the relative cover of green rabbitbrush (*Chrysothamnus viscidiflorus*) and

[5] Department of Biological Sciences, Idaho State University, Pocatello, ID 83209-8007

perennial grasses.

- We found strong evidence suggesting that biotic interactions such as competition among species may influence species abundances.

Cover of perennial grasses was negatively correlated with that of shrubs in those census years in which perennial grass cover was highest, indicating that the increase in perennial grass cover following wetter years was constrained in areas having high shrub cover.

- The average number of species per sample plot (species richness) of both shrubs and perennial grasses has increased over the 45 years of record.

In six of nine census years, cover of perennial grasses was positively correlated with species richness). Similarly, shrub cover and species richness were positively correlated in 8 of 9 years. These results are consistent with recently described patterns from grasslands in Minnesota (Tilman 1996, Tilman et al. 1996), and they support the hypothesis that there is an important mechanistic link between species diversity of an ecosystem and its productivity.

PRODUCTS

A final report on the data collected in 1995 on the Long-term Vegetation transects was prepared:

- Anderson, J. E. and R. Inouye. 1997. Long-term vegetation dynamics in sagebrush steppe at the Idaho National Engineering and Environmental Laboratory. Final Report Contract No. FOUND-94-IDAHO-04. 55pp.

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HABITAT USE BY MULE DEER ON THE INEEL

James M. Peek[6] and David E. Beaver[6]

The lands of the INEEL, which are designated as a National Environmental Research Park, constitute a possibly crucial area of winter habitat for regional populations of mule deer, and present a rare opportunity to investigate the unique type of habitat represented by the sagebrush steppe of the upper Snake River Plain. Local game management agencies are under considerable pressure from both consumptive and non-consumptive users to protect and provide for wildlife populations under their jurisdiction. Therefore, management of these populations is important not only to the INEEL, but also to other stakeholders involved in the regulation, management, and conservation of wildlife. Regulation and conservation activities are possible only if a basic understanding of mule deer requirements are known. Information from this study will allow DOE to knowledgeably discuss wildlife issues with management agencies and stakeholders, such as the Shoshone-Bannock Tribes, the Idaho Department of Fish and Game, and the Bureau of Land Management, and help make informed decisions regarding the management of deer on and near the INEEL.

OBJECTIVES

Overall objectives of this research are to determine habitat use by deer in relation to domestic livestock grazing, patch size of habitat and type of habitat, determine selective preference in homogeneous habitat between non-treated and land-surface waste-water application areas, determine seasonal movements of mule deer on the INEEL, estimate mule deer depredation on croplands adjacent to the INEEL, estimate mule deer densities on the INEEL, investigate the feasibility of establishing green strips to supplement winter forage and serve as fire breaks, and to investigate possible effects of prescribed burns on big game habitat use on the INEEL.

The primary objectives of this study for CY-97 were to complete compilation and analysis of all collected data sets. Preliminary interpretation of these results was also a task scheduled for CY-97. These included:

- Delineate home range areas of mule deer from the location data collected during the winter and summer of 1995 and 1996.
- Create a suitable geographic information system (GIS) based vegetation map of the study area from which to obtain habitat use and availability data.
- Create database of habitat use/availability and habitat-patch dynamics for each individual study animal, and statistically analyze results.
- Determine effects of waste-water application on certain components of desert vegetation.
- Complete laboratory examination of vegetation samples collected during the study period and perform statistical analysis on the results to investigate forage components such as digestibility and composition.
- Complete a survey regarding attitudes toward big game and depredation of landowners adjacent to INEEL, and analyze results.

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[6] Department of Fish and Wildlife Resources, University of Idaho, Moscow, ID 83844

- Begin preparation of manuscripts detailing the findings of all aspects of this study.

ACCOMPLISHMENTS

During 1997, data collected from field work were compiled and analyzed to determine the seasonal habitat use of mule deer (*Odocoileus hemionus*) on the INEEL. Several laboratory analyses were conducted to obtain measurements of vegetation protein content and elemental composition in order to determine possible driving forces for mule deer habitat selection. Accuracy assessments of systems used in this study were finalized and these results are available. GIS database files were used to create a new habitat map suitable for the habitat use/availability and habitat patch analysis aspects of this study. A survey of landowners adjacent to INEEL has been completed in order to determine perceptions of mule deer depredation. A draft manuscript of the results from this survey has been prepared.

- Home ranges were estimated for all animals in the study. This was done with the most recent methods available in an effort to most accurately describe the area inhabited by the study animals.
- A GIS vegetation map was developed that would be amenable to the investigation of habitat use/availability and habitat patch analysis. This was done using previously developed vegetation maps of the INEEL and current satellite images of the study area. The final result is a map that adequately represents the vegetation types of interest to this study.
- Merging of the home range and vegetation mapping data was completed and a statistical analysis of the results was performed. This analysis was done in order to assess whether the animals were preferentially selecting habitats on a seasonal basis.
- Laboratory analysis of vegetation samples taken from both the untreated and waste-water treated areas of the INEEL was completed. Data were statistically analyzed.
- A survey of landowners adjacent to the INEEL was completed and analyzed. A manuscript detailing the findings of this survey is in draft form.

IMPORTANT RESULTS

The analysis of all data sets is nearly complete but the final interpretation of these results is ongoing. It is, however, possible to state the following findings without incorporating a detailed interpretation at this time.

- Mule deer in this study did not select habitats differently between 1995 and 1996 but apparently did between summer and winter. It is likely that some environmental factor had a part to play in this observation. Several measured variables are being investigated such as precipitation, temperature and heating degree days.
- Results indicate the land application of waste-water at the CFA affects the elemental composition of the desert vegetation. Elevated levels of certain elements such as phosphorus, sodium, sulfur, zinc and manganese were found in this area relative to non-application areas.
- Non-application area vegetation components, such as digestibility and protein content, varied between 1995 and 1996. Reasons for this are being investigated and are most likely related to annual differences in precipitation.
- Results of the landowner survey on perceptions of depredation indicate that most owners feel mule deer are not a

significant problem, pronghorn antelope are only slightly more of a nuisance and that elk are indeed a problem worthy of attention.

PRODUCTS

Data analysis has been the focus of this effort during CY-97. No publications have been submitted. However, the development of a usable GIS vegetation map for the INEEL and surrounding area was a significant undertaking. Accuracy assessments of Global Positioning Systems and radio-telemetry in the desert environment typified by the INEEL are complete and available. A draft manuscript, *Landowner and permit-holder perceptions of wildlife damage around the Idaho National Engineering and Environmental Laboratory*, is in review. A manuscript entitled, *Review of supplemental feeding of big game in Western North America and Central Europe*, is in the process of being incorporated into a book discussing the management of big game.

PLUTONIUM DISTRIBUTION AMONG SOIL PHASES AROUND THE SUBSURFACE DISPOSAL AREA AT THE IDAHO NATIONAL ENGINEERING AND ENVIRONMENTAL LABORATORY

Shawki A. Ibrahim[7]

From 1954 through 1970, transuranic solid waste from the Rocky Flats Plant was buried at the Subsurface Disposal Area (SDA) at the Idaho National Engineering and Environmental Laboratory (INEEL). Soil samples collected near the SDA indicated plutonium contamination outside the SDA perimeter (Markham et al. 1978). Although knowledge about the total plutonium concentration in soil is important, it is not sufficient to assess its potential ecological mobility and human risk. Prediction of plutonium transport in soil-water systems can be significantly improved if its physicochemical association with the various solid phases of the soil are well defined.

OBJECTIVES

The overall objective of this project was to determine the physicochemical associations between plutonium and various soil phases.

The specific objectives of this project for 1997 were to:

- Complete the laboratory work on the association of plutonium in six important chemical and mineralogical soil phases controlling its transport in soils and seep waters.
- Summarize the results in a manuscript for submission in the peer-reviewed literature.

PROJECT ACCOMPLISHMENTS

We fully met our goals for 1997.

- Plutonium association with the soluble, exchangeable, carbonate, sesquioxide and silicate fractions was determined using selective sequential extraction techniques.
- A manuscript summarizing the results and findings of this work was prepared, reviewed by DOE, and accepted for publication in the Journal of Radioanalytical and Nuclear Chemistry.

IMPORTANT RESULTS

Our results suggest that plutonium in surface soil near the SDA is associated primarily with the hydrous oxide coatings of soil (37 ± 5.3%). Appreciable amounts of plutonium were also removed with the organic matter (22 ± 2.8%) and carbonates (13 ± 3.1%). On the other hand, it appears that plutonium association with the soluble and exchangeable components of the soil is relatively small (~ 4.0%). The remainder of plutonium (21 ± 4.7%) is tightly bound to the refractory silicate residue of the soil. From this work, we concluded that relatively little plutonium is available for physicochemical mobilization from soil under the present prevailing environmental conditions at the INEEL site.

[7] Department of Radiological Health Sciences, Colorado State University, Fort Collins, CO 80523-1673

PRODUCTS

The following manuscript was published:

- Ibrahim, S. A. and R. C. Morris. 1997. Distribution of plutonium among soil phases near a subsurface disposal area in Southeastern Idaho. Journal of Radioanalytical and Nuclear Chemistry 226:217-220.

LITERATURE CITED

Markham, O. D., K. W. Puphal and T. D. Filer. 1978. Plutonium and americium contamination near a transuranic storage area at Southeastern Idaho. Journal of Environmental Quality 7:442-428.

USE OF LICHENS AS BIOMONITORS OF AIR QUALITY

Lorentz C. Pearson[8]

This project was designed to develop techniques for use of lichens as biomonitors of hazardous air pollutants in semiarid areas and to use those techniques to measure the impacts of the Idaho Chemical Processing Plant and other site facilities on the sagebrush steppe of the eastern Snake River Plain. In recent years, the study focused on developing techniques requiring smaller samples of lichens and on determining how quickly effects on the lichens could be detected. The project was due to be completed in 1997. However, Dr. Pearson died unexpectedly in late February and the project manuscripts remain incomplete.

OBJECTIVES

In 1997 the objectives of the project were to:

- Complete analysis of the study results.
- Complete manuscripts describing the results of the study.

PROJECT ACCOMPLISHMENTS

Project accomplishments for calendar year 1997 include:

- Draft manuscripts were obtained from Dr. Pearson's survivors. If possible, manuscripts will be completed by Foundation staff members.

PRODUCTS

Two draft manuscripts were prepared by Dr. Pearson:

- Pearson, L. C. Draft. Air pollution affects lichen diversity and ultrastructure in a semi-arid environment in eastern Idaho.
- Pearson, L. C. Draft. Biomonitoring air quality with lichens using electrolyte leakage and energy dispersive spectroscopy.

[8] Deceased; Department of Biology, Ricks College, Rexburg, ID 83440

1997 BREEDING BIRD SURVEYS AT THE IDAHO NATIONAL ENGINEERING AND ENVIRONMENTAL LABORATORY

James R. Belthoff[9] and Brian W. Smith[9]

Thirteen permanent survey routes are located at the Idaho National Engineering and Environmental Laboratory (INEEL) and censussed annually for birds in June - July. Five routes are located in remote areas of the site, and eight routes surround different facility complexes. A computerized version of the bird survey data are maintained at Boise State University and is available for query.

OBJECTIVES

This project is designed to (1) monitor breeding birds along 13 permanent survey routes at the INEEL, (2) evaluate activities at specific Waste Area Groups in relation to birds and species of special concern, (3) update and maintain a long-term breeding bird data base for the INEEL, and (4) respond to requests for data base queries by scientists.

The specific objectives for 1997 included:

- Survey 13 permanent routes for breeding birds during June - July and complete annual technical report summarizing important results.
- Obtain GPS coordinates of bird survey routes and points, so that future analyses of bird/habitat relationships can be performed.
- Update computerized database maintained at Boise State University to include 1997 breeding bird survey data.
- Assess 1997 bird survey data in relation to longer-term data contained in the breeding bird survey database.
- Respond to queries by DOE and other agencies for information on breeding bird species and their abundance at INEEL.
- Finalize breeding bird survey manuscript for Great Basin Naturalist.

PROJECT ACCOMPLISHMENTS

Yearly surveys were conducted and the data base was managed. All previous Breeding Bird Survey records, beginning in 1985, have been verified and put in a useable computerized data base. There were seven noteworthy accomplishments in 1997:

- A manuscript on breeding birds at the INEEL (1985 - 1991) was revised and accepted for publication in Great Basin Naturalist.
- Surveys of the 13 permanent breeding bird survey routes were conducted between June 11 and June 30, 1997.
- A 14th route, located at the sewage water surface disposal area near CFA, was developed and surveyed to support another project.
- Obtained GPS coordinates for most survey points on each route to facilitate future bird-habitat relationship analyses.
- Updated computerized database of breeding birds with 1997 data.
- Responded to queries from Environmental Science and Research Foundation, Idaho Department of Fish and Game Conservation Data Center, and others for information on breeding birds at INEEL.
- Completed annual technical report and analysis of bird trend data.

[9] Department of Biology, Boise State University, Boise, Idaho, 83725

IMPORTANT RESULTS

In some respects, the 1997 Breeding Bird Survey was no different from other years; in other respects it was.

- During 1997, 6,365 individual birds were recorded along the 13 survey routes. This was the largest number of birds counted since the surveys began. There was an average of 489.6 birds per route and 12.9 birds per stop. Remote routes and Facility Complex routes had comparable numbers of birds per stop (12.8 and 12.9, respectively). But, because survey stop radii were smaller along Facility Complex routes (Belthoff et al., in press) densities were greater than along remote routes.
- Sixty-one species of birds were detected during the 1997 survey. Three, pine siskin (*Carduelis pinus*), American wigeon (*Anas americana*), and grasshopper sparrow (*Ammodramus savannarum*) were recorded along the survey routes for the first time.
- As in previous years, the five most numerous species were sage sparrow (*Amphispiza belli*), horned lark (*Eremophila alpestris*), western meadowlark (*Sturnella neglecta*), Brewer's sparrow (*Spizella breweri*), and sage thrasher (*Oreoscoptes montanus*). These comprised 70.4% of the birds detected.
- Nine species of birds were recorded in numbers noticeably larger than during previous years (i.e., greater than 2.5 standard deviations above 1985 - 1996 mean abundance). These were brown-headed cowbird (*Molothrus ater*), European starling (*Sturnus vulgaris*), barn swallow (*Hirundo rustica*), house finch (*Carpodacus mexicanus*), rock wren (*Salpinctes obsoletus*), lark sparrow (*Chondestes grammacus*), American kestrel (*Falco sparverius*), gray flycatcher (*Empidonax wrightii*), and western kingbird (*Tyrannus verticalis*). The first four of these species are closely associated with human-altered habitats. Whether increases in abundance reflects ongoing changes in native habitats is unknown. Only house finches had similar increases in 1996, which may reflect this species' continued range expansion and general population increases at the periphery of its range in the western U.S.
- Of the 61 species observed in 1997, none was more than two standard deviations below its 1985 - 1996 mean abundance.
- Species of special concern recorded in 1997 included loggerhead shrikes (*Lanius ludovicianus*, n = 47, up from 16 in 1996), ferruginous hawks (*Buteo regalis*, n = 16), Swainson's hawks (*Buteo swainsoni*, n = 3), and burrowing owls (*Athene cunicularia*, n = 3).

PRODUCTS

A summary report of the 1997 Breeding Bird Surveys was prepared and submitted to the Foundation:

- Belthoff, J. R. and B. W. Smith. 1997. 1997 breeding bird surveys at the Idaho National Engineering and Environmental Laboratory. Annual Report to ESRF.

One manuscript resulting from the breeding bird survey efforts (1985 - 1991) was accepted for publication in Great Basin Naturalist and is currently in press.

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

We also provided a report to the Conservation Data Center of the Idaho Department of Fish and Game in response to a data base query request, and another to a Foundation University Affiliate from South Dakota State University studying small owls on the INEEL.

LITERATURE CITED

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

MONITORING AMPHIBIAN AND REPTILE POPULATIONS ON THE IDAHO NATIONAL ENGINEERING AND ENVIRONMENTAL LABORATORY: INDICATORS OF ENVIRONMENTAL HEALTH AND CHANGE

John R. Lee[10], Sarah Cooper Doering[10], and Charles R. Peterson[10]

Many amphibian and reptile species are sensitive environmental indicators. Our primary research goal is to provide indicators of environmental health and change by monitoring the distribution and population trends of amphibians and reptiles on the Idaho National Engineering and Environmental Laboratory (INEEL).

