ESRF-007

# Environmental Science and Research Foundation Annual Technical Report: April 11 - December 31, 1994

Edited by

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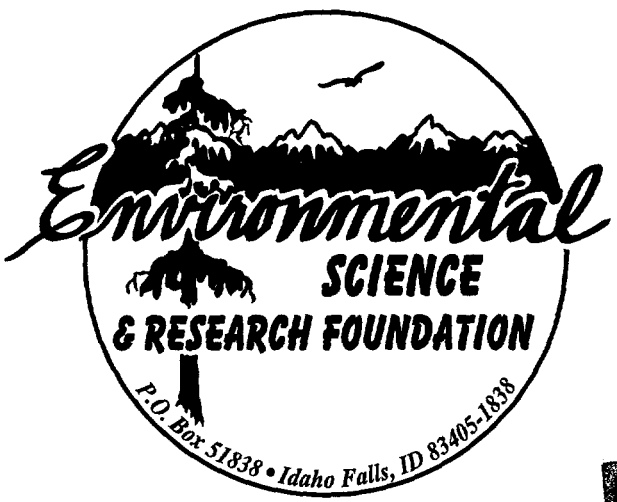
Environmental Science and Research Foundation

June 1995



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# ENVIRONMENTAL SCIENCE AND RESEARCH FOUNDATION
# ANNUAL TECHNICAL REPORT
# APRIL 11 - DECEMBER 31, 1994

## SUMMARY

This Annual Technical Report describes work conducted for the Department of Energy, Idaho Operations Office, by the Environmental Science and Research Foundation (Foundation) for work under contract DE-AC07-94ID13268. The Foundation began, on April 11, 1994, to conduct environmental surveillance near to and distant from the Idaho National Engineering Laboratory, provide environmental public relations and education related to INEL natural resource issues, and conduct ecological and radioecological research benefiting major DOE-ID programs including Waste Management, Environmental Restoration, Spent Nuclear Fuels, and Infrastructure.

The major accomplishments of the Foundation and its University Affiliates from that date through December 31, 1994 can be divided into five major categories:

- Environmental Surveillance Program

  The Foundation routinely sampled air, water, soils, and various foodstuffs throughout the upper Snake River Plain for contaminants originating from the INEL. A total of 1268 samples, consisting of 984 air samples, 51 water samples, 184 samples of foodstuffs, 24 soil samples, and 25 environmental dosimeters were collected; and 1888 analyses were performed on these samples during 1994. Results were within the expected range of background radioactivity and no significant increase in offsite radiation exposure due to INEL operations was indicated.

  Planning for Community Monitoring Stations at Fort Hall, Idaho and a school in the INEL vicinity began in 1994. An agreement with the Shoshone-Bannock Tribes for a Community Monitoring Station was drafted. Working relations were established with the Tribes for environmental surveillance assistance related to particulate monitoring on the Fort Hall Reservation.

  The Idaho National Engineering Laboratory Site Environmental Report for Calendar Year 1993 (Foundation-002) and the INEL Offsite Environmental Surveillance Program Report for the Second Quarter of 1994 [ESRF-004 (2QT94)] were written and published.

  Thirty-three procedures, including standard operating procedures for sample collection and preparation, safety and quality assurance were drafted. These included a Safety and Health Plan and a Quality Assurance Plan, which were transmitted to DOE.

  A request for proposals was issued to locate laboratories to provide analytical services

and performance test samples for the program. After a selection board review and other procurement procedures, five laboratories, including two that are university laboratories, were selected from several respondents. Contracts were drafted and final negotiations were nearly completed by December 31, 1994.

- Environmental Education and Public Relations

A Foundation Newsletter, *Foundation Focus*, was developed. An average of over 400 copies of each of three issues were distributed to individuals and organizations.

Foundation staff and University Affiliates gave over 50 presentations to audiences including professional societies, INEL tour groups, classrooms (from the elementary through university graduate level), and others. Two presentations were given to a National Academy of Science Review Committee and several were given to various technical oversight groups.

Seven news releases were prepared and issued to the media, resulting in several newspaper articles, interviews, and broadcasts. Two additional articles were written specifically for the *INEL News*.

Thirty-four articles and reports were completed, including 1 Ph.D. Dissertation, 3 Masters Theses, 4 foundation technical reports, 3 popular articles, and 23 research articles for the technical literature.

A Travelers' Information Radio Station for the INEL was planned and ordered. This station will provide information on INEL environmental topics to passengers in vehicles traveling U.S. Highways 20 and 26 through the INEL.

- Environmental Services and Support

The Foundation responded to over 180 requests for information from the public, DOE and DOE contractor personnel, scientists, and stakeholders regarding the Foundation's programs or the environmental contamination, radioecology, ecology, surveillance activities and natural resources of the INEL.

The Foundation provided 26 field evaluations and recommendations in support of National Environmental Policy Act requirements in a timely manner.

Two big-game surveys and one site-wide raptor count were conducted. Results were sent to appropriate agencies, including DOE, the Idaho Department of Fish and Game and the U.S. National Biological Service.

Working relations with State and Federal resource management agencies on behalf of the

INEL were established. The Foundation assumed responsibility for INEL interface with the U.S. Department of Agriculture Animal Damage Control programs and U.S. Fish and Wildlife Service Threatened and Endangered Species program.

- Ecological Risk Assessment

The Foundation participated in the ecological risk assessment guidance and development effort since its onset at the INEL, and led the development of the methodology for conducting screening-level ecological risk assessments. A draft document describing that methodology was completed and three associated technical presentations were given.

The Foundation was an active member of the Ecological Risk Task Group of the DOE Headquarters Risk-based Standards Working Group, and a principle reviewer of documents generated by that group.

- Research Benefiting the DOE-ID Mission

Twenty-four research projects were conducted by Foundation staff and affiliates from nine universities and colleges. Projects supported DOE-ID programs for Waste Management, Environmental Restoration, Spent Nuclear Fuels, and Infrastructure, as well as other INEL and DOE programs, such as the National Environmental Research Parks of the Office of Energy Research.

Research projects provided data to DOE-ID for use in complying with various mandates and regulations including, but not limited to, the National Environmental Policy Act, the Endangered Species Act, 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 produced 23 technical articles for publication in appropriate scientific journals, three theses and one dissertation, two Foundation Technical Reports, four articles in the popular literature, eight articles for scientific association newsletters and the general media, and several pages in a DOE Headquarters report on National Environmental Research Parks. Three of the Principal Investigators are preparing books, or chapters in books, partially based on Foundation research.

Research results were presented at regional, national, and international scientific society meetings, as well university and other classroom environments. Other products included the development of innovative computer software to allow automatic collection of erosion data, design and manufacture of various electronic

gauges to measure snowmelt runoff, multispectral images of the Butte City Burn, interpretative maps of elk distribution, various computerized databases of plants and animals on the INEL, and significant additions to lichen and invertebrate museum collections.

Overall, the Foundation was quite productive and efficient during the less than nine-month period in which it was under contract to DOE-ID during 1994. Nearly all individual program goals were accomplished and responses to requests from DOE-ID and INEL contractors were timely, complete, and cost effective.

## TABLE OF CONTENTS


Report Summary ..... iii

Table of Contents ..... vii

List of Figures ..... ix

List of Tables ..... x

Introduction ..... 1

Section I
Foundation History, Goals and Contractual Obligations ..... 3

Section II
Environmental Surveillance ..... 5

Section III
Public Relations and Environmental Education ..... 13

Section IV
Environmental Services and Support ..... 19

Section V
Ecological Risk Assessment ..... 25

Sectiion VI
Research Benefiting the DOE Mission ..... 29

Program Description and Summary ..... 29

Honey Bees as Sentinels of Environmental Hazards at the Idaho National Engineering Laboratory ..... 32

Wildlife Use of Manmade Ponds on the Idaho National Engineering Laboratory ..... 38

Breeding and Wintering Populations of Raptors on the Idaho National Engineering Laboratory ..... 42

Protective Cap/Biobarrier Experiment I: Comparison of Four Protective Cap Designs for Burial of Hazardous Waste at the Idaho National Engineering Laboratory ..... 46

Protective Cap/Biobarrier Experiment II: Comparison of Water use by Annual and Perennial Species on Simulated Waste Burial Plots at the Idaho National Engineering Laboratory ..... 53

Protective Cap/Biobarrier Experiment III: The effect of vegetation height on Snow Accumulation and Soil Water Recharge in Crested Wheatgrass at the Idaho National Engineering Laboratory ..... 57

Mitigating Long Term Impacts of Small Mammal Burrowing on the Closure of Hazardous Waste Areas ..... 60

Assessing the Potential Impact of a Candidate Threatened and Endangered Rabbit Species on INEL Operations ..... 64

Heavy Metals in Small Mammal Populations on the Idaho National Engineering Laboratory ..... 68

Factors that Affect the Distribution of Cheatgrass on the Idaho National Engineering Laboratory ..... 73

Mapping the Distribution of Cheatgrass on the Idaho National Engineering Laboratory ..... 78

The Distribution and Status of Amphibians and Reptiles on the INEL: Implications for Future Site Development and Environmental Restoration Operations .... 83

Diversity of Ant Fauna over the Idaho National Engineering Laboratory: Implications for Waste Management ..... 88

Studies on the Effectiveness of Biobarriers to Prevent Harvester Ant Excavation ... 93

Habitat Use and Movement Patterns of Deer on the INEL ..... 98

Plutonium Distribution among Soil Phases around the Subsurface Disposal Area at the Idaho National Engineering Laboratory ..... 101

Lichens as Biomonitors of Air Pollution at the INEL ..... 104

Snowmelt Erosion on and from Simulated Waste Burial Plots ..... 109

Breeding Bird Surveys on the INEL ..... 116

The Effects of Plastic Liners in Radioactively Contaminated Evaporation Ponds on Radionuclide Levels in and Radiation Doses to Waterfowl and Waterfowl Hunters ..... 120

Iodine-129 Effluents from ICPP: Long-term Concentrations in Animals and Vegetation on and off the INEL ..... 125

Surface Water Penetration at the Subsurface Disposal Area ..... 129

Monitoring Wildlife Species of Special Concern ..... 134

Trace elements and organics in surface soils at the Subsurface Disposal Area ..... 138

## LIST OF FIGURES

Locations for air and water and all other media sampled as part of the Foundations Routine Environmental Surveillance Program ..... 9

Comparison of honey bee extract to Aroclor 1260 standard demonstrating a strong correlation between relative peak intensities and retention times ..... 37

Schematic design of the four cap configurations for the Protective Cap/Biobarier Experiment at the Idaho National Engineering Laboratory ..... 51

Schematic of the experimental design of the Protective Cap/Biobarrier Experiment at the Idaho National Engineering Laboratory ..... 52

Soil Moisture profiles on 8 September, 1993 and 11 October, 1994 for *Leymus cinereus*, *Agropyron desertorum*, *Atremisia tridentata* ssp. *wyomingensis* and mixed annual grasses ..... 56

Soil moisture at 0.2 and 0.4 m depths in mowed and unmowed *Agropyron desertorum* plots during the 1994 growing season ..... 59

The number of sites at which each species of amphibian or reptile was found in 1975 and 1994 ..... 87

The number of individuals of each species of reptile observed in 1975 and 1994 ..... 87

Schematic of 'and farm' used in testing of potential biobarriers for the exclusion of *Pogonomyrmex salinus* during nest excavation ..... 97

Breeding bird survey routes on the Idaho National Engineering Laboratory ..... 119

Spring and fall total volumetric water content (%) for Plot T at the Subsurface Disposal Area on the Idaho National Engineering Laboratory, 1988-1994. . . . . 133

## LIST OF TABLES

Summary of the Foundation Environmental Surveillance Program . . . . . 7

Foundation Presentations During 1994 . . . . . 17

1994 NEPA Field Evaluations Conducted by the Environmental Science and Research Foundation . . . . . 24

DOE-ID Beneficiaries of Specific Environmental Science and Research Foundation Research Projects . . . . . 30

## APPENDIX A

Technical presentations by Foundation researchers: April 11 - December 31, 1994 . . . . . 141

## APPENDIX B

Publications by Foundation researchers: April 11 - December 31, 1994 . . . . . 143

# ENVIRONMENTAL SCIENCE AND RESEARCH FOUNDATION
# ANNUAL TECHNICAL REPORT
# APRIL 11 - DECEMBER 31, 1994

## INTRODUCTION

This is the Annual Technical Report submitted to the Department of Energy, Idaho Operations Office (DOE-ID) by the Environmental Science and Research Foundation in accordance with Basic Contract DE-AC07-94ID13268. This report summarizes the major activities conducted by the Environmental Science and Research Foundation during the period from April 11 through December 31, 1994. Because universities are involved in almost all Foundation activities, the term "Foundation" in this report collectively refers to Foundation Staff and Foundation University Affiliates. This Annual Technical Report was prepared to be readable and meaningful to DOE-ID and the general public. Efforts were made to reduce the occurrence of scientific terminology and detailed descriptions of specific experimental and statistical design. Results are presented as accomplishments and products.

The report is divided into six major sections:

- Foundation history, goals, and contractual obligations with DOE-ID

  This section briefly describes the circumstances leading up to the establishment of the Foundation in April, 1994; provides a synopsis of the mission of the Foundation, and summarizes the agreement between the Foundation and DOE-ID.

- Environmental surveillance program

  This section describes the offsite environmental surveillance program and includes a summary of the sampling effort which indicates the types, frequency, and location of routine environmental samples, plus the constituents for which each are analyzed. This section does NOT provide an analysis and interpretation of the program data for 1994. That information is presented in a separate report (The Idaho National Engineering Laboratory Site Environmental Report for Calendar Year 1994) available in July 1995.

- Public relations and environmental education

  This section emphasizes the Foundation's support for DOE-ID in its open and frank disclosure of environmental issues with various individuals and stakeholder groups. The public relations program includes an aggressive agenda of press releases, newsletters, and presentations to lay and technical audiences.

- Environmental services and support

  This section acknowledges that Foundation staff are recognized authorities on the ecology of the INEL and, as such, provide counsel and recommendations to DOE-ID regarding natural resource issues on the INEL. The Foundation is the point of contact for DOE-ID on natural resource issues with various agencies (e.g. BLM, Fish and Game), and responds to lay and professional queries on the ecology of the INEL.

- Ecological Risk Assessment

  This section describes the involvement of the Foundation in ecological risk assessment issues and efforts locally and nationally. The program provides DOE-ID the basic tools with which to comply with various regulations and mandates.

- Ecology and radioecology research

  This section summarizes the various radioecology and ecology research projects conducted on the INEL by Foundation staff and University Affiliates. The research efforts provide the basis for much of the environmental education, services and support activities, and provide sound, defensible answers to basic and applied ecological questions related to DOE-ID projects in the shrub-steppe ecosystem.

This Annual Technical Report was a collective effort of Foundation Staff and University Affiliates. Foundation contributors included A. E. Adams, O. D. Markham, R. G. Mitchell, R. C. Morris, D. S. Peterson, T. D. Reynolds, and R. W. Warren. The University Affiliates contributing to this report included Principal Investigators J. J. Bromenshenk (University of Montana); L. D. Flake (South Dakota State University); J. E. Anderson, J. W. Laundré, B. D. Eshelman, R. Inouye, and C. R. Peterson (Idaho State University); W. H. Clark (Albertson College of Idaho); J. B. Johnson and J. M. Peek (University of Idaho); S. A. Ibrahim (Colorado State University); L. C. Pearson (Ricks College, retired); J. P. Dobrowolski (Utah State University); and L. R. Powers (Northwest Nazarene College); Research Associate G. C. Smith (University of Montana); Post-Doctoral Student W. E. Limbach (Idaho State University); Senior Research Assistants T. D. Ratzlaff (Idaho State University) and P. E. Blom (University of Idaho and Albertson College of Idaho); and graduate students T. J. Christian (University of Montana), K. E. Rasmuson, T. R. Bowlin., K. I. Gabler, C. S. Sonnemann, S. L. Cooper (Idaho State University); D. E. Beaver (University of Idaho); and E. C. Duffin (Utah State University).

## SECTION I

## FOUNDATION HISTORY, GOALS, AND CONTRACTUAL OBLIGATIONS

In April 1994, the Environmental Science and Research Foundation (Foundation), a nonprofit corporation, was established and assumed contractor responsibility for environmental research and some environmental surveillance activities previously conducted by the DOE-ID, as well as some additional responsibilities. Through its professional staff and university affiliates, the Foundation manages, coordinates, and conducts ecological and environmental research, environmental surveillance, environmental services, and environmental education/public relations activities for DOE-ID. To carry out these responsibilities, the Foundation has established several principal goals.

One of the primary goals of the Foundation is to provide quality ecological research and environmental surveillance around the INEL, and environmental services in a timely manner and at reasonable costs. The Foundation involves universities in most facets of its programs. By garnering university support, the primary goal of quality work at reasonable costs is enhanced. Partnerships with universities are not only economically efficient, but expertise in a wide variety of fields can be quickly acquired through university contacts. As a by-product, the Foundation provides educational and research opportunities to university students and staff.

Another goal includes using researcher expertise and results obtained from individual research projects, as well as the environmental surveillance program, to provide the DOE and the public with information on INEL-related environmental issues. This information, including the analysis of environmental samples, is obtained independent of M&O contractors using university and commercial companies. This approach provides independence of data analyses and reporting which helps satisfy concerns expressed by the state of Idaho and the general public. Additionally, this approach is consistent with DOE's commitment to openness to the public.

Public involvement is also a goal in the Foundation's work. Environmental education at the elementary and secondary levels is encouraged, as is public involvement in certain Foundation activities and decisions, particularly with regard to the scope and activities of the environmental surveillance program.