OBJECTIVES

The overall approach of our studies involves collecting, archiving, and disseminating herpetological data for the INEEL. Our monitoring program collects data on the distribution, abundance, and breeding activities of the INEEL's amphibian and reptile populations. These data are combined with historic records and observations to maintain current databases of species distributions and abundance. As information is added to the herpetological database we will be able to track changes in distributions and abundance, from which we can give a measure of environmental health. Additionally, we provide herpetological expertise based on our research for INEEL employee training and educational programs as needed. Our specific objectives for 1997 included:

- Continue monitoring snake populations at three den sites on the INEEL (Cinder Butte, Crater Butte, and Rattlesnake Cave), and lizard populations at Circular Butte and Antelope Butte.
- Determine if breeding occurs in Great Basin spadefoot toads (*Scaphiophus intermontanus*, = *Spea intermontana*) when conditions are appropriate.
- Continue entering information on species distributions and abundance into a Geographic Information System (GIS) and updating dot-distribution maps.
- Refine a GIS model for snake den sites.
- Provide herpetological expertise as needed for venomous snake safety training and community outreach presentations.

PROJECT ACCOMPLISHMENTS

In 1997, we increased the number of marked snakes, and again observed spadefoot toad breeding. We added these data to the INEEL herpetological database and located additional snake dens on site through refinement of the GIS model for den locations. Also, we assisted DOE-ID by presenting numerous employee snake safety training sessions and educational presentations. Specific accomplishments included:

- In order to determine population trends of reptiles on the INEEL, we continued our monitoring at three den sites. To date, we have put passive integrated transponders (PIT-tags) in over 650 snakes among the three dens, and tallied 67 recaptures. The numbers of both marked and recaptured animals this year allowed us to begin to make rough population estimates using several indices/models.
- We confirmed spadefoot toad breeding activity in the Big Lost River Sinks again in 1997.

[10] Department of Biological Sciences, Idaho State University, Pocatello, ID 93209-8007

- New observations were added to the INEEL herpetological database. We distributed detailed forms for recording observations of amphibians and reptiles to attendees of our snake safety training sessions. We hope to utilize the experiences of INEEL personnel to improve our knowledge of the distributions of reptiles and amphibians across the site. These data should increase our coverage of areas on the INEEL other than our primary study sites.
- We re-visited areas predicted to be possible or probable dens by the GIS model. Observations of snake activity in the spring confirmed five previously unrecorded dens.
- We presented nine snake safety talks to INEEL employees. These talks offer employees opportunity to learn about all snake species found on the INEEL, with special emphasis placed on the safety issues involving rattlesnakes. The primary focus is to teach the natural history and behavior of rattlesnakes and include sections on how to avoid being bitten, as well as what to do in the unlikely event of venomous snakebite. By taking this approach, the attendees can appreciate that the actual risk of being bitten by a venomous snake is extremely low, despite the fact that the site is home to literally thousands of rattlesnakes. These sessions have all generated positive feedback from the employees, and many also yield invitations for additional presentations, both for the INEEL and local communities.

IMPORTANT RESULTS

Our results for 1997 reflected our focus on four elements: snakes, lizards, spadefoot toads and GIS modeling.

- Trapping brought the total number of PIT-tagged snakes on the INEEL to 667. Numbers of 1997 captures for each species were: 110 western rattlesnakes (*Crotalus viridis*), 28 gopher snakes (*Pituophis catenifer*), 26 western terrestrial garter snakes (*Thamnophis elegans*), 3 striped whipsnakes (*Masticophis taeniatus*), and 2 racers (*Coluber constrictor*). No desert night snakes (*Hypsiglena torquata*) have been captured since the first specimens were collected at Cinder Butte in 1995. Our trapping results indicate the three dens differ in both richness and diversity of the snake species using these areas (Figure 7). Of the 169 snakes captured in 1997, 23 had been previously marked, representing the highest number of recaptures for a single year since PIT-tagging started in 1994. Recapture rates approached those needed for statistical estimates of population size. We analyzed the mark/recapture data for three subpopulations having the highest recapture rates (rattlesnakes and garter snakes at Rattlesnake Cave and rattlesnakes at Cinder Butte) using both the Schnabel Method (Giles 1971) and the Jolly-Seber model (Overton 1995). The former yielded estimates of 513 rattlesnakes (95% Confidence Interval = 315 - 785) and 177 garter snakes (95% C. I. = 136 - 788) at Rattlesnake Cave, and 323 rattlesnakes (95% C. I. = 210 - 470) at Cinder Butte. The latter model estimated an average population of 187 rattlesnakes (annual estimates = 41 - 343) and 65 garter snakes (annual estimates = 16 - 135) at Rattlesnake Cave, and 119 rattlesnakes (annual estimates = 70 - 194) at Cinder Butte. We feel these results considerably under-estimate the actual population sizes. Preliminary computer modeling indicates current sampling effort (and

therefore current recapture rates) may be too low for accurate estimates. During the 1997 field season, we were able to increase recapture rates from 11% to 14% by supplementing trapping effort with manual captures at the den entrances. Hence, we are planning to modify our sampling design to increase the proportion of marked snakes in each population by encircling selected den openings with temporary drift fences during the spring dispersal on a triennial basis. We would continue the current annual sampling effort as well.

- Lizard surveys: Significant findings from the 1997 season include the first confirmed observation of the western skink (*Eumeces skiltonianus*) at East Butte, and yet another year during which no leopard lizards (*Gambelia wislizenii*) were found at Antelope Butte. Three adult leopard lizards were observed at Circular Butte this year, but none have been recorded from Antelope Butte since 1975. Determining whether or not the Antelope Butte population has gone extinct will require repeated surveys during the active season. In addition to the adult found at East Butte, more observations of skinks were made at Tower Crater and Rattlesnake Cave during May. Also during May, two adult desert short-horned lizards (*Phrynosoma douglasii*) were observed at the southwestern end of the site. Numerous sightings of sagebrush lizards (*Sceloporus graciosus*) were made across the entire INEEL.
- Spadefoot breeding: Spadefoot tadpoles were observed in the Big Lost River Sinks during May and June. We also received reports of tadpoles in the waste ponds at TRA. Such man-made aquatic areas across the site may give the toads opportunities for breeding during years in which the Big Lost River does not flow onto site. However, the consequences to the toads of breeding in these areas remain unknown.
- GIS modeling: During the spring of 1997, sites identified as probable or possible dens in the fall of 1996 were resurveyed for snake activity. Five additional areas were identified as den sites. We used these results to re-evaluate the den model using a one-tailed Fisher's exact test. With seven dens confirmed out of fifty areas predicted to potentially have dens, and with no dens having been located in fifty areas predicted to not have dens, the model was statistically significant with $P = 0.00624$. At present, the model is based on two of the more common lava types on site. However, of five sites surveyed that were characterized by a more rare lava type, one was found to be an active den. Inclusion of this less common lava into the GIS model may lead to the identification of additional dens in the future.

PRODUCTS

One publication, three professional presentations, four educational presentations, and nine snake safety presentations were given in 1997.

Publications

- Cooper, S. L. 1997. Idaho Native Species Account: Great Basin Spadefoot. Idaho Herp News, 9:7-9.

Professional presentations

- Cooper, S. L. 1997. Modeling the location of snake dens on the Idaho

National Engineering Laboratory. Idaho Chapter of Wildlife Society Annual Meeting. February 28, Boise, ID.

- Cooper, S. L. 1997. Modeling the location of snake dens on the Idaho National Engineering and Environmental Laboratory. Society for Northwestern Vertebrate Biology/Washington Chapter of Wildlife Society Annual Meetings. March 26, Yakima, WA.
- Cooper, S. L. 1997. Modeling snake dens on the eastern Snake River Plain. Society for Study of Amphibians and Reptiles Annual Meeting. June 28, Seattle, WA.

Educational presentations

- Peterson, C. R. and S. L. Cooper. 1997. Reptiles of the Pacific Northwest Workshop, Society for Northwestern Vertebrate Biology/Washington Chapter of Wildlife Society Annual Meetings. March 28, Yakima, WA.
- S. L. Cooper. 1997. Introduction to Snakes and Other Reptiles. Pint-sized Academy Program, Idaho Museum of Natural History, June 24, Pocatello, ID.
- S. L. Cooper. 1997. Introduction to Snakes and Other Reptiles. Pint-sized Academy Program, Idaho Museum of Natural History, June 25, Pocatello, ID
- Peterson, C.R. and T. Funderburg. 1997. Applications of Geographic Information Systems (GIS) Technology to Environmental Research on the INEEL. Invited Presentation, Environmental Science and Research Foundation, Idaho Falls, ID.

Snake Safety Presentations

Cooper, S. L. 1997. Snake Safety on the Idaho National Engineering and Environmental Laboratory. Invited Presentations

- RWMC personnel, INEEL, May 1
- Willow Creek Building employees, Idaho Falls, May 7
- Custer County Elementary School Teachers, Challis, June 4
- TAN personnel, INEEL, June 11
- WAC Building employees, Idaho Falls, June 19
- ICPP personnel, INEEL, June 19
- ESRF personnel, Idaho Falls, June 23

Lee, J. R. 1997. Snake Safety on the Idaho National Engineering and Environmental Laboratory. Invited Presentations:

- ICPP personnel, INEEL, October 29
- ICPP personnel, INEEL, December 10

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Overton, W. S. 1971. Estimating the numbers of animals in wildlife populations. Pp. 403 – 456 *in* R.H. Giles, ed. Wildlife Management Techniques. Edwards Brothers, Inc., Ann Arbor, Michigan.

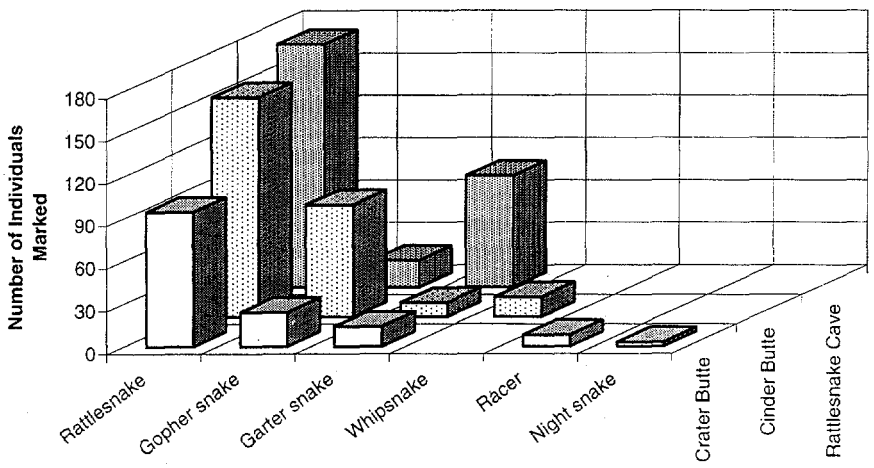

Figure 7. Species richness and diversity represented by number of snakes marked with Passive Integrated Transponders (PIT tags) at three den sites from 1994 to 1997.

DIVERSITY OF THE ANT FAUNA AT THE IDAHO NATIONAL ENGINEERING AND ENVIRONMENTAL LABORATORY: IMPLICATIONS FOR WASTE MANAGEMENT

William H. Clark[11] and Paul Blom[12]

Many invertebrates, including ants, tunnel and nest in soils. Because of these habits, they are potentially important at the Idaho National Engineering and Environmental Laboratory (INEEL) where they may tunnel into and disturb buried wastes. Further, ants are highly important components of a desert ecosystem. For these reasons, the kinds of ants present at INEEL were investigated.

OBJECTIVES.

Field research involving a variety of collection methods and on-site locations took place from 1986 through 1996 at the INEEL. For 1997, objectives were to continue curatorial work on the INEEL ant collection, to report the projects' findings, and to plan a final report, *A Checklist of the Ants (Hymenoptera: Formicidae) on the Idaho National Engineering and Environmental Laboratory*, to be published as a Foundation technical report and to be submitted, in a more concise version, to an appropriate scientific journal.

PROJECT ACCOMPLISHMENTS

Field efforts and subsequent curatorial work on the collected specimens identified 43 ant species from three subfamilies and 20 genera. This doubles the known number of INEEL ant species, as reported by Allred and Cole (1971). Our research found five species in Idaho for the first time: *Liometopum luctuosum, Camponotus hyatti, Formica gynocrates, Formica montana*, and an undescribed species of *Myrmica*. During 1997:

- Identification and curation of thousands of specimens was completed. In all, nearly 1,150 nest collections were processed throughout the project.
- Findings were reported through scientific meetings and at universities.
- Plans were drawn up to compile our findings in a comprehensive report which will include keys to worker ants, black-and-white illustrations, distribution maps, descriptive material for each taxon, and suggestions about ecological impacts these ants might have on wastes.

IMPORTANT RESULTS.

Blom showed that harvester ant burrowing is an important consideration in waste disposal (Blom 1990, Blom et al. 1991). As these studies focused on a single species, harvester ants (*Pogonomyrmex salinus*), there is a great need for adequate knowledge about the ecologies of the other ant species now known to inhabit the INEEL. Identification, accomplished by this project, is a critical yet precursory step in explaining the habits of these creatures and identifying important considerations for

[11] Orma J. Smith Museum of Natural History, Albertson College of Idaho, Caldwell, ID 83605-4494

[12] Department of Plant, Soil, and Entomological Sciences, University of Idaho, Moscow, ID 83844-2339 (Current address: Department of Entomology, Pennsylvania State University, University Park, PA 16802-3508)

planning and implementing DOE environmental restoration and waste management.

PRODUCTS

Extensive efforts have been made to fully document the ants of the INEEL. Voucher specimens have been deposited in the entomological collections at the Orma J. Smith Museum of Natural History, Albertson College of Idaho and the William F. Barr Entomological Museum, University of Idaho. In addition, a specimen-level data management system has been implemented and is available for better informing management decisions.

We have also reported our findings via traditional scientific channels. Our *Checklist of the Ants (Hymenoptera: Formicidae) on the Idaho National Engineering and Environmental Laboratory* was presented four times:

- Clark, W. H. and P. E. Blom. 1997. A checklist of the ants (Hymenoptera: Formicidae) of the Idaho National Engineering and Environmental Laboratory. Idaho Academy of Science, Idaho Falls, ID.
- Clark, W. H. and P. E. Blom. 1997. A checklist of the ants (Hymenoptera: Formicidae) of the Idaho National Engineering and Environmental Laboratory. Idaho Entomology Group.
- Clark, W. H. and P. E. Blom. 1997. A checklist of the ants (Hymenoptera: Formicidae) of the Idaho National Engineering and Environmental Laboratory. Museum Workday Seminar, Orma J. Smith Museum of Natural History, Albertson College of Idaho.
- Clark, W. H. 1997. A checklist of the ants (Hymenoptera: Formicidae) of the Idaho National Engineering and Environmental Laboratory. Centro de Investigacion Cientifica y de Educacion Superior de Ensenada, Ensenada, Baja California, Mexico.

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Allred, D. M., and A. C. Cole Jr. 1971. Ants of the National Reactor Testing Station. Great Basin Naturalist 31: 237-242.

Blom, P. E. 1990. Potential impacts on radioactive waste disposal situations by the harvester ant, *Pogonomyrmex salinus* Olsen (Hymenoptera: Formicidae). Unpublished M. S. thesis, University of Idaho, Moscow, Idaho. 241 pp.

Blom, P. E., J. B. Johnson, and S. Rope. 1991. Concentrations of ^{137}Cs and ^{60}Co in nests of the harvester ant, *Pogonomyrmex salinus*, and associated soils near nuclear reactor waste water disposal ponds. American Midland Naturalist 126: 140-151.

RADIONUCLIDE CYCLING IN PLASTIC LINED EVAPORATION PONDS AND EFFECTS ON RADIONUCLIDE LEVELS IN AND RADIATION DOSES TO WATERFOWL AND WATERFOWL HUNTERS

Ronald W. Warren[13]

Research is being conducted to determine the fate of radionuclides released as liquid effluent to two plastic-lined evaporation ponds at the Test Reactor Area on the INEEL. In order to determine the fate of radionuclides at the TRA ponds, it is necessary to quantify all inputs to, and losses from, those systems. Emphasis was placed on determining potential radionuclide transport from the ponds, especially transport to humans via waterfowl which have spent time on the ponds.

OBJECTIVES

Overall objectives for this research are to determine the potential for transport of radioactive contamination off-site by waterfowl which use the lined ponds and the potential for radiation dose to humans from eating them, determine the transport of radionuclides from the ponds by vectors other than waterfowl, specifically mourning doves, barn swallows, and tumbleweeds, determine radionuclide cycling in the ponds through time, create a dynamic model of radionuclide cycling in the pond system to be used to estimate future potential radiation doses to waterfowl and humans, and compare results with the potential for dose to waterfowl and humans determined for the previously used percolation pond system.