Finally, a goal of the Foundation is to serve DOE, INEL contractors, and INEL stakeholders as the provider of expertise for natural resource issues related to the INEL.

The Foundation provides services to DOE-ID under DOE contract DE-AC07-94ID-13268. This contract requires that the Foundation shall:

- Conduct an environmental surveillance program which samples all relevant exposure pathways off of the INEL site, with limited surveillance on site. The program shall complement the INEL contractor surveillance program.

- Prepare the annual Idaho National Engineering Laboratory Site Environmental Report, which includes analysis and interpretation of all INEL-related environmental monitoring data collected by the Foundation and INEL contractors.

- Provide public education and information relating to environmental surveillance and wildlife, land use and other INEL natural resource issues.

- Provide various wildlife, habitat and vegetation surveys and results of research on and near the INEL necessary to document baseline conditions and population levels, as well as to establish trends in important ecological parameters and provide advice to DOE on management of ecosystems and ecosystem components.

- Provide assistance by on-location surveys of proposed surface-disturbing activities and possible impacts on wildlife, critical habitat, wetlands, and threatened and endangered species.

- Provide information, recommendations, and assessments for National Environmental Policy Act documents.

- Provide data to, and exchange data with, state and federal resource management and resource agencies.

- Provide assistance in ecological risk assessment (ERA) through participation in the INEL Baseline ERA process, development of ERA guidance, review of ERA documents, and participation on DOE-contractor working groups.

- Provide DOE-ID, INEL contractors, and INEL stakeholders with support and information regarding natural resource issues on the INEL.

- Conduct and manage radioecology and ecology research that benefits DOE-ID programs, such as Waste Management and Environmental Restoration, and supports regulatory compliance (e.g. National Environmental Policy Act and the Endangered Species Act).

In summary, the Foundation's role is to provide quality and economical service to DOE and the public in the areas of ecological research, environmental surveillance, environmental education and public relations, and environmental support services. The following sections summarize the activities conducted during the period April 11 through December 31, 1994.

## SECTION II

## INEL OFFSITE ENVIRONMENTAL SURVEILLANCE PROGRAM

The Environmental Science and Research Foundation conducted the INEL Offsite Environmental Surveillance Program for DOE-ID during the period from April 11 through December 31, 1994. The primary purposes of the program are to sample media representing exposure pathways for contaminants from the INEL to the general public, to obtain radiological analyses for these samples, and to report and interpret the results of these analyses for the general public. The program is required to be conducted to satisfy the requirements of DOE Order 5400.1, General Environmental Protection Program. This order establishes environmental protection program requirements for DOE operations in order to assure compliance with environmental laws and regulations, executive orders, and DOE policies. Data obtained are compared to derived concentration guides listed in DOE Order 5400.5, Radiation Protection of the Public and the Environment, which establishes standards and requirements for DOE operations with respect to protection of members of the public and the environment.

## PROGRAM GOALS AND OBJECTIVES

The primary goals of the Foundation's INEL Offsite Environmental Surveillance Program are to:

- Sample and analyze media from all relevant exposure pathways to the offsite environment for contaminants (primarily radionuclides) potentially released from INEL operations.
- Evaluate results of offsite environmental surveillance data and coordinate with other agencies performing environmental monitoring both on and offsite, including INEL contractors as well as Federal and State organizations.
- Collect the necessary data to determine whether INEL operations are in compliance with applicable environmental standards and assess the offsite impact, if any, of INEL operations on humans and the environment.
- Report and interpret environmental surveillance results to DOE and the general public.
- Promote public awareness of the surveillance program and its results, and provide opportunities for public comment on environmental surveillance issues at the INEL.

In order to achieve these goals, seven specific objectives were established for 1994:

- Implementation of a routine surveillance program to sample media representing potential exposure pathways for contaminants from the INEL.
- Preparation of technical reports which present and interpret environmental surveillance data for DOE and the general public, including preparation of the Annual INEL Site Environmental Report.
- Development and implementation of an ongoing quality assurance program to assure that the Environmental Surveillance Program is operated in a manner consistent with the requirements of DOE Orders.
- Selection and contract development for independent university or commercial analytical services previously provided by the Radiological and Environmental Sciences Laboratory (DOE-ID).
- Dissemination of environmental surveillance data, analyses, and interpretation to the general public through various avenues, including periodic reports, news releases, the Foundation Focus newsletter, and public presentations.
- Development of a plan to evaluate the Offsite Environmental Surveillance Program through public input as well as through internal review.
- Initiate development of a community monitoring station program.

## PROGRAM DESCRIPTION AND ACCOMPLISHMENTS

The Foundation assumed responsibility for conducting the INEL Offsite Environmental Surveillance Program from DOE/RESL in April of 1994. The objectives described in the previous section were satisfied by major accomplishments in all phases of the surveillance program.

### Routine Sampling Program

Nearly 1300 samples of air, water, foodstuffs, soil, and environmental dosimeters were collected during the last nine months of 1994. A total of 1888 analyses were performed on these samples (Table 1). Of this total, quality control samples (replicates and duplicates) accounted for 153 samples and 281 analyses.

## Table 1 Summary of the Foundation Environmental Surveillance Program

| Sample Type / Analysis | Collection Frequency | Number of 1994 Analyses | Locations | | |
|---|---|---|---|---|---|
| | | | Distant | Boundary | INEL |
| **Air** | | | | | |
| Gross Alpha | weekly | 274 | Blackfoot, Craters of the Moon | Arco, Mud Lake | Main Gate, EFS |
| Gross Beta<br>$^{131}I$ | weekly | 470<br>469 | Blackfoot, Craters of the Moon, Idaho Falls, Rexburg | Arco, Atomic City, FAA Tower, Howe, Monteview, Mud Lake, Reno Ranch | Main Gate, EFS, Van Buren |
| Gamma Spec<br>Particulate Mass | quarterly | 61<br>61 | Blackfoot, Craters of the Moon, Idaho Falls, Rexburg | Arco, Atomic City, FAA Tower, Howe, Monteview, Mud Lake, Reno Ranch | Main Gate, EFS, Van Buren |
| $^{90}Sr$<br>Transuranics | quarterly | 24<br>23 | Rotating schedule | Rotating schedule | Rot. schedule |
| **Moisture (Air)** | | | | | |
| Tritium | 6 to 13 weeks | 9 | Idaho Falls | Atomic City | None |
| **Precipitation** | | | | | |
| Tritium | monthly | 20 | Idaho Falls | None | CFA |
| Tritium | weekly | 16 | None | None | EFS |
| **Surface $H_2O$** | | | | | |
| Gross Alpha<br>Gross Beta<br>Tritium | semiannual | 19<br>19<br>19 | Bliss, Buhl, Hagerman, Idaho Falls, Twin Falls | None | None |
| **Drinking $H_2O$** | | | | | |
| Gross Alpha<br>Gross Beta<br>Tritium | semiannual | 32<br>32<br>32 | Aberdeen, Blackfoot, Carey, Idaho Falls, Minidoka, Roberts, Shoshone | Arco, Atomic City, Howe, Monteview, Mud Lake | None |
| **Milk** | | | | | |
| $^{131}I$ | weekly | 52 | Idaho Falls | None | None |
| $^{131}I$ | monthly | 99 | Blackfoot , Carey, Dietrich, Minidoka, Roberts | Howe, Terreton, Arco | None |
| Tritium<br>$^{90}Sr$ | annually | 9<br>9 | Blackfoot , Carey, Dietrich, Idaho Falls, Minidoka, Roberts | Howe, Terreton, Arco | None |
| $^{129}I$ | annually | 0 | Idaho Falls, Carey | Terreton | None |
| **Potatoes** | | | | | |
| Gamma Spec<br>$^{90}Sr$ | annually | 6<br>6 | Blackfoot, Idaho Falls, Rupert | Arco, Mud Lake | None |
| **Wheat** | | | | | |
| Gamma Spec<br>$^{90}Sr$ | annually | 11<br>11 | American Falls, Blackfoot, Dietrich, Idaho Falls, Minidoka, Carey | Arco, Monteview, Mud Lake, Tabor, Terreton | None |
| **Lettuce** | | | | | |
| Gamma Spec<br>$^{90}Sr$ | annually | 7<br>7 | Blackfoot, Carey, Idaho Falls, Pocatello | Arco, Atomic City, Howe, Mud Lake | None |
| **Fish** | | | | | |
| Gamma Spec | annually | 0 | None | None | Big Lost River |
| **Sheep** | | | | | |
| Gamma Spec | annually | 8 | Blackfoot | None | INEL grazing areas |
| **Waterfowl** | | | | | |
| Gamma Spec<br>$^{90}Sr$<br>Transuranics | annually | 0<br>0<br>0 | Fort Hall | None | waste disposal ponds |
| **Game** | | | | | |
| Gamma Spec | Varies | 10 | None | None | INEL roads |
| **Soil** | | | | | |
| Gamma Spec<br>$^{90}Sr$<br>Transuranics | biennially | 24<br>12<br>12 | Carey, Crystal Ice Caves, Blackfoot, St. Anthony | Butte City, Monteview, Atomic City, FAA Tower, Howe, Mud Lake (2), Reno Ranch | None |
| **(TLDs)** | | | | | |
| Gamma Radiation | semiannual | 25 | Aberdeen, Blackfoot, Craters of the Moon, Idaho Falls, Minidoka, Rexburg, Roberts | Arco, Atomic City, Howe, Monteview, Mud Lake, Reno Ranch | None |

A network of 14 low-volume air samplers, including 11 at offsite locations and 3 on the INEL, operated continuously (Figure 1). Data from onsite samplers were compared with data collected offsite. Our onsite data were also used to evaluate data obtained by the onsite surveillance program conducted by the INEL M&O contractor. Filters were changed at each location weekly, and screening analyses (gross gamma followed by a selected number of Iodine-131 analyses for charcoal cartridges, gross alpha and gross beta for particulate filters) were performed each week. No Iodine-131 was detected on any of the cartridges analyzed. Although some gross beta concentrations at boundary and onsite locations were statistically greater than those at background locations, and at least some of these differences may have been related to operations at the INEL, no specific source or release event could be identified to account for the elevated levels. Quarterly composites of the weekly filters were analyzed for gamma-emitting radionuclides, and selected locations were also analyzed for Strontium-90 and transuranic radionuclides (plutonium and americium). One gamma-emitting radionuclide was found at an onsite location and Strontium-90 at two offsite locations, but again no specific INEL source was identified. No transuranic radionuclides were found at any location.

Atmospheric moisture was collected at two offsite locations and precipitation at three locations (two onsite and one offsite) to assess levels of tritium. No tritium was detected in any of these samples during 1994.

The Foundation assumed responsibility for funding of the Interagency Monitoring of Protected Visual Environments (IMPROVE) samplers located at Craters of the Moon National Monument and the INEL, which are operated under a Memorandum of Understanding between the DOE and the National Park Service. The Foundation also assumed responsibility for operation of the INEL sampler, and for sending biweekly samples to the University of California-Davis for analysis. The IMPROVE program is used nationwide at National Parks and wilderness areas to measure parameters that can cause reduced visibility. To date, no major differences in these parameters have been noted between the Craters of the Moon and INEL samplers.

Semiannual water samples were obtained from 11 drinking water locations and 2 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. Gross alpha and gross beta concentrations were consistent with those representing natural background activity, and tritium was not detected in any of the samples.

Milk was collected from one dairy weekly and from eight other dairies monthly. No Iodine-131 or tritium was found in any samples during 1994. Concentrations of Strontium-90 detected in two samples were consistent with those reported nationwide by the Environmental Protection Agency as resulting from worldwide fallout. Annual samples of lettuce, wheat, and potatoes indicated no differences in concentrations of gamma-emitting radionuclides or Strontium-90 at distant and boundary locations.

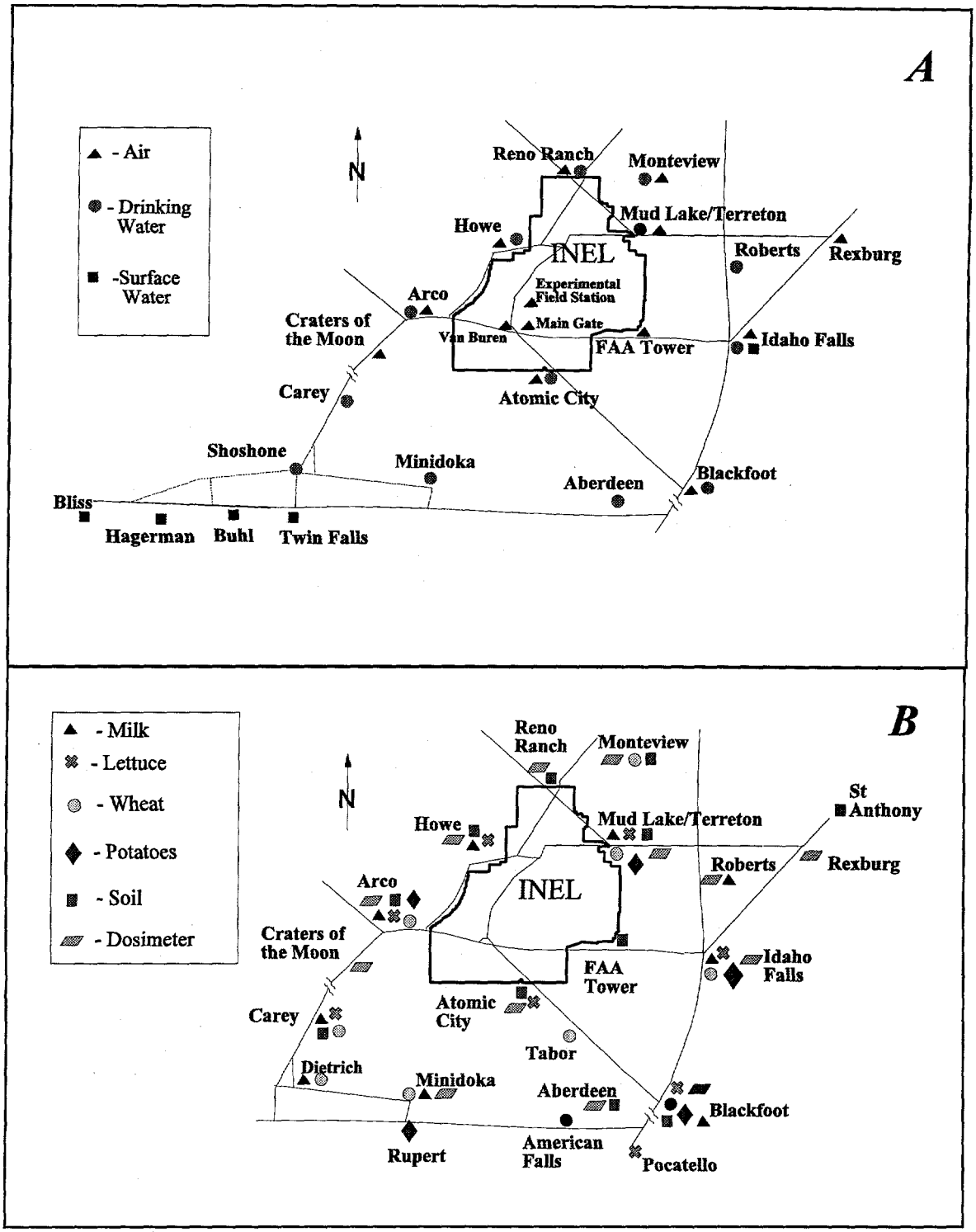


**Figure 1. Locations for Air and Water (A) and All Other Media (B) Sampled as Part of the Foundation's Routine Environmental Surveillance Program**

Soil samples were obtained from 12 locations in 1994 and analyzed for gamma-emitting radionuclides, Strontium-90, and transuranic radionuclides. Concentrations found were similar to those obtained in prior years, and no differences were seen between boundary and distant samples.

Environmental dosimeters were collected from 13 sites during May and November to assess radiation exposure at distant and boundary sites. No differences were noted between the two groups, indicating that only background levels of radiation exposure were found.

## Environmental Reports

The Foundation drafted the *Annual INEL Site Environmental Report for Calendar Year 1993* as required by DOE Order 5400.1. The report contained environmental monitoring data collected by DOE-ID, U.S. Geological Survey, National Oceanic and Atmospheric Association, the Foundation, and other INEL contractors. In addition, the report summarized the INEL's compliance status with respect to major environmental laws and regulations, and provided a summary of significant environmental restoration and waste management issues. Also included was an evaluation of the hypothetical dose to a member of the public resulting from operations at the INEL. Following review by DOE and INEL contractors, the report was printed and distributed to over 400 individuals. The Foundation was given responsibility for preparation of the Annual Site Environmental Report for 1994, and a schedule was drafted for completion of this report.

A format for quarterly environmental surveillance reports was designed, and the second quarter report for 1994 was drafted. This report was reviewed by DOE-ID and was published at the end of 1994.

## Quality Assurance Program

A list of procedures, including standard operating procedures for sample collection and preparation, safety, and quality assurance was developed. Drafts of 33 procedures had been completed by the end of 1994. A Quality Assurance Plan, consistent with the requirements of DOE Order 5700.6c, was prepared and transmitted to DOE. In addition, an outline was prepared for a Quality Assurance Project Plan, to be written in early 1995 according to the guidance of QAMS-005/80. A controlled procedure manual was developed and provided to all Foundation staff members.

We began an effort to improve documentation and tracking for environmental surveillance program activities. New procedures were developed, and implemented at the beginning of 1995, requiring the use of field logbooks and chain of custody forms for sample collection. A schedule was prepared for routine assessments to be performed on field activities, and new training and qualification requirements were developed for staff members. We initiated a quality improvement program, including a routine maintenance and inspection program for air sampling equipment, to reduce the numbers of samples lost due to mechanical failures.