Specific objectives for CY-97 were to:

- Collect multiple samples of pond components through time and analyzed them for radionuclides.
- Conduct regular surveys of the pond to record bird use and the number of tumbleweeds present in the ponds.
- Collect multiple ducks, doves, and swallows from the pond area and analyze them for radionuclides.
- Conducted an experiment to determine radionuclide adsorption rates and equilibrium concentrations on the Hypalon liner material.
- Identify invertebrates taken from the ponds and have them analyzed for radionuclides.
- Complete data entry and continue data analysis.

PROJECT ACCOMPLISHMENTS

Throughout a 35 month period starting August 1994, samples of pond components (e.g. water, seston, and sediment) have been collected on 22 days. Over that same period, a total of 15 ducks have been collected from the TRA ponds and about 340 visits were made to the ponds to record bird usage and water depths. The radionuclide inventory released to the ponds has been maintained and an evaporation model constructed for the ponds. During CY-97 project accomplishments included:

- Collection of eight samples each of water, seston, and sediment and two periphyton samples.
- Maintained dosimeters on the pond through July.
- Collected six ducks from the TRA ponds.
- Collected four barn swallows from TRA.

[13] Environmental Science and Research Foundation, Idaho Falls, ID 83405-1838

- Collected four barn swallows from TRA.
- Collected four mourning doves from TRA and banded 22 more for dispersal and hunter take data.
- Conducted an experiment to quantify radionuclide adsorption to the plastic liner.
- Identified 43 invertebrate samples taken from the ponds and submitted samples for radiological analysis.
- Wrote abstract, "The fate of radionuclides in plastic lined ponds and potential dose to persons consuming waterfowl from those ponds," submitted to the Health Physics Society for presentation at their annual meeting in July, 1998.

IMPORTANT RESULTS

By 20 July 1997, the evaporation ponds had received over 26 million gallons of wastewater containing 10.7 Tbq (289 Ci). Of the total activity released, tritium accounted for 95% and approximately 4% was ^{51}Cr (0.3 TBq), ^{60}Co (62.9 GBq), ^{137}Cs (7.4 GBq), and ^{90}Sr (3.7 GBq). The total concentration in the water column was about 2.0 nCi/ml. Over 97% of this was from tritium. Concentrations of some of the major radionuclides in filtered water, seston, and sediment are listed in Table 9. Concentrations of ^{54}Mn and ^{60}Co in filtered water in the evaporation ponds were lower than those in the old percolation ponds by average factors of 20 and 6.2, respectively. Yet, evaporation pond sediments had ^{54}Mn and ^{60}Co concentrations about 1.7 times higher than those measured in the old percolation ponds. The summed average concentrations of ^{51}Cr, ^{60}Co, and ^{137}Cs in filtered water of the lined ponds (0.4 Bq/mL) was about 260 times lower than those measured during the late 1970s in the previously used percolation ponds. However, radionuclides in water accounted for a higher percentage of the total inventory released to the lined ponds compared to the percolation ponds.

During 1997, no new bird species were observed using the ponds. The total number of bird species observed using the ponds over the entire study thus far is 69, of which 26 were waterfowl species. According to research conducted from April 1989 through October 1991 (Cieminski 1993), a total of 68 species of birds were observed at the,

Table 9. Concentrations of selected radionuclides in filtered water, seston (particulate matter), and sediment from the lined evaporation ponds and the former percolation ponds at TRA.

	Average Concentration ($pCi\ g^{-1}$)					
	Lined Ponds			Percolation Ponds		
Radionuclide	Filtered Water	Seston	Sediment	Filtered Water	Seston	Sediment
^{51}Cr	8.4	13.8	2,600	2500	4.6×10^7	12,000
^{54}Mn	0.01	0.02	270	0.2	1.2×10^5	150
^{60}Co	1.0	1.4	51,000	6.2	1.1×10^6	32,000
^{65}Zn	0.003	0.08	140	0.6	2.0×10^5	690
^{137}Cs	0.27	0.19	3,000	2.8	2.7×10^5	28,000
^{90}Sr	0.91	0.1	900	NM	NM	NM

NM = not measured

now reclaimed, TRA percolation ponds. Our data indicate that, in regard to bird species richness, the TRA evaporation ponds rank fourth out of 22 waste ponds on the INEEL. Over the entire study, about 340 visits were made to the ponds to conduct bird surveys.

The average total radionuclide concentration in the muscle of ducks collected from the lined ponds was 1.1 Bq/g (wet weight) (n=15) with a maximum of 10.8 Bq/g. The average 50-year committed effective dose equivalent for someone immediately consuming a duck sampled from the lined ponds was 1.2 μSv (0.12 mrem) with a maximum of 4.5 μSv (0.45 mrem). The average committed dose from consuming waterfowl collected 1974 - 1977 from the previously used percolation ponds was 120 μSv (12 mrem) (Halford et al. 1981).

Data from barn swallows and mourning doves collected during CY-97 have not been analyzed at this time. All five barn swallows collected from TRA in 1996 had higher total concentrations than control samples. Of the 13 mourning doves collected from TRA during CY-96, three had elevated total concentrations in the edible tissue. The average concentration in TRA barn swallow samples was 12.1 pCi/g (wet weight) with a range of 4.4 to 25.7 pCi/g. The average concentration in control barn swallow samples was 2.4 pCi/g. Previous research conducted in the late 1970s by Millard et al. (1990) showed average concentrations in adult barn swallows taken at TRA to be about 1,380 pCi/g, a factor of about 54 to 314 times higher than those observed in 1996. Markham and Halford (1982) reported the highest concentration in muscle tissue from a mourning dove collected at TRA to be 171 pCi/g, a factor of about 15 times higher than the maximum observed in 1996.

PRODUCTS

A paper entitled, *Sorption and transport of radionuclides by tumbleweeds from two plastic-lined evaporation ponds*, was presented at the 42nd annual Health Physics Society meeting in San Antonio, TX, July 2, 1997. An abstract entitled, *The fate of radionuclides in plastic lined ponds and potential dose to persons consuming waterfowl from those ponds*, was submitted to the Health Physics Society for presentation at the annual meeting in July, 1998.

An evaporation model based on the Penman equation was created for the lined ponds.

LITERATURE CITED

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Halford, D. K., J. B. Millard, and O. D. Markham. 1981. Radionuclide concentrations in waterfowl using a liquid radioactive waste disposal area and the potential radiation dose to man. Health Physics 40:173-181.

Markham, O. D., and D. K. Halford. 1982. Radionuclides in mourning doves near a nuclear facility complex in southeastern Idaho. Wilson Bulletin 94:185-197.

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RADIOECOLOGY OF IODINE-129 IN THE SAGEBRUSH STEPPE ECOSYSTEM

Randall C. Morris[14]

The short-term goal of this project is to determine the extent of environmental contamination and the potential human and environmental impacts of ^{129}I released from the Idaho Chemical Processing Plant. Our long-term goal is to use ^{129}I as a tracer to help elucidate ^{129}I cycling in the sagebrush steppe environment. The current project objectives reflect both the short-term goal and the longer-term goal.

OBJECTIVES

The primary goals to this study are to:

- Determine the long-term trends of ^{129}I concentration in the INEEL environment.
- Estimate the radiation dose to humans and non-human organisms from this ^{129}I contamination

In order to complete these goals, our initial objectives are to:

- Estimate the total ^{129}I inventory on the INEEL and to partition that inventory into sagebrush, grass-forb, litter, small mammals, and four soil compartments.
- Estimate the mean residence time of ^{129}I in plant litter and soil from four depths on the INEEL.

Accomplishing these objectives will enable us to address the question of potential offsite transport of ^{129}I and the impacts thereof. In addition, the data are necessary for a comprehensive iodine cycling model for the sagebrush steppe ecosystem.

For calendar year 1997, our objectives were to:

- Complete laboratory analyses of the environmental samples collected to date.
- Begin data analyses to estimate inventories and residence times.

PROJECT ACCOMPLISHMENTS

In 1997, we completed analyses of most samples collected in 1996. Significant problems with samples analysis were encountered and overcome. This was not unexpected because the analysis method employed, Accelerator Mass Spectrometry, is largely experimental for the media and analyte of interest. We abandoned neutron activation as a means of determining total iodine in the samples (necessary for calculating $^{129}I/^{127}I$ ratios) because the resulting analytical errors were too large. Alternative techniques are under discussion.

IMPORTANT RESULTS

^{129}I concentrations have been determined for all onsite samples (Table 10).

PRODUCTS

This project is in the data collection and analysis phase. No products are completed.

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[14] Environmental Science and Research Foundation, Idaho Falls, ID 83405-1838

Table 10. Iodine-129 concentrations in various environmental media from the Idaho National Engineering and Environmental Laboratory.

Medium	Number of samples	^{129}I Concentration (atoms g^{-1})		
		Minimum	Mean	Maximum
Sagebrush	45	2.440e+09	4.138e+10	2.438e+11
Grass & forbs	44	4.050e+09	4.157e+10	2.113e+11
Litter	45	6.250e+09	1.204e+11	6.070e+11
Small mammal tissue	37	5.460e+08	8.147e+09	3.420e+10
Soil (0-5 cm)	39	2.429e+09	2.357e+10	1.439e+11
Soil (5-10 cm)	39	2.435e+09	1.308e+10	4.930e+10
Soil (15-20 cm)	39	4.520e+08	4.978e+09	1.751e+10
Soil (60-65 cm)	11	2.550e+07	4.773e+09	2.109e+10

SURFACE WATER PENETRATION AT THE SUBSURFACE DISPOSAL AREA

Timothy D. Reynolds[15] and Teresa D. Ratzlaff[16]

Various EPA and DOE regulations require that shallow-land burial sites for low-level radioactive wastes remain effective for at least 100 years. Primary to the success of a waste management is controlling the annual influx of moisture into the soil to keep wastes isolated from water (Fisher 1986, Nativ 1991). At the Idaho National Engineering and Environmental Laboratory, most of the annual soil moisture recharge results from precipitation that occurs during the months when plants are dormant (October - March). Improvements in management practices since 1952 at the Subsurface Disposal Area (SDA) have resulted in differences in soil covers, thickness, land contours, vegetation types, and proximity of buried wastes to roads and ditches. Each of these factors influences soil moisture dynamics in the protective soil caps. Since 1988, we have measured soil moisture at 20-cm intervals to depths of 1.6 m on eight study sites within the SDA.

OBJECTIVES

This study has two related long-term objectives:

- Monitor and compare the fluctuations in soil moisture content in the soil profiles of areas within the SDA likely affected by different management strategies.
- Monitor and compare the maximum depth of moisture infiltration in areas with different management histories.

Specific objectives for 1997 were to:

- Take field measurements and calculate soil moisture for each plot after snow melt and periodically during the growing season.
- Interpret the results of data analysis for 1997 and previous years.
- Prepare a manuscript summarizing the results.

PROJECT ACCOMPLISHMENTS

We took soil moisture measurements mostly during the late winter, early summer, and fall (March, May, June, July and November). We analyzed data from 1997 and compared results to previous years.

IMPORTANT RESULTS

Precipitation during the non-growing season (October, 1996 through March, 1997) was 129 mm. This was 128% of the long term average of 99.7 mm, and represented the third year in a row in which non-growing season precipitation was near or above the average.

Maximum soil moisture penetration was 1.0 m on several plots, and may have reached 1.2 m on one plot (Figure 8). These data are consistent with our observations of moisture to or beyond 1.0 m following winters with near-normal or above normal precipitation.

Progress was made in analyzing data and preparing graphics for a technical manuscript.

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[15] Environmental Science and Research Foundation, Idaho Falls, ID 83405-1838

[16] Department of Biological Sciences, Idaho State University, Pocatello, ID 83209-8007

PRODUCTS

A manuscript summarizing this research is being prepared: *Soil moisture patterns at a hazardous waste site*. One presentation was given:

- Reynolds, T. D. 1997. Soil moisture dynamics at a low-level radioactive waste management site. Northwest Scientific Association Annual Meeting, Spokane, WA.

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Fisher, J. N. 1986. Hydrogeologic factors in the selection of shallow land burial for the disposal of low-level radioactive waste. Geological Survey Circular (U.S.) 973.

Nativ, R. 1991. Radioactive waste isolation in arid zones. Journal of Arid Environments 20:129-140.

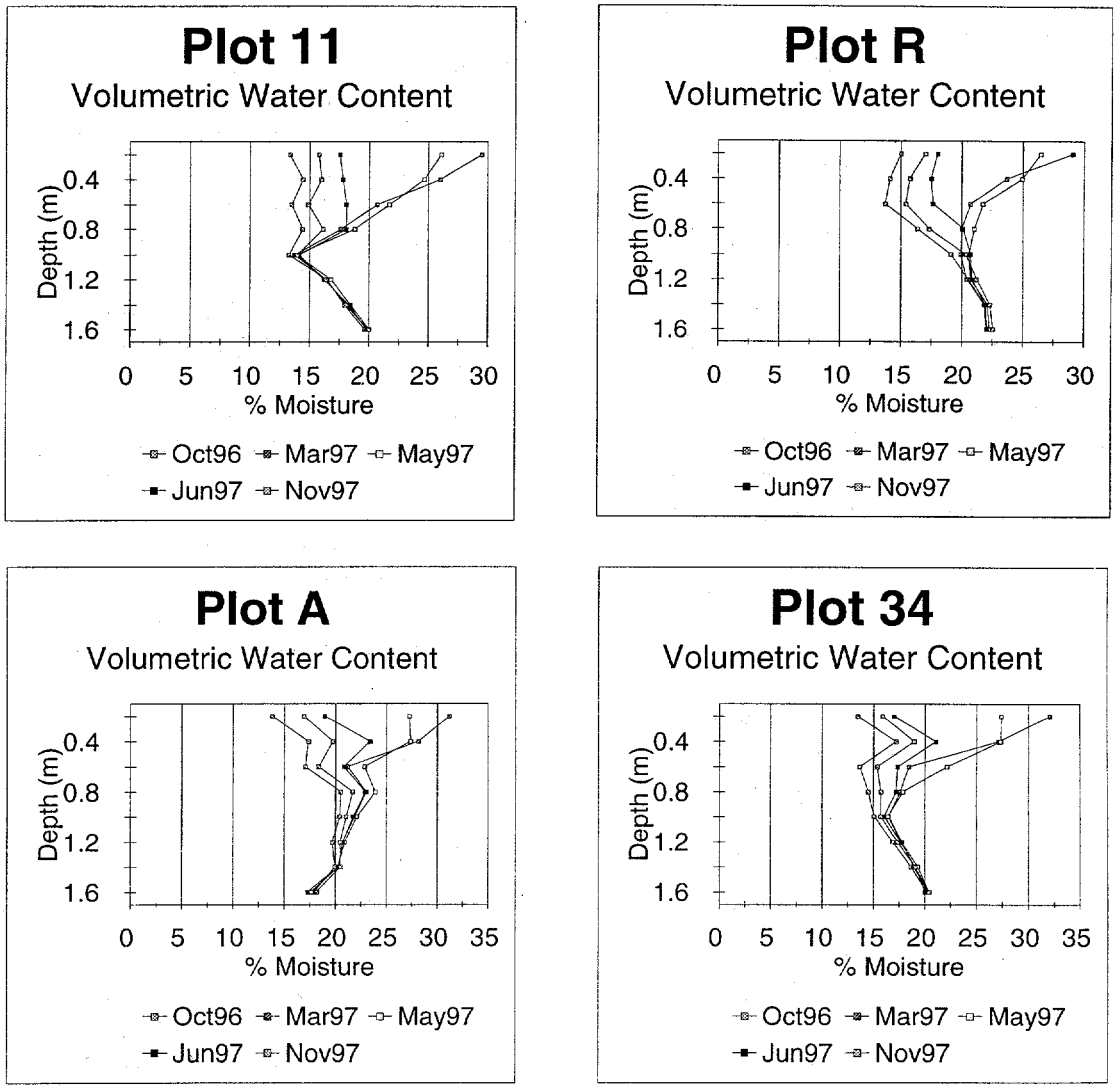

Figure 8. Examples of 1997 soil moisture patterns from selected study plots at the Subsurface Disposal Area at the INEEL.

FIRE ECOLOGY OF THE IDAHO NATIONAL ENGINEERING AND ENVIRONMENTAL LABORATORY

Jay E. Anderson[17] and Seanne M. Patrick[17]

Fire has played an important role in the vegetation history of sagebrush steppe ecosystems. Large fires at the Idaho National Engineering and Environmental Laboratory (INEEL) in 1994, 1995, and 1996 underscore the need for a comprehensive fire management plan and provided unique opportunities for research. To document postfire vegetation development, we measured plant cover and seedling densities in 1995, 1996, and 1997 on permanent vegetation plots that were burned in 1994 and on adjacent unburned plots. To further examine the role of annual species in postfire vegetation dynamics, we established plots in an area burned in 1995. These plots were located in areas where exotic annuals, especially cheatgrass, were abundant in the first postfire year. We also investigated mineralization of nitrogen in soils in an area burned in 1996 and an adjacent burned area. This information may help us predict the impact of wildfire on the availability of nitrogen to plants in a postfire community.