Initial stages of a plan to prepare and submit spiked samples (samples to which a known amount of radioactive material is added) to laboratories performing radiological analyses were started. This provides a verification of a laboratory's ability to accurately perform a given analysis. Commercial vendors that could prepare spiked samples of various media were identified.

## Analytical Laboratories

The Foundation reached agreement with the Environmental Monitoring Laboratory at Idaho State University (ISU) to perform routine analyses (gross alpha, gross beta, tritium, and gamma spectrometry) for the surveillance program. ISU conducted an independent verification program for DOE for over five years, and has proven its capabilities in performing these analyses. Moreover, selection of the ISU laboratory is consistent with the Foundation mission to involve universities in all aspects of the program. An evaluation of the laboratory was conducted and a number of potential areas for improvement were noted. ISU personnel expressed an interest in working with Foundation staff to improve the quality of the laboratory.

We compiled information on various laboratories in the western United States who could perform additional radiological analyses, including Strontium-90, plutonium, and americium. A Request for Proposal was drafted and submitted to several of these laboratories. A Selection Board was convened to evaluate these proposals and Quanterra, Inc. of Richland, Washington was selected by the Board. Selection was followed by a thorough onsite evaluation of the laboratory. A contract was drafted and negotiations were nearly completed at the end of the year.

We arranged for continuing analytical support for the Interagency Monitoring of Protected Visual Environments program from the Crocker Nuclear Laboratory at the University of California-Davis.

## Public Information

One of the primary goals of the Foundation is to inform and educate the public about environmental surveillance at the INEL. We made plans to use a variety of avenues for providing information on the environmental surveillance program to the general public. An initial article on the Environmental Surveillance Program was prepared and published in the first issue of the Foundation's newsletter, the *Foundation Focus*. Press releases, one coinciding with the release of the Annual Site Environmental Report and a second on milk monitoring, were distributed to local media. As a result of the press release on milk monitoring, television station KPVI in Pocatello arranged for a television interview dealing with that activity.

Presentations on environmental surveillance were provided to a visiting group of Colorado State University graduate students, and to classes at Buhl Junior High (Buhl, Idaho) and Taylorview Jr. High (Idaho Falls).

## Public Input/Program Review

A plan was developed for soliciting public input into the environmental surveillance program through a variety of methods. Scheduled to begin in early 1995, this plan includes a series of presentations to community groups (e.g. city councils and chambers of commerce) to inform the public about the surveillance program. These will be followed by staffed displays to be placed in malls and other public areas around the state of Idaho. At each presentation or display, the public will be asked to provide comments or concerns about the program. To facilitate the comment process, a toll-free number and an electronic mail address were planned to be made available to the public.

A minimum of one in-depth focus group will be conducted in Idaho Falls to discuss various aspects of the surveillance program, including evaluation of the economics of the program. Following the meeting of the initial focus group, a decision will be made whether additional groups will be held at other locations in the state.

In addition to gaining public input into the surveillance program, the Foundation also developed plans to conduct a thorough internal program review. Based upon results of that review, and results of the public input, we will recommend changes in the program to DOE.

## Community Monitoring Stations

Initial discussions were held with stakeholders on the development of a Community Monitoring Program. This program includes the establishment of community monitoring stations in the INEL vicinity. The present plan is to first establish a station at the Shoshone-Bannock Reservation in Fort Hall. Initial discussions with the Shoshone-Bannock representatives have been extremely positive. Later, an additional community monitoring station would be established at a school somewhere in the INEL region. Both of these stations will contain instruments to monitor radiation in the air, air quality, and weather conditions. A display area will explain the instrumentation and its use in the Foundation's surveillance program. Data will be posted for public information.

By the end of 1994, a draft agreement for the Fort Hall Community Monitoring Station was developed and submitted to the Shoshone-Bannock Tribes for their review and approval. The Tribes will provide station managers to conduct routine duties at the station and to act as liaisons with public and local schools in the Fort Hall area. The Foundation will provide training for the managers. The data produced at the station will be included in Foundation reports.

## SECTION III

## ENVIRONMENTAL EDUCATION AND PUBLIC RELATIONS

Many of Idaho's residents and visitors are outdoor enthusiasts, and are concerned about how the federal government manages its land. The perceptions of politicians, stakeholder groups, adjacent landowners, tribal leaders, INEL employees, and the general public concerning how the Department of Energy manages the environment on the INEL can be a critical element in support for DOE activities. Therefore, the underlying goal of our public relations and environmental education program is to educate the public about environmental issues, ecological research, and environmental surveillance on the INEL which will support DOE's policy of open communication with the public.

## PROGRAM OBJECTIVES

The Foundation's Public Relations and Environmental Education Program has four primary objectives:

- Educate the public about the physical and biological environment of the INEL, including, but not limited to, topics such as natural resources, species of special concern, habitats, and wetlands.

- Involve the public in the Environmental Surveillance Program by inviting participation in a program review and in establishing community monitoring stations.

- Support and assist environmental education activities in schools and universities by giving presentations, organizing field trips, and hosting workshops.

- Educate the public about cost effective ecological and environmental research on the INEL, including topics such as risk assessment methodologies and results, environmental studies supporting waste management and environmental restoration objectives, and surveys and research regarding threatened or endangered species.

## PROGRAM ACCOMPLISHMENTS

The accomplishments for Public Relations and Environmental Education Program during the period of April 11 through December 1994 are divided into seven major categories:

- Newsletter

  A Foundation newsletter (*Foundation Focus*) was developed, and three issues were produced and distributed. The first newsletter was distributed in June to a mailing list of approximately 350 persons and organizations. By the end of 1994,

this list had grown to over 430 people and organizations. The August/September issue was dedicated to the Protective Cap/Biobarrier Experiment and was in such demand that a second printing was required. The newsletters are also routed to a much larger audience by the recipients.

- Presentations

The Foundation gave a total of 52 presentations during 1994 to professional, classroom, and general public audiences (Table 2). A list of the exact titles for technical presentations is in Appendix A.

- Educational Outreach

The Foundation served as a "mentor" for an 11 year-old child who was completing a "gifted and talented" project on the Amazon.

The Foundation served as a reviewer for "Science Quest" projects at a local high school.

Amphibian and reptile research on the INEL was featured in a May 1994 PBS telecast of "Incredible Idaho."

A poster showing some aspects of a Foundation ant diversity project is on display at the Orma J. Smith Museum of Natural History, Albertson College of Idaho, Caldwell.

- News Releases

The Foundation prepared seven News Releases during 1994. Six of these were distributed by the Foundation, while the seventh was issued by the Department of Energy. The titles of the six news releases issued by the Foundation were:

> The Environmental Science and Research Foundation Opens its Doors to Conduct INEL Environmental Surveillance and Research
>
> Monitoring Our Environment with Milk
>
> Hunting on the INEL
>
> Cave Excavation Shows INEL Located in a Stable Environment
>
> Deer Capture Scheduled for INEL
>
> New Species of Ant Discovered on INEL

The news release prepared by the Foundation, but issued by DOE-ID, was titled:

> Annual Environmental Report Shows Negligible Effects of INEL Activities on the Public During 1993.

- Press Coverage

Foundation news releases resulted in:

> Several newspaper articles.
>
> Five interviews (two newspaper, two radio, one television).
>
> Many television and radio news broadcasts.

Foundation research projects on the INEL were mentioned or featured in a minimum seven articles not directly resulting from news releases.

- Publications and Reports

The Foundation had 33 articles and reports published, in press, or submitted during the period of April 11 - December 1994. For a complete listing of these publications, refer to Appendix B. These publications include 14 technical, peer-reviewed articles based on Foundation research. Another eight technical articles were completed and are in internal review. Three Masters Theses and one Ph.D. Dissertation were completed. Three articles were published in the popular literature. Four Foundation reports were produced. These were:

> *Late Quaternary Plants and Animals From Rattlesnake Cave, Snake River Plain, Idaho* (Foundation-001).
>
> The Idaho National Engineering Laboratory Site Environmental Report for Calendar Year 1993 (Foundation-002).
>
> Radioecology and Ecology Publications of the Idaho National Engineering Laboratory: 1974-1994 (ESRF-003).
>
> *INEL Offsite Environmental Surveillance Program Report for the Second Quarter of 1994* [ESRF-004 (2QT94)].

- INEL News

  Two articles were written specifically for the *INEL News*:

  "After the Fire..." which appeared in the August 16 issue of *INEL News*.

  "Environmental Scientists to Collect Waterfowl Data" which appeared in the January 10, 1995 issue of *INEL News*.

In addition to routine activities, the Foundation also developed plans for several unique environmental public relations activities:

- A Travelers' Information Radio Station for the INEL was planned and ordered in 1994. The station will be located at the junction of US Highways 20 and 26 and will broadcast information about the history, natural history, and environment of the INEL to the occupants of the over 850,000 vehicles that pass this junction each year. In addition to educating the traveling public about the INEL, the Foundation will involve local residents, stakeholders and students in message preparation. The radio will be installed in the spring of 1995.

- An interpretive sign was planned for the Experimental Field Station on the INEL next to the Protective Cap/Biobarrier Experiment to educate visitors about the project. The sign will be directed to a lay audience to facilitate the education of INEL visitors and employees. The text and preliminary plans for the sign design were completed in 1994. The sign will be installed in spring 1995.

- The environmental surveillance program will undergo technical and public review in 1995. A plan for soliciting public involvement in the program was written in 1994. A display to explain the surveillance program was purchased, and a draft of the text and layout for the display were completed. Surveillance program personnel began creating presentations to give to community groups to discuss the offsite surveillance program.

- One method of involving the public in the environmental surveillance program will be through placing Community Monitoring Stations in communities near the INEL. Several other DOE sites were contacted to obtain information about their community monitoring programs. During 1994, the planning process for the placement of two Community Monitoring Stations was initiated and a draft agreement to place a station at Ft. Hall, Idaho, was written and submitted to the Shoshone-Bannock Tribes for review. Initial plans for placing a second station at a local school were also developed. The stations will contain monitoring equipment and educational messages. The stations and the surveillance data they generate will be used in schools as an educational tool.

## Table 2. Foundation Presentations During 1994

| Topic of Presentation | Audience |
|---|---|
| Ecological Risk Assessment on the INEL | EPA Region 10 |
| The New West and Wildlife | Jon Billman, Freelance Writer, Cheney, WA |
| Threatened and Endangered Species on the INEL | Idaho Department of Parks and Recreation, Idaho Foundation for Parks and Lands |
| INEL Research on Sage Grouse, Mourning Doves, Raptors, and Birds Use of Ponds | Wildlife Management Class at South Dakota State University |
| Bird Studies on the INEL | Ornithology Class at South Dakota State University |
| Ecological Relationships between Nesting Swainson's and Red-tailed Hawks in Southeastern Idaho | Raptor Research Foundation |
| Wildlife Habitat on the INEL | INEL Tour Group |
| Protective Cap / Biobarrier Experiment | National Research Council, National Academy of Sciences |
| Nesting of three *Buteo* species on the Upper Snake River Plain | The Wildlife Society, South Dakota Chapter |
| Raptor studies on the Idaho National Engineering Laboratory | South Dakota State University, Graduate Seminar |
| Wildlife & Environmental Surveillance on the INEL | Buhl Jr. High (Buhl, ID) |
| Selected Radiotracer Results from the INEL | NASA/DOE Contractors Meeting |
| Evolution of the Protective Cap / Biobarrier Experiment | Nuclear Regulatory Commission, Washington DC |
| An "Ant Farm" for Laboratory Colonies of *Pogonomyrmex salinus* (Hymenoptera: Formicidae) | Idaho Academy of Sciences |
| Design and Evolution of the Protective Cap / Biobarrier Experiment | ICPP Waste Managers |
| Evapotranspiration of Cold Deserts: Applications to Hazardous Waste Management | University of Nevada, Las Vegas |
| Summary of Radioecology & Ecology Research on the INEL | Minico High School Students (Rupert, ID) |
| Tour of INEL | Ecological Risk Assessment Staff |
| 1994 Accomplishments in the Protective Cap / Biobarrier Experiment | National Academy of Science Review Team |
| Seed-priming Enhanced Emergence of Thickspike Seedlings at Cool Temperatures | Society of Range Management |
| Soil Water Dynamics in Sagebrush Steppe Habitats (Poster Presentation) | Idaho Academy of Sciences |
| Evolution of the Protective Cap / Biobarrier Experiment | WAG 7 Cleanup & Risk Assessment Meeting, EPA, Idaho Division of Environmental Quality (DEQ) |
| A Career as a Radioecologist | Taylorview Jr. High (Idaho Falls, ID) |
| Ecological Risk Assessment | Society of Environmental Toxicology and Chemistry |
| Seed-priming Enhanced Emergence of Thickspike Wheatgrass Seedlings at Cool Temperatures | Idaho Academy of Sciences |
| Protective Cap / Biobarrier Experiment | Six Madison Jr. High School Environmental Science Classes (Rexburg, ID) |
| Remote Sensing for Resource Monitoring in Arid Rangelands | Advanced Science Class, Malad High School (Malad, ID) |
| Physiological and Growth Responses of *Bromus tectorum* | Idaho Academy of Sciences |
| Ecological Risk Assessment (poster presentation) | Society of Environmental Toxicology and Chemistry |
| Design of the Protective Cap / Biobarrier Experiment | LITCO Waste Management Personnel |
| Low Altitude Multi-spectral Video Mapping of Vegetation in Arid Rangelands | Advanced Science Class, Malad High School (Malad, ID) |
| Wildlife on the INEL | Rick's College Geology Students |
| Using Lichens to Monitor Air Pollution | Agronomy Class, Ricks College |

**Table 2. Continued**

| Topic of Presentation | Audience |
|---|---|
| Results of Monitoring Air Pollution with Lichens and Other Plants | Two General Studies Classes, Ricks College |
| Design & Implementation of the Protective Cap / Biobarrier Experiment at the INEL | 33rd Hanford Symposium on Health and the Environment on In-Situ Remediation |
| Progress of Snowmelt Erosion Study: 1993-1994 Field Season | Foundation Research Review Seminar |
| Ecological Risk Assessment (poster presentation) | Society of Environmental Toxicology and Chemistry |
| Waste Management Related Research | Richard Stallings - Office of Nuclear Waste Negotiator |
| Summary of Ecological & Environmental Research at the INEL | INEL Tour Guides |
| Design and Evolution of the Protective Cap / Biobarrier Experiment on the INEL | FFA/CO Managers' Retreat (Managers from DOE, EPA and Idaho DEQ) |
| Wildlife on the INEL | DOE and EG&G Personnel in Preparation for National Academy of Science Tour |
| Summary of Radioecology & Ecology Research on the INEL | INEL Tour Guides |
| Assessing Ecological Risks in Terrestrial Ecosystems with Honeybees | International Symposium on Biomonitors as Indicators of Environmental Change |
| Protective Cap / Biobarrier Experiment | Six Hobbs Middle School Environmental Science Classes (Shelley, ID) |
| Radioecology & Ecology Research on INEL Relating to Waste Management | EG&G Employees |
| Ecological Risk Assessment on the INEL | FFA/CO Managers Retreat |
| A Career as an Environmental Scientist | Taylorview Jr. High (Idaho Falls, ID) |
| Overview of the Environmental Science & Research Foundation | Colorado State University Health Physics Graduate Students |
| Environmental Surveillance on the INEL | Colorado State University Health Physics Graduate Students |
| Waterfowl Identification | Foundation Staff |
| Camouflage | Fox Hollow Elementary School Second Grade Classes (Idaho Falls, ID) |
| Environmental Public Relations | Two Public Relations Classes at Washington State University |

## SECTION IV

## ENVIRONMENTAL SERVICES AND SUPPORT

A major component of the mission of the Environmental Science and Research Foundation is to provide DOE-ID with a variety of environmental services and support. In 1994, the Foundation performed NEPA field evaluations and conducted environmental surveys to provide information for NEPA documentation, Risk Assessments, and other activities. The Foundation acted as the interface between DOE-ID and the Idaho Department of Fish and Game (IDF&G), the U.S. Fish and Wildlife Service and other natural resource management agencies. For example, we performed wildlife surveys and provided data on elk and pronghorn populations to DOE-ID and IDF&G. Information on threatened and Endangered Species was obtained from the U.S. Fish and Wildlife Service and interpreted for DOE-ID as part of this function. In addition, the Foundation was a valuable source of ecological expertise for the INEL in 1994. Foundation staff members served on committees dealing with a variety of ecological, radioecological, ecological risk, and natural resource related issues. The Foundation also responded to over 180 queries about environmental or surveillance related issues by INEL personnel.

Ecological and natural resource related information is vital to the completion of environmental compliance documents such as Environmental Assessments and Environmental Impact Statements. In addition, current Ecological Risk Assessment efforts at the INEL as well as day-to-day management of the INEL site requires information about the environment. Foundation staff members have approximately 45 years of collective experience interpreting the environment at the INEL. This knowledge resource is not duplicated anywhere else within the INEL family and this part of the Foundation's mission makes it available to DOE-ID, LITCO, and INEL Stakeholders. Responding to requests for information and expertise is a growing segment of the Foundation's activities, currently accounting for approximately a person-year of effort.

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 plant and animal populations which inhabit it. For this reason, plant and wildlife surveys must be completed on a regular basis. Generally speaking, such surveys must then be interpreted by competent ecologists to be of value to decision makers; the Foundation provides both the surveys and their interpretation.

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. The quality of the environment on and near the INEL is important to most local residents because it is one of the last large, undisturbed areas on the Snake River Plain, and an important habitat for game animals. Our knowledge of the current condition of the populations of plants and animals which use the INEL enables us to respond quickly and accurately to public concerns about environmental quality. In the past, wildlife depredation on the agricultural areas surrounding the INEL has prompted criticism of DOE by IDF&G and local legislators. Current knowledge about

the depredating populations of elk and pronghorn help the Foundation to anticipate problems and guard against or respond to such criticism.