OBJECTIVES

The ultimate objectives of this project are to improve the understanding of postfire vegetation development and fire history in sagebrush steppe at the INEEL, and to provide recommendations for a comprehensive INEEL fire management plan. Specific objectives for 1997 were to:

- Document postfire vegetation development on recent INEEL burn sites.
- Collect and analyze soil samples to examine nitrogen mineralization.
- Investigate the hypothesis that the principal lineament resulted from a large wildfire.

PROJECT ACCOMPLISHMENTS

- Plant cover and seedling densities were estimated on all plots sampled in 1995 and 1996.
- Mineralization tubes were used to compare the rates of nitrogen mineralization of soils between burned and unburned plant communities. Two sites were designated for this study; within each site a burned plot was adjacent to an unburned plot. The unburned plant community on Site 1 contained mostly *Chrysothamnus vicidiflorus* (green rabbitbrush), *Bromus tectorum* (cheatgrass), and an abundance of dead sagebrush, while Site 2 consisted mainly of living sagebrush and native perennial grasses. We placed mineralization tubes near dead sagebrush on Site 1, and near living sagebrush on Site 2. Mineralization tubes were placed near the remnants of burned shrubs on both of the burned plots.
- We searched for written accounts of large wildfires in the vicinity of the INEEL in the Idaho Falls Post Register through the year 1906.

IMPORTANT RESULTS

- Three years following the Butte City Fire, vegetation on the permanent plots was still dominated by native perennial

[17] Department of Biological Sciences, Idaho State University, Pocatello, ID 83209-8007

species. Plant cover in 1997 was 12% greater than that of 1996; most of this increase in cover was due to increases in shrub and grass cover (Figure 9). Squirreltail *(Elymus elymoides)* alone increased more than 3%, while the cover of thickspike wheatgrass *(Elymus lanceolatus)*, Indian ricegrass *(Oryzopsis hymenoides)*, and bluebunch wheatgrass *(Pseudoroegneria spicata)* more than doubled. Green rabbitbrush *(Chrysothamnus vicidiflorus)* remained the most abundant native perennial on these plots, contributing 14% cover. The total cover of exotic species decreased slightly. However, Russian thistle *(Salsola kali)* increased by 2%, and remained the most abundant exotic species.

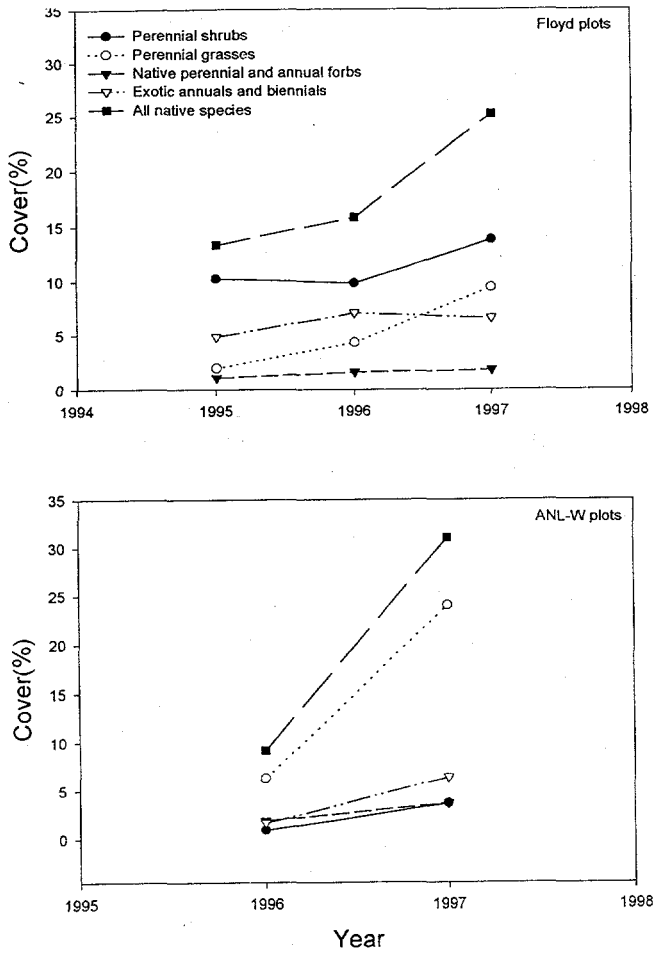

Figure 9. Cover (%) of perennial shrubs, perennial grasses, native perennial and annual forbs, exotic annuals and biennials, and all native species for plots located in two postfire communities. The top graph represents cover estimates from the permanent plots established in 1980 that were burned by the Butte City Fire in 1994. The bottom graph represents cover estimates from the plots that were established in an area burned by the 1995 Argonne National Laboratory-West Fire.

- The plots in the area near the 1995 Argonne National Laboratory-West were dominated by native perennial and native annual species. The total native perennial and annual cover increased 22% in 1997. Grass cover increased four-fold from 1996. Thickspike wheatgrass was the most abundant species; its cover increased from just 3% in 1996 to 14% in 1997. Exotic annuals and biennials increased 5% from 1996. This increase of almost 5% was mainly due to cheatgrass *(Bromus tectorum)*, halogeton *(Halogeton glomeratus)*, and tansy mustard (*Descurainia sophia*). Cheatgrass was the most abundant exotic on these plots; contributing 2.4% cover. The dominant exotics changed from 1996, when salisfy (*Tragopogon dubius*) contributed the most cover of the introduced species.
- There were no consistent effects of fire on net nitrogen mineralization rates on either site during the 1997 growing season. Cumulative nitrification and cumulative net mineralization results showed a consistently higher amount of nitrate on the unburned plot than the burned plot on Site 1 over the six month period (Figure 10). However, cumulative nitrification and net mineralization results from the unburned and burned plots at Site 2 were more variable over the season. Analysis of carbon content of these soils are in progress. Availability of carbon is an important factor controlling net nitrogen mineralization.
- Charcoal found beneath the principal lineament provides strong evidence that this feature resulted from a large wildfire. The conventional ^{14}C age was 200 +/- 50 BP. However, the ^{14}C age intercepts the calibration curve four times, resulting in predicted fire dates of 1640-1890 and 1905-1950 (95% confidence intervals). Because the fire scar adjacent to the principal lineament appears on the aerial photographs and satellite imagery to be much older than scars from fires known to have burned in the 1940's and 1950's, we believe it is most likely that the fire responsible for the principal lineament occurred in the 1800's.
- We found no written accounts of wildfire in the vicinity of the INEEL in the Post Register for the years 1891-1906.

PRODUCTS

This project is in the data accumulation and analysis phase.

PRESENTATIONS:

- Anderson, J. E. 1997. Fire history of sagebrush steppe ecosystems. U.S. Bureau of Land Management Spring Fire and Aviation Meeting, Twin Falls, ID, April 16, 1997.
- Anderson, J. E. 1997. Fire ecology in lodgepole pine and sagebrush steppe. Fire Ecology and Policy: Reality versus Rhetoric. Co-sponsored by Gallatin Institute and American Wildlands at Chico Hot Springs, Montana and Yellowstone National Park.

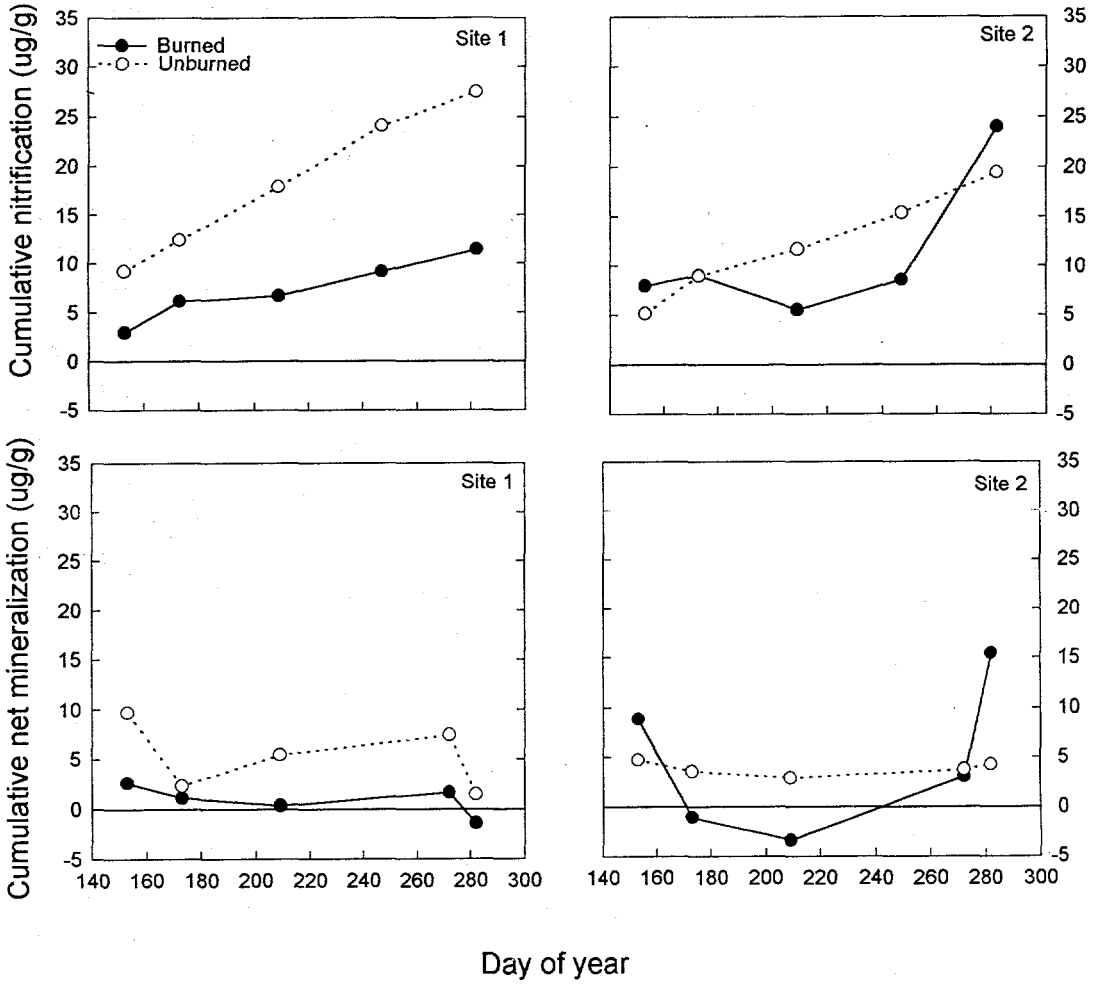

Figure 10. Cumulative nitrification and net nitrogen mineralization estimates of soils from May, 1997, to October, 1997, in two plant communities in adjacent burned and unburned plots. Mineralization of nitrate and ammonium were estimated by incubation of soil cores in mineralization tubes in the field. Net nitrification and ammonification were calculated as the difference in nitrate or ammonium content between the initial and incubated buried soil cores. Net mineralization was calculated as the sum of net ammonium production and net nitrification.

OFFSITE TRANSPORT OF RADIONUCLIDES FROM INEEL FACILITIES BY, AND EFFECTS TO, BARN SWALLOWS (*Hirundo rustica*)

Ronald W. Warren[18]

Research is being conducted to quantify transport of radionuclides from liquid waste sites on the INEEL by barn swallows (*Hirundo rustica*). Barn swallows are common at most facilities on the INEEL and are known to nest near many wastewater ponds found on site (Halford and Millard 1978, Cieminski 1993). In a study conducted 1976 through 1978, barn swallows nesting at the Test Reactor Area were found to build nests with radionuclide contaminated materials and to accumulate radionuclides internally by ingesting arthropods from radioactive leaching ponds at TRA (Millard et al. 1990).

OBJECTIVES

The objectives for CY-97 were to continue to collect data on barn swallow populations at various facilities, on radionuclide concentrations in barn swallow nesting materials, and on radionuclide concentrations in barn swallows. Specific tasks for CY-97 were to:

- Survey the TRA, ICPP, and TAN facilities for total numbers of barn swallow nests.
- Determine how many nests were active and the number of eggs or young present.
- Place dosimeters in the nests to determine exposure rates.
- Collect a sample of barn swallow nests from each facility and have them analyzed for radionuclides.
- Collect a sample of barn swallows from each facility and have them analyzed for radionuclides.

PROJECT ACCOMPLISHMENTS

All objectives set for CY-97 were completed and data analysis is underway.

- All buildings and structures in the TAN (TSF), TRA and ICPP facilities were surveyed for the presence of swallow nests. All observed nests were recorded.
- The activity of all accessible nests was determined and the number of eggs or young present were recorded.
- A total of 24 dosimeters were placed in barn swallow nests: six at ICPP, five at TAN, three at TRA, and 10 at the control site north of Idaho Falls.
- Twenty barn swallow nests were collected after the end of the nesting season: four from ICPP, five from TAN, seven from TRA, and four from the control site.
- Fourteen barn swallows were collected: one from ICPP, three from TAN, four from TRA, and six from the control site.

IMPORTANT RESULTS

The number of barn swallow nests observed during facility surveys in 1997 did not appear to be significantly different from that observed in 1996. Analysis is ongoing for data collected in 1997 but data collected in previous seasons is summarized.

- During 1997, facility surveys located a total of 43 barn swallow nests at TRA, 44 at TAN (TSF), and 132 at ICPP. This compares with 47 at TRA, 44 at TAN, and 138 at ICPP located during surveys

[18] Environmental Science and Research Foundation, Idaho Falls, ID 83405-1838

in 1996.

- In 1996, the percent of total nest that were active were 65% at TRA, 50% at TAN, and 44% at ICPP.
- In 1995, average exposure rates were higher at TRA compared to those in nests at TAN, ICPP and control sites. In 1996 the total average of measured exposure rates did not significantly differ between any of the sites, although one nest at TRA had an average daily exposure rate nearly twice that of the maximum measured in control nests. The highest measured exposure rate in any nest was 8.3 mR d^{-1} at TRA during 1995, a factor of about 26 times lower than the average exposure rate measured in previous research conducted in the late 1970s by Millard et al. (1990).
- Of five barn swallows collected from the TRA facility in 1996, all had higher total concentrations than control samples. The average concentration in the samples was 12.1 pCi/g (wet weight) with a range of 4.4 to 25.7 pCi/g. The average concentration in control barn swallow samples was 2.4 pCi/g. Previous research conducted in the late 1970s by Millard et al. (1990) showed average concentrations in adult barn swallows taken at TRA to be about 1,380 pCi g^{-1}, a factor of about 54 to 314 times higher than those observed in 1996.

PRODUCTS

This project is in the data analysis phase. No products have been produced as of this time.

LITERATURE CITED

Cieminski, K. L. 1993. Wildlife use of wastewater ponds at the Idaho National Engineering Laboratory. Unpublished M.S. Thesis, South Dakota State University, Brookings, South Dakota. 311 pp.

Halford, D. K. and J. B. Millard. 1978. Vertebrate fauna of a radioactive leaching pond complex in southeastern Idaho. Great Basin Naturalist 38:64-70.

Millard, J. B., F. W. Whicker, O. D. Markham. 1990. Radionuclide uptake and growth of barn swallows nesting by radioactive leaching ponds. Health Physics 58:429-439.

OCCURRENCE OF SMALL OWL SPECIES ON THE IDAHO NATIONAL ENGINEERING AND ENVIRONMENTAL LABORATORY

Natalie A. Fahler[19]

This is a baseline study of small owl occurrence on the Idaho National Engineering Laboratory (INEEL). Although emphasis is placed on the status and productivity of species classified by the State of Idaho or Federal agencies as Sensitive or Species of Special Concern, data on other owl species also is being collected.

OBJECTIVES

The primary project goals are to (1) determine the density, productivity, and habitat use of nesting burrowing owls on the INEEL, and (2) determine late winter and spring use of juniper woodlands and riparian habitats by small arboreal owl species. Specific objectives for 1997 were to:

- Estimate burrowing owl population size on the INEEL and compare current data with prior research.
- Evaluate burrowing owl occurrence and nest sites in relation to vegetation, burrow, and soil characteristics on the INEEL.
- Determine the status of small owl species on the INEEL listed as sensitive or species of concern by Idaho federal and state agencies.
- Determine small owl species occurrence on the INEEL during late winter and spring and obtain baseline data for use in long-term population analysis.
- Attempt to confirm the presence of small owl species suspected or reported, but never verified on the INEEL.
- Evaluate the differences in owl responsiveness to broadcasts of calls over the course of the night.

PROJECT ACCOMPLISHMENTS

The playback method (broadcast of conspecific calls to elicit responses) was utilized to detect arboreal species and burrowing owls. Burrowing owl nests were monitored throughout the season. Baseline data on long-eared owls were obtained.