## PROGRAM OBJECTIVES

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

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

  INEL managers, as well as resource managers at other DOE facilities or with other State or Federal agencies, require information about the INEL 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 INEL's initiative to be open and honest about environmental issues. Because the environmental picture at the INEL is generally positive, this also provides positive public relations for DOE.

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

  Most Environmental Checklists require biological evaluations and many require field investigations. The Foundation performs these evaluations. The Foundation also provides current information about the plant and animal species which inhabit the INEL, particularly threatened or endangered or otherwise listed species, for use in Environmental Assessments and Environmental Impact Statements.

- Coordinate and participate in studies and surveys to determine the status of Threatened and Endangered, or otherwise important, species on the INEL. See the chapter titled "Monitoring Wildlife Species of Special Concern" in Section VI of this report for further detail on this effort.

  The INEL is habitat for one Endangered Species (Bald Eagle), seven candidate (C2) species, and 10 other listed species of concern. Monitoring these species is important to ensure that DOE is able to meet its legal obligations. In addition, depredating species (pronghorn and elk) and game species (sage grouse, pronghorn, elk, and mourning doves) are of concern to the local public and other State and Federal agencies. Monitoring these species helps establish and improve DOE's credibility with these groups (see below).

  Breeding Bird Surveys have been shown to be an effective method of monitoring ecosystem health. For this reason, the Foundation continues to conduct annual breeding

bird surveys. See the chapter titled "Breeding Bird Surveys on the INEL" in Section VI of this report for further detail on this effort.

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

  Sharing information with these agencies is important to enhance and maintain DOE's credibility with them. The Foundation has specific responsibilities with respect to some of them. For example, as part of DOE's interagency agreement with BLM which established the grazing zones on the INEL, DOE agreed to fund predator control by ADC in the grazing areas. The Foundation funds and administers that program for DOE.

  At times, the INEL is winter range for 1/3 of all the pronghorn in Idaho (about 5500 animals) and up to 250 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 and, because the animals spend time on the INEL, an area closed to hunting, looks to the DOE for assistance. The Foundation contributes to the dialogue between DOE and IDF&G. The Foundation coordinates depredation hunts with IDF&G and has assisted in trapping elk for removal from the site. Most importantly, the Foundation provides current information about population trends to IDF&G.

  Raptors are important indicators of ecosystem health. In addition, three of the raptors which potentially inhabit the INEL are either listed as endangered or candidates for listing (C2). For this reason, the Foundation participates in the annual mid-winter eagle count sponsored by the NBS. On the INEL, the Foundation expands this count to include all raptors. This count enables us to track population trends and to compare trends on the INEL with those in other, similar locations. These data help in the biological evaluation of construction and other activities on the INEL to prevent further decreases in sensitive species. See Section VI (Monitoring Wildlife Species of Special Concern) for further detail on this effort.

- Coordinate and encourage use of the Idaho National Environmental Research Park by scientists.

  The boundaries of the INEL enclose a large expanse of nearly undisturbed sagebrush steppe habitat. This unique environment provides an excellent opportunity for environmental scientists to study natural processes and, in particular, the impact of human energy development on such systems. For this reason, the INEL was designated by DOE as a National Environmental Research Park in 1972. The Foundation, as coordinator of

the Research Park, encourages environmental scientists to perform research on the INEL, coordinates their work and assists them with logistics. DOE obtains valuable data about the INEL environment from the studies performed by these scientists. In addition, by supporting this work DOE demonstrates to the public that they are concerned about the environment. Finally, because much of the research is conducted by students seeking graduate degrees, DOE is supporting strong scientific education.

- Correspond with the USDI Fish and Wildlife Service to satisfy the requirements of Section 7 of the Endangered Species Act and exercise local authority to determine whether proposed developments on the INEL require formal Biological Assessment consultation with that agency.

- Review and contribute to documents describing the ecology and radioecology of the INEL whether generated at the INEL, by other DOE sites, or by outside agencies.

## PROGRAM ACCOMPLISHMENTS

The following list provides a brief synopsis of the variety and scope of the environmental service and support provided by the Foundation staff during the eight and one-half contract months of 1994. Use of the Idaho National Environmental Research Park by scientists is described in Section VI of this document.

- We conducted two big game surveys (mid-winter and mid-summer) and the resulting data were supplied to DOE-ID and the Idaho Department of Fish and Game.

  A total of 51 elk were observed during the winter survey. This is significant because in 1993, about 200 elk were captured and removed from the INEL by the IDF&G in an attempt to reduce depredation problems. Elk numbers appear to be rising again and this may lead to further depredation problems. It may be necessary to trap elk again within the next one or two years. However, increased understanding of the population size and habitat use of big game on site may lead to management strategies which reduce the need to trap and remove animals. This will result in improved relations between DOE-ID and other agencies as well as the public. See the chapter titled "Monitoring Wildlife Species of Special Concern" in Section VI of this report for further detail on this effort.

- The Foundation was the district coordinator for the annual mid-winter eagle count sponsored by the USDI National Biological Service.

  The district covered the INEL and surrounding counties. Several staff members participated in this count. For the INEL this was an expanded effort to count all raptors observed rather than just eagles. This year, we counted 237 raptors, including 6 Golden eagles. See the chapter titled "Monitoring Wildlife Species of Special Concern" in Section VI of this report for further detail on this effort.

- The Foundation established a purchase order to pay ADC for predator control on the INEL. In the last quarter of 1994, four sheep were killed by coyotes on the INEL and ADC killed 19 coyotes.

- Because of wolf sightings on and near the INEL by Foundation personnel in 1993, we continue to interact with NBS on this issue. Foundation staff members attended training on wolf identification in 1994 and continue to actively search for wolf sign.

- We corresponded with the USDI Fish and Wildlife Service to satisfy the requirements of Section 7 of the Endangered Species Act. Information concerning listed species was disseminated to the DOE-ID NEPA Compliance Officer, the LITCO NEPA Permitting Group, and various INEL contractors as requested.

- We conducted 26 NEPA field evaluations (Table 3).

- We responded to over 180 requests for information about our environmental surveillance and research programs, or the environmental contamination, radioecology, and ecology of the INEL.

  Requests came from DOE and DOE contractor personnel, interest groups, and the public. Responses ranged from short telephone conversations to formal presentations to written documents. For example, we responded to many requests from the scientific community for reprints of articles from our publication list. We responded to questions from INEL contractor staff and members of the public concerning the presence or absence of particular species on the INEL or levels of contamination in particular areas. The Foundation supplied environmental data for inclusion in the Programmatic Environmental Impact Statement including a book chapter on the Ethnobotany of the INEL.

**Table 3. 1994 NEPA Field Investigations Conducted by the Environmental Science & Research Foundation**

| Contractor | Project |
|---|---|
| EG&G | - Construction of Health Physics Instrument Lab at CFA<br>- Removal of gravel to support the INEL sewer upgrade program<br>- Cold Test Pit expansion<br>- INEL gravel pits<br>- Topography survey of INEL floodplains<br>- Adding soil caps to SL-1 and BORAX-I burial sites<br>- Overland pipe from Aquifer Infiltration Stress Test to Spreading Area A<br>- Core samples for minable clay soils<br>- Replacement of Nitrogen Oxide Ambient Monitoring Station<br>- Expansion at Mixed Waste Storage Facility at PBF<br>- CFA ditch rerouting project<br>- PacificCorp Fibre optic cable from Antelope to Scoville substations<br>- Removal of power pole at EBR-1 |
| MK- F | - Proposed well drilling at RWMC, TAN, PBF, and CFA<br>- Ordnance clearing and disposal action at NODA and near ANL-W<br>- Additional sampling wells near PBF, CFA and RWMC<br>- Additional drilling sites near CFA |
| PTI | - Grubbing vegetation at Range 7<br>- Vegetation maintenance at Range 1<br>- Extension of surface danger zone<br>- Use of Range 1 for fire suppression training with a helicopter tank |
| LITCO | - Addition of new Borrow Areas near PBF and WRRTF<br>- Use of wood chips for dust suppression<br>- Test Trenches for road base evaluation along Van Buren Blvd |
| ESRF | - Portable storage shed |
| NOAA | - Maintenance on INEL roads T-5 and T-11 |

## SECTION V

## ECOLOGICAL RISK ASSESSMENT

From the beginning of the guidance effort, members of the Foundation have participated in the ecological risk assessment development on the INEL. During April - December 1994, one Foundation ecologist was a member of the three-person team that led the development of a methodology for conducting screening-level ecological risk assessments on the INEL and drafted a document describing that methodology. Three papers describing the methodology were presented at a scientific meeting, and the team was invited to submit three articles for a special issue of the International Journal of Environment and Pollution on innovative approaches to ecological risk assessment. Foundation staff also participated in activities of the Ecological Risk Task Group of the DOE headquarters-based Risk-based Standards Working Group.