- Surveys for arboreal owl species were completed in late winter and early spring during crepuscular and nighttime hours.
- Potential habitats on the INEEL were surveyed for nesting burrowing owls.
- Productivity data were gathered on nesting burrowing owls.
- Burrow and surrounding vegetation measurements were recorded for each nesting burrow.
- 25 km of the Big Lost River was surveyed for nesting long-eared owls.

IMPORTANT RESULTS

Burrowing Owls

There were 16 known burrowing owl nests and nesting attempts in 1996. This includes 14 confirmed pairs, 13 of which were known to have hatched chicks. Confirmed pair criteria includes observations of:

- Two adult birds at a burrow.

[19] Wildlife and Fisheries Sciences, South Dakota State University, Brookings, SD 57006

- One or more chicks.
- Eggshells in pellets indicating hatching,
- Other compelling evidence.

One confirmed nest site was found after the nesting season. It is unknown whether chicks were fledged from this site. Sixty-two chicks were produced by 11 known successful pairs in 1996.

Twenty-four nest sites were studied in 1997. Eight were reoccupied 1996 nest sites and 16 were new nests and new nest attempts (including two just outside the INEEL boundary). Two additional nest sites were suspected but were not confirmed. There were 21 confirmed pairs in 1997. Fifteen were known to have hatched chicks, and eight pairs successfully fledged a total of 20 chicks. Known burrowing owl nest sites were located in grazed areas, burned sites, and grasslands adjacent to agriculture. The number of destroyed and/or abandoned burrows rose from 4 of 16 (25%) in 1996 to 16 of 24 (67%) in 1997. Possible factors include flooding in sites adjacent to croplands and changes in predator/prey densities.

Other Owls

The presence of a northern saw-whet owl was confirmed at Middle Butte with the sighting and tape-recording of the male primary call in late February 1997. Two other small owl species were heard on the INEEL. A boreal owl was heard in April 1996 at the foothills of the Lemhi mountains, and a vocalization made by a western screech owl was heard near the Twin Buttes in late February 1997. Unfortunately, on each occasion the call was given only once. Neither a sighting nor a tape-recordings for official documentation was obtained.

The more common owls on the INEEL appeared less abundant in 1997 than 1996. Long-eared and great horned owls were commonly detected during night-long surveys. The maximum number of long-eared owls heard in a night in 1997 was only two compared with a maximum of seven heard in a single night in 1996. Great horned owl numbers were also below 1996 levels on established survey routes. Incidental sightings of short-eared owls were less frequent in 1997 than in 1996. It is unknown if these apparent declines in numbers were the result of late season fires in 1996 that substantially reduced nesting and hunting habitats, a change in prey densities, or other unknown factors.

PRODUCTS

This was the final data acquisition field season for this study. Data analysis is currently underway. Future products we anticipate, in addition to some technical presentations, are one Masters Thesis, two technical journal publications, and one popular article.

UPTAKE OF CONTAMINANTS BY VEGETATION AND BURROWING ACTIVITY ON A DECOMMISSIONED RADIOACTIVE WASTE POND COMPLEX

Ronald W. Warren[20]

Research is being conducted to quantify contaminant uptake by vegetation and burrowing organisms on decommissioned radioactive waste ponds at the Test Reactor Area (TRA) on the Idaho National Engineering and Environmental Laboratory (INEEL). The three liquid radioactive waste leaching ponds, constructed in 1952, 1957, and 1964, received an estimated 53.5 kCi of activity between 1952 and 1993. All ponds were taken out of service in 1993. Two were closed in late 1993 and early 1994 with a soil cover containing no biobarriers to inhibit root infiltration or burrow penetration. Vegetation species and biomass were determined for those two pond covers, and samples of vegetation were analyzed for gamma-emitting radionuclides, ^{90}Sr, ^{238}Pu, $^{239/240}Pu$, ^{241}Am, and selected trace metals.

OBJECTIVES

The goal of this research is to determine the extent and magnitude of radionuclide uptake by vegetation on the covers, to determine the extent and magnitude of radionuclide transport to the surface of the covers by burrowing animals, to predict future exposure rates and surface contamination levels based on measured uptake and redistribution of radionuclides, and to determine heavy metal concentration in vegetation and soil on the covers. Objectives for CY-97 were to:

- Measure vegetation biomass on the 1964 and 1952 pond covers.
- Analyze vegetation taken from the covers for radionuclides and trace metals.
- Record the location of burrowing activity on each cover.
- Determine the mass of excavated soil.
- Analyze excavated soil for radionuclides and trace metals.
- Estimate total radionuclide uptake in vegetation and excavated soils on the covers.

PROJECT ACCOMPLISHMENTS

Vegetation and excavated soil samples were collected and samples sent for radiological and metal analysis. Analysis of data is underway.

- Vegetation species were recorded and biomass measured for samples plots on the 1964 and 1952 pond covers. The vegetation on eight 1-m^2 randomly located plots were clipped on the 1952 pond cover and seven 1-m^2 randomly located plots were clipped on the 1964 pond cover. Species were separated, identified, and biomass determined. Five 1-m^2 plots were also clipped at a control site approximately three miles northwest of TRA.
- Both covers were surveyed for burrowing activity. The specific location of all burrows were recorded, and all soil brought to the surface was weighed and samples were taken.
- A map of burrow locations was created.

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IMPORTANT RESULTS

Analysis is ongoing for data collected in 1997, but most data collected in the previous season is summarized. In 1996, radionuclide concentrations were found to be higher in vegetation taken from the 1952 pond cover, compared to the vegetation from both the 1964 pond cover and control site.

- In 1996, total radionuclide concentrations in the vegetation averaged 45.8 ± 7.4 pCi g^{-1} for the 1952 pond cover, 23.5 ± 5.9 pCi g^{-1} for the 1964 pond cover, and 16.4 ± 4.6 pCi g^{-1} for control plots. Average concentrations of ^{60}Co, ^{137}Cs, and ^{90}Sr, respectively, in vegetation taken from the 1952 pond cover were 11.5, 135, and 66.5 times higher than those measured from control plots. Preliminary results of metal concentrations showed no differences between vegetation taken from the pond covers and control vegetation.
- The 1997 survey for burrowing activity located a total of nine burrows on the 1952 pond cover, of which seven were from ants and two were from small mammals. We located 32 burrows on the 1964 pond cover (13 from ants and 19 from small mammals). Compared to 1996, the number of ant mounds is about the same, but the number of small mammal burrows is down by 40 - 75%.
- The total amount of soil brought to the surface, as measured in November 1997, was 269 kg. This is down from 337 kg measured in October, 1996, mostly due to the decrease in small mammal burrows. Of the total excavated soil measured in 1997, ant burrow activity accounted for 194 kg on the 1964 pond cover and 51 kg on the 1952 pond cover. Small mammal burrow activity accounted for 22 kg and 1.2 kg of soil being brought to the surface of the 1964 and 1952 pond covers, respectively. Average ^{60}Co, ^{137}Cs, and ^{90}Sr concentrations in excavated soil from 1996 are listed in Table 11. Average concentrations in soil excavated from pond covers were significantly higher than control soils in all cases. Cobalt-60 concentrations ranged from 16 to 133 times higher than control soils, ^{137}Cs concentrations ranged from 3 to 14 times higher than control soils, and ^{90}Sr concentrations ranged from 3 to 37 times higher than control soils. Concentrations were about 1.5 to 7.5 times higher in ant-excavated soils compared to small mammal-excavated soil on each pond. The exception to this was ^{90}Sr on the 1952 pond cover, where concentrations were higher in small mammal excavated soils. Concentrations were not different between the 1952 and 1964 pond covers, except for ^{90}Sr which was higher in excavated soil from the 1952 pond cover.

PRODUCTS

This project is currently in the data collection and analysis phase. No products have been produced to date.

Table 11. Average concentrations (pCi/g) in soils excavated by ants and small mammals.

	1952 Pond Cover		1964 Pond Cover		
	Ant Excavated Soil	Small Mammal Excavated Soil	Ant Excavated Soil	Small Mammal Excavated Soil	Control Soil
^{60}Co	0.36±0.07	0.05±0.04	0.40±0.06	0.11±0.05	0.003±0.04
^{137}Cs	3.06±0.20	0.77±0.08	3.85±0.24	1.30±0.13	0.28±0.06
^{90}Sr	1.06±0.10	3.16±1.13	0.35±0.18	0.23±0.03	0.09±0.01

ECOLOGICAL IMPACTS OF IRRIGATING NATIVE VEGETATION WITH SEWAGE WASTEWATER

Roger D. Blew[21] and Randall C. Morris[21]

Disposal of wastewater is a necessity common to most municipal and industrial wastewater treatment facilities. In 1995, the INEEL began disposing of treated wastewater by applying it to the surface of soils and native vegetation using a center pivot irrigation system. Research conducted on this disposal method at the INEEL provides an opportunity to determine the benefits and/or hazards of disposal of wastewater on native vegetation in arid and semi-arid regions.

OBJECTIVES

Objectives for this program are to determine changes in vegetation, wildlife use, trace metal contamination and deep percolation of water due to land application of wastewater.

The specific objectives for 1997 were to:

- Monitor soil moisture.
- Monitor permanent vegetation transects.
- Establish small mammal trapping grids and begin trapping.

PROJECT ACCOMPLISHMENTS

- Soil moisture was monitored weekly through the growing season and monthly during the remainder of 1997. Soil moisture was measured using a neutron hydroprobe at each of 19 sites in the irrigated area and 20 in the non-irrigated control area. Measurements were taken at 20-cm intervals to a maximum depth of 2.0 m.
- Vegetation surveys were conducted which determined percent cover using point frames. At each point, five frames were counted along a transect beginning at the access tube and extending 10 m (33 ft.) toward the center of the circle.
- Small mammal trapping transects were established at each of the sampling points used for soil moisture and vegetation sampling. Each transect had 10 Sherman live traps placed 5 m apart.
- Three trapping sessions were conducted. Each was done on three consecutive nights during the same moon phase in June, July, and August. Numbers of small mammals in each area was calculated using the Schumacher-Eschmeyer Estimation.

IMPORTANT RESULTS

There are three different plant communities represented in the study area: sagebrush steppe, crested wheatgrass planting, and a transition area between these communities. Differences between treatments and community type were estimated using a factorial analysis of variance. Total vascular plant cover did not differ between plant community types. When the plant community types were pooled, the irrigated area had a significantly higher cover ($p<0.001$). There was also an interaction ($p<0.001$) between irrigation treatment and plant community type (Figure 11). The differences in cover were due to increased grass cover primarily in the crested wheatgrass and transition communities (Figure 12). Litter cover was significantly lower in the irrigated treatment ($p<0.041$) of the crested wheatgrass and

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sagebrush steppe communities (Figure 13). This suggests increased rates of litter decomposition because of increased moisture and nutrients when soil temperatures are conducive to higher microbial activity.

These results support the hypothesis that irrigation with sewage wastewater can be expected to modify plant communities primarily by increasing the relative dominance of grass species. The decrease in litter, presumably by increased decomposition rates, suggests changes in soil quality by decreasing soil organic matter may be a long-term consequence of irrigating native systems with sewage wastewater.

Small mammals captured during 1997 included deer mice, pocket mice, and least chipmunks. A total of 84 individuals were captured and 56 of those were captured more than once. This represents too few individuals to make any species by species comparisons between treatments, but general conclusions of overall small mammal populations can be made. There was a significant difference (p=0.043) in population size between plant communities with sagebrush steppe having the greatest and crested wheatgrass having the least number of small mammals. There was no significant difference (p=0.703) between irrigation treatments.

These results support other observations that small mammal numbers and diversity are lower in crested wheatgrass monocultures than in more diverse plant communities. Even though grass cover was higher in the irrigated transition plant community than in the not irrigated transition community, it remains structurally and compositionally diverse vegetation type. Unless the suspected trend in vegetation change approaches a grass monoculture, we do not expect small mammal population to change.

PRODUCTS

This project is in the early data-collecting phase. Technical publications and presentations have yet to be developed from this project.

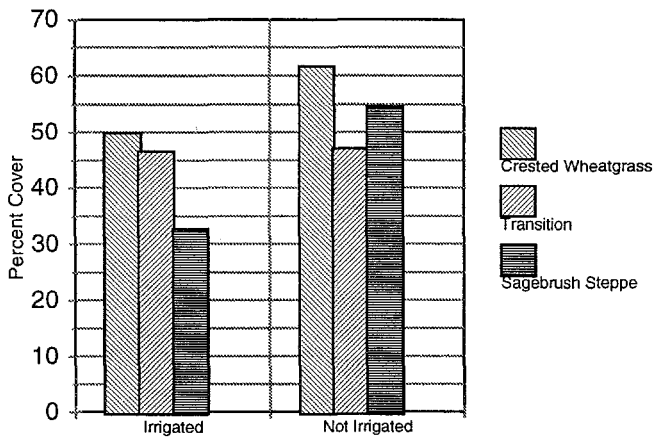

Figure 11. Mean vascular plant cover in irrigated and not irrigated treatments in three plant community types associated with the CFA sewage wastewater disposal treatment facility.

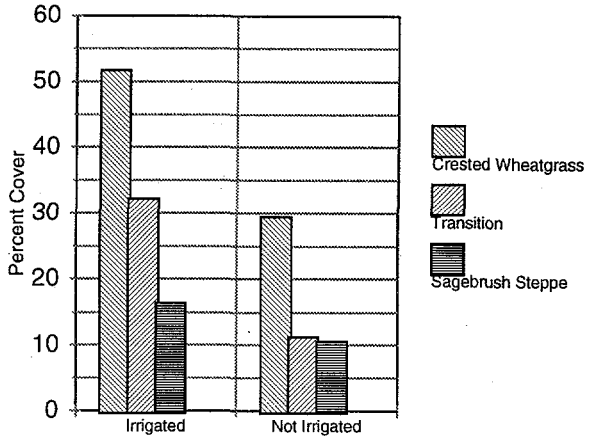

Figure 12. Mean grass cover in irrigated and not irrigated treatments in three plant community types associated with the CFA sewage wastewater disposal treatment facility.

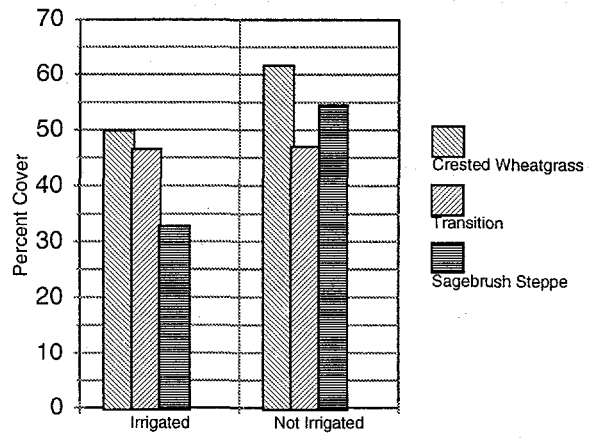

Figure 13. Mean litter cover in irrigated and not irrigated treatments in three plant community types associated with the CFA sewage wastewater disposal treatment facility.

NOXIOUS WEED SURVEY OF THE IDAHO NATIONAL ENGINEERING AND ENVIRONMENTAL LABORATORY

Roger D. Blew[22]

The close link between land use change and biological invasions has resulted in long-term ecological problems for many rangeland areas in the western United States. These invasions have brought about changes in the dominant vegetation in many rangeland types in the West. Conversion of shrublands to annual grasses is perhaps the most widespread consequence of these invasions. Other plant species listed as noxious weeds have also impacted large areas of rangeland.

OBJECTIVES

The objective of this project was to examine the distribution of exotic plant species on the INEEL. Primary consideration was given to regulatory noxious weeds. Specific objectives for 1997 were to:

- Survey areas on site southeast of Howe and along the northeast boundary of the site which are potentially at risk to weeds associated with crops.
- Survey areas potentially at risk to invasion along water courses including the reach of the Big Lost River upstream from the diversion to the site boundary, the spreading areas and the Birch Creek drainage, including the diversion return canal, down to the TAN gravel pit.
- Develop a GIS database of noxious weed infestation locations.

PROJECT ACCOMPLISHMENTS

- Field surveys were conducted in areas previously reported to have noxious weeds present and in areas that could be infested.

Many noxious weeds and other invasive species are known to make initial invasions by being brought into the area on animals, vehicles, flowing water, or similar means. Corridors for their movement are likely areas to contain weeds. On the INEEL, these corridors include the Big Lost River and Birch Creek Diversion and all roads and highways. Areas of soil disturbance along these corridors are especially vulnerable to invasion. Primary focus during 1997 was on areas near croplands and water courses.

The principle survey method used was based on those used for rare plant surveys. This involved visual inspection of those areas where weeds were suspected, likely to occur, or considered to be at risk. These area were primarily invasion corridors such as roads and rivers, and burned areas.

- Where target weed species were observed, an intensive localized search was conducted to determine the extent of the invasion and additional data about the plant community in the area were collected.

Those data included species richness, relative dominance and cover. Information about soil texture was also collected at these sites.

- A GIS database of infestations was established. This was accomplished by recording GPS coordinates at infestations as they were found. The

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coordinates were differentially corrected and entered into a database suitable for use in ArcView.

RESULTS

Surveys in areas near cropland located several infestations of spotted knapweed, Russian knapweed, and black henbane. These infestations were primarily along the northeast border of the site. No infestations were found in the area near Howe.

Infestations of black henbane, leafy spurge, and Canada thistle were found along the Big Lost River upstream of the diversion. In the Birch Creek drainage,

Canada thistle was found along the diversion return canal near the TAN gravel pit. Yellow toadflax has been reported in riparian habitat on Birch Creek several miles above the INEEL boundary but was not found on the site.

GPS data files were collected at most of the noxious weed sightings made during 1997. A total of 32 location files were collected and differentially corrected. These data are presently available for use in ArcView and form the basis for the information displayed in Figure 14. Some known infestations are not yet in the database. These sites will be georeferenced in the near future and added to the database.

PRODUCTS

This project is still in the data collection phase. No reports or manuscripts have been produced.

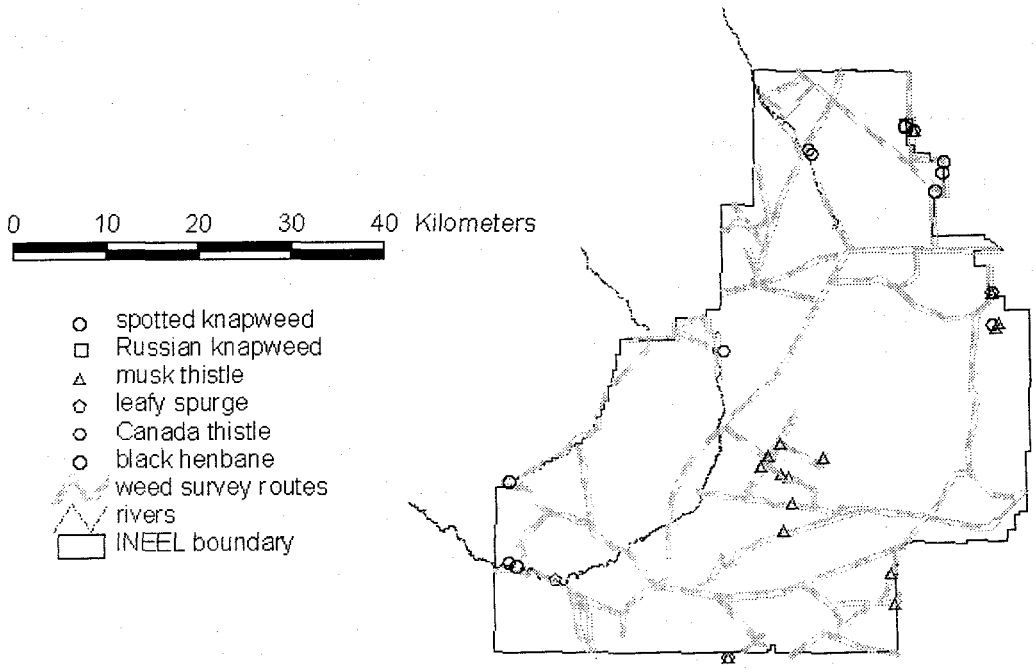

Figure 14. Locations of noxious weed sightings on the INEEL and the routes covered during the surveys.

HABITAT USE BY SUMMER POPULATIONS OF BATS IN SAGEBRUSH-STEPPE

Shauna Haymond[23] and Duke S. Rogers[23]

Because of its abundance of caves and protection from recreational disturbance, the Idaho National Engineering and Environmental Laboratory (INEEL) provides ideal habitat for many of southeastern Idaho's species of bats, including four former C2 species. Little is knows about summer bat populations on the INEEL.

OBJECTIVES

The overall goal of this project is to determine summer utilization of available habitat on the Idaho National Engineering and Environmental Laboratory (INEEL) by bats. The 1996 field season focused on: summer surveys of bat use of lava-tube caves, locating significant day and night roosts, locating maternity roosts, and identifying major foraging areas. Based on the 1996 results, the specific objectives of the 1997 calendar year were to:

- Determine summer locations of bats that winter on the INEEL.
- Identify major foraging areas.
- Locate maternity roosts.

PROJECT ACCOMPLISHMENTS

During the 1996 calendar year, lava-tube caves, rock outcrops and Central Facilities Area buildings were surveyed for bat use. Several roost sites were located, but none were maternity roosts. Some general foraging preferences were also identified. The following is a list of accomplishments for Calendar Year 1997.

- In the spring we surveyed caves on the INEEL used as hibernacula to determine when bats disperse.
- We recorded locations of 16 lava-tube caves on the INEEL using a Global Positioning System.
- We captured and fitted eight female Townsend's big-eared bats (*Corynorhinus townsendii*) with radio transmitters prior to their dispersal from hibernacula. Species of *myotis* are too small to attach radio transmitters to without adversely affecting their behavior (Aldridge and Brigham 1988).
- We captured four female Townsend's big-eared bats during the nighttime activity period and fitted them with radio transmitters. No big brown bats (*Eptesicus fuscus*) were captured although they are known to occur on the INEEL (Genter 1986).
- We conducted 6.5 hours of overflight surveys to locate bats carrying transmitters.
- We monitored bat activity with radio telemetry equipment on 29 nights.
- Located foraging areas of three of the bats carrying radio transmitters.

IMPORTANT RESULTS

By using radio-transmitters we were able to get additional information on the natural history of bats using the INEEL. For example:

- Dispersal from hibernacula was completed by mid-May. Species observed hibernating were: Townsend's big-eared bat, western small-footed myotis (*Myotis ciliolabrum*), and long-eared myotis (*Myotis evotis*). The long-eared myotis was known to migrate

[23] Department of Zoology, Brigham Young University, Provo, UT

through the site (Genter 1986), but has not previously been recorded hibernating on the INEEL.

- The foraging area of a Townsend's big-eared bat that was radio tagged prior to leaving the hibernacula was located ca. 17 km south-east of the hibernacula in the Hell's Half Acre lava flow. Hell's Half Acre is managed by the Bureau of Land Management.
- Two foraging areas on the INEEL are located east of East Butte. These were located with bats carrying radio transmitters that were captured during the nighttime activity period.
- Preliminary results indicate all three foraging areas identified are in juniper woodland and sagebrush steppe. This suggests these may by important habitat components.
- Aerial surveys, conducted ca. 40 km from capture sites, failed to locate all of the radio tagged bats. Townsend's big-eared bats typically migrate 10 to 30 km from hibernacula to summer roost sites (Pearson et al. 1952; Barbour and Davis 1969; Humphrey and Kunz 1976). Because not all of the radio tagged bats were located within this area, it suggests that Townsend's big-eared bats are able to migrate much further than is believed.
- No day roosts (maternity roosts) of radio-tagged bats were located on the INEEL. Because these bats typically day roost in caves and crevices, it is difficult to locate radio transmitters from above ground. We were unable to follow bats to day roosts after a night of foraging.

PRODUCTS

This project is in the data acquisition phase and, as such, there are no tangible products.

One presentation was given on this research.

- Haymond, S. 1997. Monitoring bats on the INEEL. Brigham Young University, Department of Zoology, Ecology and Systematics Division.

LITERATURE CITED

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Barbour, R. W. and W. H. Davis. 1969. Bats of America. University Press, Kentucky, Lexington. 286 pp.

Genter, D. L. 1986. Wintering bats of the upper Snake River plain: occurrence in lava-tube caves. Great Basin Naturalist 46: 241-244.

Humphrey, S. R. and T. H. Kunz. 1976. Ecology of a Pleistocene relict, the western big-eared bat (*Plecotus townsendii*), in the southern Great Plains. Journal of Mammalogy 57: 470-494.

Pearson, O. P., M. R. Koford and A. K. Pearson. 1952. Reproduction of the lump-nosed bat (*Corynorhinus rafinesqui*) in California. Journal of Mammalogy 33: 273-320.

TRACE ELEMENTS AND ORGANICS IN SOILS AT THE SUBSURFACE DISPOSAL AREA

Ron W. Brooks[24] and Randall C. Morris[24]

Since 1952, radioactively contaminated waste has been disposed at the INEEL Subsurface Disposal Area (SDA). Due to deterioration of waste containers, contamination has occurred in SDA subsurface soils. Other hazardous waste components, including trace elements and organics, are buried with the radioactive waste at the SDA.

Trace elements and organics have increasing political visibility relative to radioactive contaminants and, similar to radioactive contaminants, they have potential for dispersal through biotic pathways. Thus, it is important to understand and monitor the ways in which these contaminants might be transported in the environment. One potentially important means of transport is small mammals bringing contaminants to the surface in soil excavated by their burrowing. This contaminated soil is then available for dispersal by wind.

A relative wealth of information is available concerning radionuclide transport by biota at the SDA. However, no published studies report similar investigations of trace elements and organics. Therefore, our objective was to determine whether small mammals were bringing up trace metals, organics, and PCB's in concentrations significantly higher than those found in surface soils and control soils. Because the organic pesticide Aldrin was found in soils excavated by small mammals the objectives were expanded to include determining if Aldrin entered the SDA in cover soils contaminated by upstream agriculture.

OBJECTIVES

To meet the overall goals of the study, the following objective was established for 1997:

- Re-analyze the analytical results using statistical tests more appropriate for the data set.

PROJECT ACCOMPLISHMENTS

Complete descriptions of types and quantities of trace elements and organics buried at the SDA do not exist for the four sampling areas (A-D). Given the lack of this type of information, we pooled analytical results from surface soils across areas and analytical results from excavated soils across areas before statistical comparisons were made.

A multi-variate analysis (SPSS for Windows) was used to detect significant differences between SDA surface soils and SDA excavated soils. Comparisons were also made between SDA soils and control soils.

IMPORTANT RESULTS

Aldrin was detected in concentrations significantly higher in excavated soils than surface or control soils. The additional sampling from the Spreading Area showed no evidence of Aldrin above detection limits. Although no records or institutional memory of Aldrin use exists at the SDA, this implies that the Aldrin detected in original sampling was derived from

[24] Environmental Science and Research Foundation, Idaho Falls, ID 83405-1838

either INEEL operations or Rocky Flats waste stored at the SDA. Concentrations of mercury were significantly higher in surface soils than excavated soils, but were not different than concentrations observed in control samples. Because mercury is a common industrial pollutant, its higher concentrations in surface soils may be due to industrial operations and from automobile traffic. Copper was found significantly higher in excavated soils than surface soils, but was not significantly different than control soils. These results suggest small mammals are bringing trace elements and organics to the surface, although in very low amounts.

PRODUCTS

A revised draft manuscript entitled, *Trace elements and organic compounds in soils at the Subsurface Disposal Area on the INEEL*, is in preparation. This revision will reflect changes made as a result of the data re-analysis.

UPTAKE PARAMETERS OF CONTAMINANTS AND SPECIES IMPORTANT TO INEEL ECOLOGICAL RISK ASSESSMENT

Randall C. Morris[25]

Accurate risk assessments require high-quality data. This experiment is designed to provide site-specific data for risk assessments, reducing the dependence on values estimated from other sites and other species. This will benefit DOE-ID by increasing the accuracy of ecological risk assessments and, potentially, reducing the cost of remediation.

The overall objectives of this experiment are to:

- Determine the equilibrium plant-soil concentration ratio for Cs and Sr in the parts of several plant species existing on the INEEL.
- Determine the deer mouse (*Peromyscus maniculatus*)-soil concentration ratio for the contaminants of interest.

The specific objectives for 1997 were to:

- Continue to attempt establishment of the plants in the experimental tanks.
- Spike the tanks with stable Cs and Sr.
- Sample the plant material for later analysis.

PROJECT ACCOMPLISHMENTS

- The transplants attempted in spring 1997 had limited success. Sagebrush and rabbitbrush were established but did not thrive. Successful establishment cannot be determined until we observe overwinter mortality. Failing successful establishment, we will investigate using undisturbed plants at the Experimental Field Station.
- A spiking methodology was developed and the soil in the experimental tanks was uniformly spiked with non-radioactive CsCl and SrCl.
- Limited sampling of sagebrush and rabbitbrush occurred. Because the plants did not thrive, it is doubtful whether the samples we were able to collect are of sufficient size to assess their Cs and Sr content.

IMPORTANT RESULTS AND PRODUCTS

A methodology for spiking soil in a uniform fashion up to 0.6 m deep was developed.

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SOIL SUBSIDENCE AND SNOWMELT EROSION ON WASTE DISPOSAL SITES

James P. Dobrowolski[26] and Eric K. Duffin[26]

Low-level radioactive wastes are buried beneath a shallow soil mantle at the Subsurface Disposal Area at the Idaho National Engineering and Environmental Laboratory (INEEL). These disposal sites must be designed to withstand the normal geomorphological processes that occur in a sagebrush-steppe ecosystem. Some of these processes include soil erosion induced by wind and water, disruption of the soil surface from freeze-thaw and shrink-swell cycles, and soil settling after waste burial (Cooke et al. 1973). The impact of these processes varies from year to year, according to the climatic patterns specific to the area. Our investigations of soil settling and erosion are designed to complement other Foundation research that aims to comprehensively define, and ultimately resolve, the effects of environmental factors that compromise waste management success and environmental restoration efforts. To accurately predict the snow melt erosion impact, we need to measure the physical condition of the local snow pack and the energy fluxes incident on it. We also need to monitor the properties of the soil surface and near surface layers during the same period. These measurements can be used to characterize accurately the processes of snow melt infiltration, runoff, and erosion on simulated waste burial sites at INEEL. These date are needed to assess the long-term effectiveness of various cap designs at shallow-land waste disposal sites.

OBJECTIVES

Our 1997 objectives in relation to the Protective Cap/Biobarrier Experiment (PC/BE) were to:

- Continue to characterize soil subsidence and erosion on PC/BE plots. Surface measurements made during the maximum plant growth period (spring) and dormancy period using tachometry (laser electronic distance measurement) without interfering with other PC/BE research efforts. Comparisons of surface change verses plot type, vegetation cover, and irrigation treatment will be made.

Our 1997 objectives for the determination of snow melt erosion at the Simulated Waste Burial trench Caps (SWBTC) were to:

- Continue to document the natural deposition of snow and redistribution mechanisms associated with available snow melt volumes.
- Continue to measure the controls on snow melt (radiative versus turbulent exchange) and identify the mechanisms associated with the snow ripening process.
- Monitor the process of melt infiltration, three-dimensional flow paths, and subsequent runoff production.
- Complete data analysis and interpretation to estimate the volume of runoff and sediment production from rain-on-snow events.
- Continue to parameterize and improve a snow melt model that is meaningful to the INEEL

[26] Department of Watershed Science, Utah State University, Logan, UT 84322-5230.

PROJECT ACCOMPLISHMENTS

In support of the PC/BE we collected soil settling data during the dormant (fall) and growing (spring) seasons. Efforts included data management and construction of three-dimensional contour/surface maps of the PC/BE. In support of the snow melt erosion experiment we collected data (averaged over 10-minute intervals) on air temperature, relative humidity, wind speed, incoming net radiation, outgoing net radiation, and surface albedo. We also collected winter data, averaged over 60-minute intervals, for soil temperatures (10-cm increments to 1 m), soil heat flux, snow depth and precipitation. We used these data to refine model parameterization for snow melt and sublimation (Tarboton 1994). We also completed data analysis for rain-on snow experiments with natural and simulated snow using analysis of variance (ANOVA) and multiple regression analysis.

IMPORTANT RESULTS

Soil Settling.

Soil settling continued to be uninfluenced by vegetation cover type or irrigation regime (Figure 15). Plot elevations remained similar over the growing season. With several years data, we will be able to analyze the differences in settling rates for biobarrier types using repeated measures analysis of variance.

Rain-On-Snow Experiment

- No significant differences were noted among water temperature treatments for measurements of total runoff volume from natural snow covered plots, although the warm water treatment did produce higher mean total runoff volumes. No significant differences in infiltration capacity were noted among natural snow, simulated snow, and saturated/frozen cover types. There were significant differences among the summer (thawed) cover type and all other cover types (Figure 16). Natural snow and saturated/frozen soil showed no significant differences for infiltration capacity among cover type or water temperature treatments. In order of increasing mean infiltration rate, the response by cover type was natural snow, saturated/frozen, simulated snow, and summer (thawed).
- Interrill erosion was significantly different among saturated/frozen plots and all other cover types (Figure 17). Natural snow and saturated/frozen soil showed no significant differences for interrill erosion among cover type or water temperature treatments. In order of increasing interrill erosion, response by cover type was simulated snow, natural snow, summer (thawed), and saturated/frozen. These differences are believed to be influenced by soil moisture content, soil temperature, cohesiveness of soil aggregates, as well as the presence or absence of snow cover. No significant differences were noted among water temperature treatments for natural snow or saturated/frozen plots although warm water treatments did produce higher mean values of interrill erosion than cold water treatments. Melting rates of simulated snow were significantly different than those exhibited by natural snow. The primary reason for this is the difference in

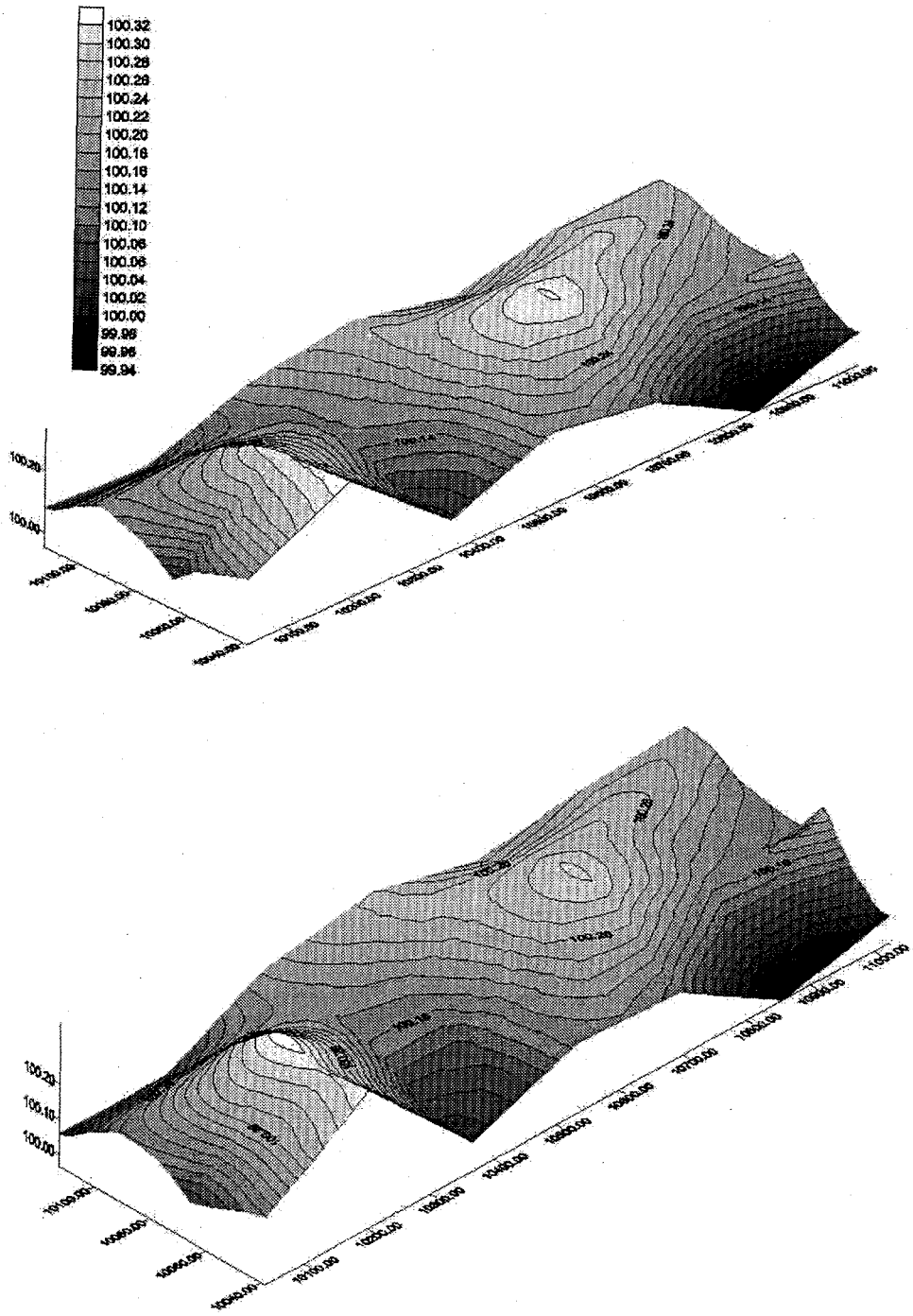

Figure 15. Surface/contour map of the PC/BE surveyed during the spring growing (top) and fall dormant (bottom) seasons, 1997 (n = 360). North and east coordinate horizontal distances are in feet. North coordinate axis and elevations (cm) are slightly exaggerated.

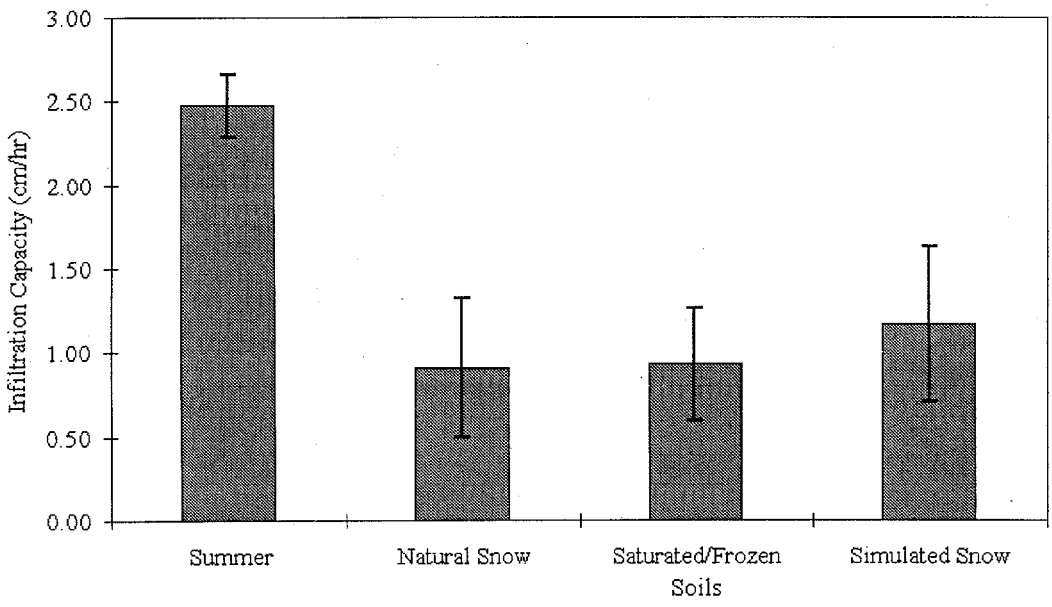

Figure 16. Mean infiltration capacity with standard error bars for four surface treatments.

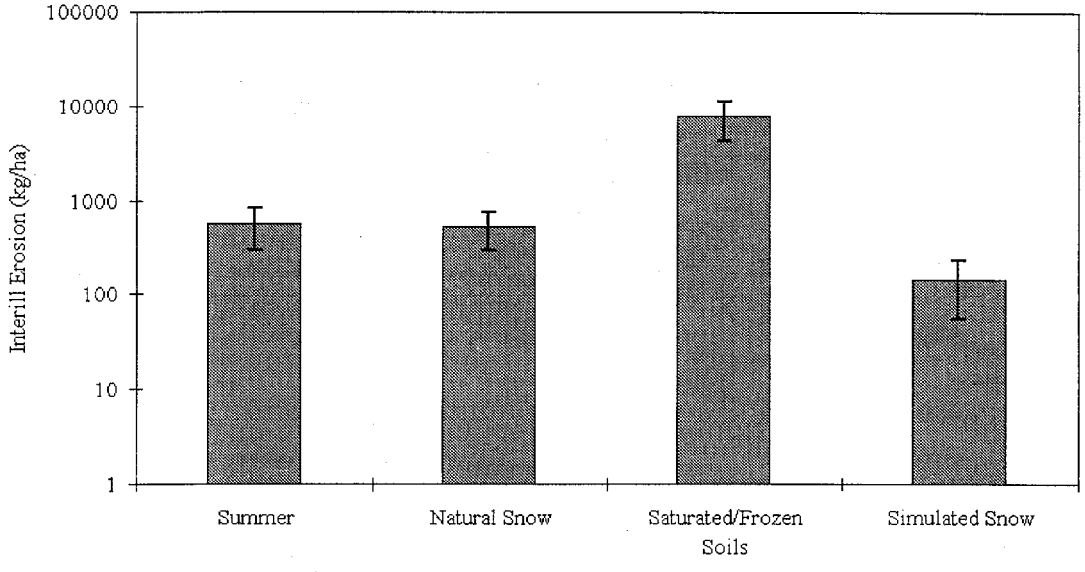

Figure 17. Mean interrill erosion and standard error bars for the four surface treatments.

measured change of snow density. Natural snow cover exhibited a mean decrease in snow density following rainfall simulation while simulated snow covers at both depths increased in density.

PRODUCTS

Efforts at the PC/BE resulted in improved data management techniques and construction of three-dimensional contour/surface maps. Rainfall simulation on simulated and natural snow showed that simulated snow likely requires multiple episodes of melting and freezing before it will resemble natural snow at INEEL.

Using runoff data collected from plots covered with simulated snow will likely underestimate the amount of snow melt erosion possible under similar natural conditions. In contrast, the use of our improved Tarboton model will overestimate snow melt runoff and represents a very conservative approach.

We developed a presentation of the research to be given at three venues in 1998: Northwest Scientific Association, Idaho Academy of Sciences, and a Post-project Seminar for the USU Rangeland Resources Graduate Seminar Series.

Other products include contour/surface maps of the PC/BE showing spatially distributed elevation changes, a predictive model for snow melt runoff from waste burial sites at INEEL, and an assessment of the use of simulated snow for runoff/erosion estimates was accomplished.

LITERATURE CITED

Cooke, U. C. and A. Warren. 1973. Geomorphology in Deserts, University of California Press, Berkeley and Los Angeles. 374 pp.

Tarboton, D. G. 1994. The source hydrology of severe sustained drought in the southwestern United States. Journal of Hydrology 161:31-69.

WILDLIFE USE OF MAN-MADE PONDS ON THE IDAHO NATIONAL ENGINEERING AND ENVIRONMENTAL LABORATORY

Lester D. Flake[27]

Wastewater ponds on the Idaho National Engineering and Environmental Laboratory (INEEL) provide one of the only sources of water for wildlife in this shrub desert ecosystem. This project involves documentation of wildlife use of ponds, evaluation of pond use in relation to pond characteristics, and development of presentations and publications from this data.

OBJECTIVES

The overall objective of this effort is to develop publications based on the extensive amount of field data collected by Cieminski (1993) on wildlife use of wastewater ponds on the INEEL. Specific objectives for 1997 were to:

- Develop and submit manuscripts for publication to appropriate journals, symposium proceedings, or as INEEL publications from data previously collected on wildlife use of wastewater ponds on the INEEL.
- Respond to journal reviews with appropriate editing and analysis on accepted papers through final publication

PROJECT ACCOMPLISHMENTS

In the past this effort produced two papers in peer reviewed journals and two papers in the proceedings of an international symposium. During 1997 one technical manuscript underwent major revision (including partial reanalysis of data) in response to reviews from the Great Basin Naturalist, and has since been published.

IMPORTANT RESULTS

One manuscript was published during 1997.

- Cieminski, K. L., and L. D. Flake. 1997. Mule deer and pronghorn use of wastewater ponds in a cold desert. Great Basin Naturalist 57:327-337.

This paper documents the daily and seasonal use patterns of INEEL wastewater ponds by pronghorn and mule deer. Pronghorn were most common at ponds from July through September, Mule deer from August through November. Mule deer were more nocturnal than pronghorn although time of year influenced daily activity patterns. Distance of facilities from ponds was not related to use by mule deer and pronghorn. Pond isolation from other water sources and presence of vegetated uplands around ponds increased pond use.

LITERATURE CITED

Cieminski, K. L. 1993. Wildlife use of wastewater ponds at the Idaho National Engineering Laboratory. Unpublished master's thesis, South Dakota State University, Brookings. 311 pp.

[27]Department of Wildlife and Fisheries Sciences, South Dakota State University, Brookings, SD 57006

BREEDING AND WINTERING POPULATIONS OF RAPTORS ON THE IDAHO NATIONAL ENGINEERING AND ENVIRONMENTAL LABORATORY

Lester D. Flake[28]

Birds of prey are sensitive to unacceptable levels of environmental contamination and other man-induced changes and disturbances in natural ecosystems. This project continues efforts to document population trends of raptors on the INEEL and to publish and present that information.

OBJECTIVES

A significant field research project on birds of prey of the INEEL was previously completed by Hansen (1994). The primary objective was to:

- Evaluate the status of raptors of the INEEL listed by state or federal agencies as endangered, threatened, or candidate species, or species of special concern.

This present effort continues the analysis, presentation, and publication of that information. The objectives were to:

- Develop and submit manuscripts to appropriate technical journals or popular periodicals.
- Respond to journal reviews with appropriate editing and analyses or reanalyses as necessary to ensure publication in the scientific literature.
- Develop and present seminars or other talks on raptor research on the INEEL.

PROJECT ACCOMPLISHMENTS

Significant past accomplishments include publication of two peer reviewed papers in professional research journals and one paper in a popular conservation periodical.

During 1997, one article on hawks was revised and accepted for publication as a popular article in Idaho Wildlife. Publication is expected in spring 1998.

IMPORTANT RESULTS

One article from 1997 in press for 1998.

- Hansen, R. W. In Press. Hawks of Idaho's high desert. Idaho Wildlife.

This article provides basic information to the public on red-tailed hawks, Swainson's hawks, ferruginous hawks, and rough-legged hawks on the INEEL. The article explains why monitoring and research on hawks on the INEEL is important and encourages readers to learn more about birds of prey and their role in the ecosystem.

LITERATURE CITED

Hansen, R. W. 1994. Raptor use of the Idaho National Engineering Laboratory. Unpublished masters thesis, South Dakota State University, Brookings. 127 pp.

[28]Department of Wildlife and Fisheries Sciences, South Dakota State University, Brookings, SD 57006

PLANTING AND IRRIGATING INFLUENCE ON POST-FIRE VEGETATION RECOVERY

Roger D. Blew[29] and K. C. Jones[30]

The return of large wildfires to the INEEL in recent years has brought attention to both the effects of fire on the ecology of the sagebrush steppe and concerns for protection of facilities and the people working at the INEEL.

JUSTIFICATION

Fire is a natural process in the sagebrush steppe. It has been estimated that the fire interval in sagebrush steppe of eastern Idaho was about 50 years (Wright and Bailey 1982). Although the aftermath of these fires leaves a landscape apparently devoid of anything living, many of the plants of the sagebrush-steppe have mechanisms for surviving fire. The initial recovery of plant communities following fire relies primarily on re-sprouting of the resident plants that were able to withstand the fire. Regeneration from seeds is less important for the initial recovery following fire. A phenomenon common to all burned areas on the INEEL is soil erosion. Data collected by the Bureau of Land Management at the 1994 Butte City Burn indicate losses of as much as six-tenths of an inch of soil during the first two months following the fire.

Unfortunately on the INEEL, blowing dust can create significant problems for the normal operations of facilities located directly downwind of a recent burn. Argonne National Laboratory - West (ANL-W) faced this problem following the1995 and 1996 fire seasons. The 1995 burn exposed a large area of bare soil directly upwind of that facility. The blowing dust following that burn resulted in substantial increases in maintenance costs for buildings and equipment and made working conditions for ANL-W employees difficult. Blowing dust after the 1996 fire near ANL-W closed the road into the facility and portions of U.S. Highway 20. The low visibility on those roads resulted in at least two traffic accidents and prompted suspension of activities at ANL-W for safety reasons.

Efforts to control dust following the 1996 fires included placing snow fences along the road into ANL-W, planting a cover crop to minimize erosion, and irrigating to aid establishment of the cover crop. The seed mixture included oats (*Avena sativa*), "Hy-Crest" crested wheatgrass (*Agropyron cristatum*), "Luna" pubescent wheatgrass (*Elytrigia intermedia*) and "Critina" thick spike wheatgrass (*Elymus lanceolatus*). The planting included the perennial grasses to address the goal of providing cover for long-term control of erosion. Planting was done using a grain drill in August of 1996.

Natural recovery processes following wildfire in the sagebrush steppe generally make artificial planting unnecessary. Exceptions to this would be for areas that did not have healthy native plant communities prior to the fire. This would include areas where weeds dominated before the fire and natural recovery is unlikely.

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[29] Environmental Science and Research Foundation, Idaho Falls, ID 83405-1838

[30] Skyline High School, Idaho Falls, ID 83401

Ratzlaff and Anderson (1995) reported seeding reduced vegetal cover, plant density and species diversity on a burn near Pocatello, ID. These differences were due to the physical disturbance associated with drilling seed. Because of rapid recovery of the indigenous plant species, they concluded seeding was not necessary to establish plant cover and may have reduced the potential for vegetation recovery. They also reported that recovery on the seeded area was not sufficient to stabilize the soil, but the unseeded area did recover enough to provide adequate soil protection. Based on these reports, there were questions about the long-term recovery of the burned area near ANL-W following the 1996 fire and subsequent erosion control and rehabilitation activities.

OBJECTIVES

The goal of this study was to investigate the effects of seeding and irrigation on the recovery of the resident plant community and/or establishment of the planted species. Specific objectives for 1997 were to:

- Locate suitable sites for assessing the effects of the erosion control activities.
- Establish transects for monitoring vegetation.
- Collect plant cover data on those transects to assess effects to first year recovery.

PROJECT ACCOMPLISHMENTS

During 1997, activities focused on establishing the research sites and initiating data collection.

- Two sites were found where all four treatment combinations intersected. Those four treatment combination included: 1) planted and irrigated, 2) planted and not irrigated, 3) irrigated and not planted, and 4) not planted and not irrigated (control sites).
- Within each treatment at each of the two sites, five 20-m transects for data collection were established and permanently marked.

Plant cover was measured in all treatments at both sites using point frames.

IMPORTANT RESULTS

Data on plant cover in the study areas indicated several important effects of the erosion control treatments. In planted areas, total vascular plant cover, cover by perennial species, and cover by native species was 38 percent ($P = 0.019$), 47 percent ($P = 0.011$), and 50 percent ($P = 0.007$), respectively, below cover values on unplanted sites. Moreover, on planted sites cover by non-native species was 430 percent greater ($P = 0.049$) than on control sites. Irrigation had little measurable impact on vegetation.

PRODUCTS

Because this was the first year of data collection, no manuscripts or other products were produced in 1997.

LITERATURE CITED

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

Wright, H.A. and A. W. Bailey. 1982. Fire ecology. John Wiley and Sons, New York.

APPENDIX A

TECHNICAL PUBLICATIONS BY FOUNDATION RESEARCHERS DURING 1997

MANUSCRIPTS PUBLISHED IN 1997

Anderson, J. E. 1997. An ecological engineering approach for keeping water from reaching interred wastes in arid or semiarid regions. Pp. 243-251 *In* S. Chamberlain, C. Chien, and N. Lailas. Proceedings of the 1997 International Containment Technology Conference, 9-12 February 1997, St. Petersburg, FL.

Anderson, J. E. 1997. Soil-plant cover systems for final closure of solid waste landfills in arid regions. Pp. 27-37 *In* Reynolds, T. D. and R. C. Morris (eds). Landfill capping in the semi-arid west: problems, perspectives and solutions. Environmental Science and Research Foundation, ESRF-019, Idaho Falls, ID.

Brooks, R., R. Mitchell, D. Roush, and D. Peterson. 1997. INEEL offsite environmental surveillance program report: fourth quarter of 1996. ESRF-016(4QT96). Environmental Science and Research Foundation, Idaho Falls, ID. 33 pp.

Brooks, R., D. Peterson, and D. Roush. 1997. INEEL offsite environmental surveillance program report: first quarter of 1997. ESRF-021(1QT97). Environmental Science and Research Foundation, Idaho Falls, ID. 25 pp.

Cieminski, K. L. and L. D. Flake. 1997. Mule deer and pronghorn use of wastewater ponds in a cold desert. Great Basin Naturalist 57:327-337.

Cooper, S. L. 1997. Idaho Native Species Account: Great Basin Spadefoot. Idaho Herp News, 9:7-9.

Gabler, K. I. 1997. Distribution and habitat requirements of the pygmy rabbit (*Brachylagus idahoensis*) on the Idaho National Engineering and Environmental Laboratory. Masters thesis. Idaho State University, Pocatello, ID.

Laundré, J. W. 1997. The impact of a shallow biobarrier on water recharge patterns in a semi-arid environment. Pp. 270-274 *In* S. Chamberlain, C. Chien, and N. Lailas. Proceedings of the 1997 International Containment Technology Conference, 9-12 February 1997, St. Petersburg, FL.

Miller, M. 1997. Benefits of an evergreen canopy: seasonal photosynthetic rates of evergreen leaves of *Artemisia tridentata*. D.A. Thesis. Idaho State University, Pocatello. 29 pp.

Mitchell, R. G., R. W. Brooks, D. Peterson, L. R. Paulus, D. Roush, D. B. Martin, and B. S. Lantz. 1997. Idaho National Engineering and Environmental Laboratory site environmental report for calendar year 1996. ESRF-018. DOE/ID-12082(96). Environmental Science and Research Foundation, Idaho Falls, ID. 189 pp.

Mitchell, R. G., D. E. Roush, Jr., and D. S. Peterson. 1997. In summary: Idaho National Engineering Laboratory site environmental report for calendar year 1996. ESRF-022. Environmental Science and Research Foundation, Idaho Falls, ID. 19 pp.

Morris, R. C. and R. D. Blew, eds. 1997. Environmental Science and Research Foundation annual technical report to DOE-ID, Calendar Year 1996. ESRF-017. Environmental Science and Research Foundation, Idaho Falls, ID. 187 pp.

Peterson, D., R. Mitchell, and D. Roush. 1997. INEEL offsite environmental surveillance program report: second quarter of 1996. ESRF-016(2QT96). Environmental Science and Research Foundation, Idaho Falls, ID. 29 pp.

Peterson, D., R. Mitchell, and D. Roush. 1997. INEEL offsite environmental surveillance program report: third quarter of 1996. ESRF-016(3QT96). Environmental Science and Research Foundation, Idaho Falls, ID. 27 pp.

Reynolds, T. D. and R. C. Morris, eds. 1997. Landfill capping in the semi-arid west: problems, perspectives, and solutions. ESRF-019. Environmental Science and Research Foundation, Idaho Falls, ID. 263 pp.

Roush, D. 1997. Resources in review, atomic ghosts: poets respond to the nuclear age, edited by John Bradley. Journal of Environmental Education 29:45-46.

Smith, S. D., R. K. Monson, and J. E. Anderson. 1997. Physiological ecology of North American Desert Plants. Springer-Verlag, Berlin. 286 pp.

Warren, R. W. and O. D. Markham. 1997. INEEL elk related depredation problems: information and potential solutions. ESRF-024. Environmental Science and Research Foundation, Idaho Falls, ID. 14 pp.

Manuscripts in Press

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

Bromenshenk, J. J., J. L. Gudatis, and R. C. Cronn. In Press. Post-closure assessments of industrial complexes with honey bees. Environmental Contamination and Toxicology.

Cieminski, K. L., and L. D. Flake. In Press. Bird communities at wastewater ponds in southeastern Idaho. Proceedings of the 23rd Annual Conference on Ecosystem Restoration and Creation, Tampa, FL.

Cronn, R. C., and J. J. Bromenshenk. In Press. Radionuclide accumulation in honey bees at the Idaho National Engineering Laboratory. Journal of Environmental Quality.

Flake, L. D. and K. L. Cieminski. In Press. Waterfowl use of wastewater ponds on the Idaho National Engineering Laboratory. Proceedings of the 23rd Annual Conference on Ecosystem Restoration and Creation, Tampa, FL.

Hampton, N. L., R. C. Morris, and R. L. VanHorn. In Press. Methodology for conducting screening-level ecological risk assessments for hazardous waste sites. Part II. Grouping ecological components. International Journal of Environment and Pollution.

Hansen, R. W. In Press. Hawks of Idaho's high desert. Idaho Wildlife.

Ibrahim, S. A. and R. C. Morris. In Press. Distribution of plutonium among soil phases near a subsurface disposal area in southeastern Idaho, USA. Journal of Radio analytical and Nuclear Chemistry.

Laundré, J. W. In Press. Effect of ground squirrel burrows on plant productivity in a cool desert environment. Journal of Arid Environments.

Laundré, J. W. Accepted. The relationship between carbon isotope ratios and sagebrush productivity. Oecologia.

Reynolds, T. D. In Press. Efficiency of Sherman and Longworth livetraps in southeastern Idaho. Northwestern Naturalist

Roush, D. In Press. Magazines as a medium for environmental communications. Proceedings of the Fourth Biennial Conference on Communication and Environment, July 1997, Syracuse, NY.

VanHorn, R. L., N. L. Hampton, and R. C. Morris. In Press. Methodology for conducting screening-level ecological risk assessments for hazardous waste sites. Part I. Overview. International Journal of Environment and Pollution.

Manuscripts Submitted

Aguiar, M. R., I. C. Burke, W. K. Lauenroth, and J. E. Anderson. Submitted. Changes in plant functional types in a shrub-steppe: the response of soil. Ecological Applications.

Bromenshenk, J. J., J. L. Gudatis, and R. C. Cronn. Submitted. Heavy metal uptake in honey bees. Environmental Monitoring and Assessment.

Bromenshenk, J. J., R. C. Cronn, J. J. Nugent, J. L. Gudatis, and R. L. McGraw. Submitted. Dispersal of inorganic contaminants in the upper Snake River Plain of Idaho. Apidologie.

Cieminski, K. L., and L. D. Flake. Submitted. Avian communities of wastewater ponds in southeastern Idaho. Great Basin Naturalist.

Hansen, R. W., and L. D. Flake. Submitted. Nesting ecology of *Buteo* spp. hawks on the upper Snake River Plain of southeastern Idaho. Wilson Bulletin.

Hansen, R. W., and L. D. Flake. Submitted. Owl occurrence in the sage-steppe desert of southeastern Idaho. Great Basin Naturalist.

Hansen, R. W., and L. D. Flake. Submitted. Wintering and prebreeding raptor populations on the Snake River Plain of southeastern Idaho. Journal of Raptor Research.

APPENDIX B

TECHNICAL PRESENTATIONS DURING 1997

Anderson, J. E. 1997, February. An ecological engineering approach for keeping water from reaching interred wastes in arid or semiarid regions. International Containment Technology Conference, St. Petersburg, FL.

Anderson, J. E. 1997, April. Fire history of sagebrush steppe ecosystesm. U.S. Bureau of Land Management Spring Fire and Aviation Meeting, Twin Falls, ID.

Anderson, J. E. 1997, April. A soil-plant cover system for keeping water from reaching interred hazardous wastes. Conference on Hazardous Wastes and Materials, Pocatello, ID.

Anderson, J. 1997, May. Protective Cap/Biobarrier Experiment and long-term vegetation dynamics. INEEL Citizens Advisory Board, Sun Valley, ID.

Anderson, J. E. 1997, May. Soil-plant covers systems for final closure of solid waste landfills in arid regions. Landfill Capping in the Semi-Arid West: Problems, Perspectives, and Solutions, Grand Teton National Park, WY.

Anderson, J. E. 1997. Fire ecology in lodgepole pine and sagebrush steppe. Fire Ecology and Policy: Reality versus Rhetoric. Gallatin Institute and American Wildlands, Chico Hot Springs, MT and Yellowstone National Park.

Blew, R. 1997, April. Ecology of watershed uplands. Blackfoot River Watershed Council, Blackfoot, ID.

Blew, R. 1997, October. The relationship between soil microbial biomass and climate. Department of Biological Sciences invited seminar, Idaho State University, Pocatello, ID.

Blew, R. 1997, October. Rangeland resource-related research at the INEEL. Natural resources conservation class, Idaho State University, Pocatello, ID.

Burger, J., D. Roush, and J. Sanchez. 1997, June. Recreation rates, risk perception and future land use preferences of people living near the Idaho National Engineering and Environmental Laboratory. Consortium for Risk Evaluation with Stakeholder Participation Annual Meeting, Seattle, WA.

Cooper, S. L. 1997, February. Modeling the location of snake dens on the Idaho National Engineering and Environmental Laboratory. Idaho Chapter of Wildlife Society Annual Meeting, Boise, ID.

Cooper, S. L. 1997, March. Modeling the location of snake dens on the Idaho National Engineering and Environmental Laboratory. Society for Northwestern Vertebrate Biology/Washington Chapter of Wildlife Society Annual Meetings, Yakima, WA.

Cooper, S. L. 1997, June. Modeling Snake Dens on the Eastern Snake River Plain. Society for Study of Amphibians and Reptiles Annual Meeting, Seattle, WA.

Haymond, S., and D. S. Rogers. 1997, March. Habitat use by summer populations of bats in sagebrush-steppe. Department of Zoology, Ecology and Systematics Division, Brigham Young University, Provo, UT.

Hakonson, T. E. 1997, May. Capping as an alternative to landfill closures: perspectives and approaches. Landfill Capping in the Semi-Arid West: Problems, Perspectives, and Solutions, Grand Teton National Park, WY.

Laundré, J. W. 1997, February. The impact of a shallow biobarrier on water recharge patterns in a semi-arid

environment. International Containment Technology Conference and Exhibition. St. Petersburg, FL.

Laundré, J. W. 1997, September. Effect of ground squirrel burrows on plant productivity. Seventh International Theriological Congress, Acapulco, Mexico.

Luft, A. A. 1997, May. Protective Cap/Biobarrier Experiment a replicated, field-scale comparison of barrier performance. INEEL Citizens Advisory Board Meeting, Sun Valley, ID.

Luft, A. A. 1997, May. Protective Cap/Biobarrier Experiment: a replicated, field-scale comparison of barrier performance. Landfill Capping in the Semi-Arid West: Problems, Perspectives, and Solutions, Grand Teton National Park, WY.

Mitchell, R. 1997, May. INEEL Offsite Environmental Surveillance Program. INEEL Citizens Advisory Board, Sun Valley, ID.

Mitchell, R. 1997, June. INEEL Offsite Environmental Surveillance Program. INEEL Health Effects Advisory Subcommittee, Center for Disease Control and Prevention, Pocatello, ID.

Mitchell, R. 1997, May. INEEL Offsite Environmental Surveillance Program. INEEL Interagency Monitoring and Surveillance Committee, Idaho Falls, ID.

Morris, R. 1997, May. Overview of the Environmental Science and Research Foundation. INEEL Citizens Advisory Board, Sun Valley, ID.

Morris, R. 1997, June. Past radioecological research on the INEEL. INEEL Health Effects Advisory Subcommittee, Center for Disease Control and Prevention, Pocatello, ID.

Morris, R. 1997, April. Locations and status of sensitive and other species of interest on the INEEL. DOE-HQ Peer Review Committee for INEEL Sitewide Ecological Risk Assessment, Idaho Falls, ID.

Morris, R. 1997, March. Ecological resources of the INEEL. Shoshone-Bannock Tribes, Ft. Hall, ID.

Reynolds, T. 1997, May. History of ecological research at the INEEL leading to the Protective Cap/Biobarrier Experiment. National Risk Management Research Laboratory, U.S. Environmental Protection Agency, Cincinnati, OH.

Reynolds, T. D. 1997, March. Soil moisture dynamics at a low-level radioactive waste management site. Northwest Scientific Association Annual Meeting, Spokane, WA.

Reynolds, T. D. 1997, August. Protective Cap/Biobarrier Experiment. INEEL Technical Information Exchange Conference, Idaho Falls, ID.

Reynolds, T. D. 1997, May. Idaho National Environmental Research Park and ecological research at the INEEL. INEEL Citizens Advisory Board, Sun Valley, ID.

Reynolds, T. D. 1997, November. Bird monitoring programs on the INEEL. Upper Snake River Audubon Society, Idaho Falls, ID.

Roush, D., D. Beaver, and J. Burger. 1997, April. Surveying perceptions about the Idaho National Engineering and Environmental Laboratory's Environment. 39th Annual Meeting of the Idaho Academy of Science, Idaho Falls, ID.

Roush, D. 1997, July. Magazines as a medium for environmental communications. Fourth Biennial Conference on Communication and the Environment, Syracuse, NY.

Roush, D. 1997, August. DOE's National Environmental Research Parks. North American Association for Environmental Education Annual Conference, Vancouver, British Columbia, Canada.

Roush, D. 1997, April. Thinking like a watershed. Blackfoot River Watershed Council, Blackfoot, ID.

Warren, R. 1997, July. Sorption and transport of radionuclides by tumbleweeds from two plastic lined evaporation ponds. Health Physics Society Annual Meeting, San Antonio, TX.

Warren, R. 1997, May. The hydrologic evaluation of four cover designs for hazardous waste landfills. Landfill Capping in the Semi-Arid West: Problems, Perspectives, and Solutions, Grand Teton National Park, WY.

Warren, R. 1997, February. Potential doses from game animals. Environmental monitoring class, Idaho State University, Pocatello, ID.