## JUSTIFICATION

The Environmental Protection Agency (EPA), under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requires that all Superfund sites perform both human health and ecological risk assessments. In addition, the Action Plan for Implementing the Federal Facility Agreement and Consent Order (FFA/CO) for the INEL requires the development of risk assessment guidance for the entire INEL site.

Human health risk assessment is a well-developed discipline and these assessments can be conducted using existing guidance from the EPA. Ecological risk assessment, on the other hand, is not well-developed, particularly for primarily terrestrial ecosystems like the INEL. In this case, guidance is not available and must be developed specifically for the site. The tremendous variety of contaminants, pathways, and species of potential concern across the INEL makes this a particularly difficult and time-consuming task and requires knowledge of the contaminant distribution on the site, its ecology and radioecology, and expertise in risk assessment methodology.

The Foundation has participated in the development of guidance for ecological risk assessment from the beginning of this effort at the INEL. As coordinators of the National Environmental Research Park and the primary organization for the study of the ecology and radioecology of the INEL, we have a unique expertise which has been critical to the success of the guidance development effort.

Successful ecological risk assessment cannot occur in a vacuum. It is important to coordinate our efforts at the INEL with those of other sites so that we can benefit from one another's experience. Thus, participation in the Ecological Risk Task Group of the Risk Based Standards Working Group has been part of the Foundation's mission. This group is developing guidance for ecological risk assessment which is applicable across the DOE complex. In addition to this forum, Foundation staff have presented papers at scientific meetings and in scientific journals in

order to share our methodology with, and receive input from, other organizations involved in ecological risk assessment around the world.

## OBJECTIVES

The objectives of this project for April - December 1994 were to:

- Participate, with the INEL Ecological Risk Assessment Group, in developing guidance for conducting screening level ecological risk assessments at the Waste Area Groups on the INEL.

- Participate, with the INEL Ecological Risk Assessment Group, in drafting a guidance document for conducting screening-level ecological risk assessments on the INEL.

- Contribute to the development of DOE complex-wide ecological risk assessment strategies and guidance by participation on the Ecological Risk Task Group of the DOE Headquarters-based Risk Based Standards Working Group.

- Share INEL's ecological risk assessment expertise with the rest of the ecological risk assessment community through oral presentations at scientific meetings and writing papers for publication in scientific journals.

## ACCOMPLISHMENTS

The Foundation had accomplishments related to all objectives during April - December 1994.

- The development of guidance for conducting screening-level ecological risk assessments continued.

  This development effort was headed by one Foundation staff member and two Lockheed Idaho Technologies Company (LITCO) employees. Other team members included LITCO employees and personnel from two consulting firms. The team, interacting regularly with one another and with personnel from the EPA, the State of Idaho, and DOE, continued to refine guidance for screening potential contaminants of concern, group ecological components, develop conceptual models and ecologically-based screening levels, and interpret the results of screening-level ecological risk assessments. A case study was conducted and the results incorporated into the guidance.

- The team leaders, with input from other team members and regulators, continued to draft a guidance document for conducting screening-level ecological risk assessments throughout the INEL.

- The Foundation provided environmental data and reprints of articles describing research conducted by Foundation affiliates that were used to develop conceptual models, select contaminants of concern, group ecological components, and other activities necessary for ecological risk assessment.

- A Foundation staff member reviewed a draft document entitled "Survey of Ecological Resources at Selected U. S. Department of Energy Sites" which was produced by the Ecological Risk Task Group of the Risk Based Standards Working Group.

- A Foundation staff member interacted regularly by telephone and e-mail with other members of the Ecological Risk Task Group to discuss ideas and share solutions to ecological risk problems which are of interest across the DOE complex.

- A Foundation staff member attended the annual meeting of the Society of Environmental Toxicology and Chemistry in Denver, Colorado.

  This society is the leading society for ecological risk assessment. Attendance provided an opportunity for several fruitful discussions with colleagues in Los Alamos, Savannah River, Oak Ridge, and elsewhere as well as the opportunity to hear papers which addressed problems of interest at the INEL. A Foundation staff member was coauthor on three presentations at the meeting.

- The INEL Ecological Risk Assessment Team was invited to present three papers for publication in a special issue of the "International Journal of Environment and Pollution" which will address innovative approaches in ecological risk assessment.

  A Foundation staff member will be coauthor on two of those papers, one of which will present an overview of our methodology and the other of which discusses our methodology for grouping ecological components. At the end of 1994, these papers were in early draft stage.

## PRODUCTS

A Foundation staff member participated in developing four products of the INEL Ecological Risk Assessment Team in April - December 1994.

- The staff member collaborated with two LITCO employees in drafting "Guidance manual for conducting screening level ecological risk assessments on the INEL" (VanHorn et al. 1994).

  The draft includes the justification and methodology for conducting the screening-level assessments as well as appendices describing the ecological resources on the INEL, the functional grouping methodology, background data for various contaminants of concern,

and the case study. It has been circulated for review and has already been used, with input from the team, to perform the screening-level ecological risk assessment at Waste Area Group 2 on the INEL.

- A Foundation staff member was coauthor on three presentations at the annual meeting of the Society of Environmental Toxicology and Chemistry in Denver, Colorado.

  The presentations included a discussion of the case study conducted to support the guidance development effort (Peterson et al. 1994), an overview of the INEL guidance (VanHorn et al. 1994), and a description of the methodology for grouping ecological components (Hampton et al. 1994).

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Hampton, N. L., R. C. Morris, R. L. VanHorn, and R. Brewer. 1994. An approach to grouping species for ecological risk assessment. 15th Annual Meeting of the Society of Environmental Toxicology and Chemistry. Denver, CO.

Peterson, S., R. Brewer, R. Morris, and R. VanHorn. 1994. A case study for evaluation of ecological risks at the Idaho National Engineering Laboratory. 15th Annual Meeting of the Society of Environmental Toxicology and Chemistry. Denver, CO.

VanHorn, R., T. Bensen, T. Green, N. Hampton, C. Staley, R. Morris, R. Brewer, and S. Peterson. 1994. Ecological risk assessment at the Idaho National Engineering Laboratory: Overview. 15th Annual Meeting of the Society of Environmental Toxicology and Chemistry. Denver, CO.

## SECTION VI

## RESEARCH BENEFITING THE DOE-ID MISSION

### Program Description and Summary

At the Idaho National Engineering Laboratory, the Foundation develops scientific goals and conducts environmental research consistent with the needs of DOE-ID. Because the INEL is a National Environmental Research Park, the Foundation also coordinates ecological research on the INEL that is supported by funds not directly from DOE-ID. Research projects benefit DOE-ID by providing credible and defensible data for decision making and regulatory compliance in support of Waste Management, Environmental Restoration, Spent Nuclear Fuels, and Infrastructure Programs. Foundation research provides data to DOE-ID for use in complying with various mandates and regulations including, but not limited to, the National Environmental Policy Act, the Endangered Species Act, Natural Resource Damage Assessment and Risk Assessment sections of the Comprehensive Environmental Response, Compensation, and Liability Act, and the Federal Noxious Weed Act. Moreover, projects generally are consistent with and promote the Secretary's statements on land stewardship responsibilities and the mission statement for National Environmental Research Parks.

Some research projects and ecological surveys conducted by the Foundation are INEL-wide in scope. These are not tied specifically to any particular DOE-ID program, but generally benefit all programs. For example, the pygmy rabbit is classified by the U.S. Fish and Wildlife Service as a C2 candidate for listing as a Threatened or Endangered species. Surveys conducted for this species indirectly benefit all site activities and programs by providing data regarding its population and distribution on the INEL. These data are needed to satisfy the mandate of the National Environmental Policy Act. Big game surveys (pronghorn, deer, and elk) are also not tied to a particular program, but provide information which allows DOE-ID 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.

Some projects are more program specific, such as the research into the effect of plastic liners on radionuclide cycling and transport in evaporation ponds. Although an individual project generally has a single funding source, the research is often of benefit to more than one major INEL program. Table 4 summarizes the Foundation's interpretation of which major INEL programs benefit most from particular research projects.

Between April 11 and December 31, 1994, the Foundation conducted research and/or data analysis and interpretation on 24 projects. Technical publications were developed from three projects for which field work was previously completed. Many of the individual research projects were related, providing a more comprehensive approach to a particular goal or theme and 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 from

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

**Table 4. DOE-ID Program Beneficiaries of Specific Environmental Science and Research Foundation Research Projects.[1]**

| Research Project | DOE Program[2] | | | |
|---|---|---|---|---|
| | Infra. | WM | ER | SF |
| Honey Bees as Sentinels of Environmental Hazards | | ■ | ■ | ■ |
| Wildlife Use of Man-Made Ponds on the INEL | | ■ | ■ | ■ |
| Breeding and Wintering Populations of Raptors on the INEL | ■ | | | ■ |
| Comparison of Four Protective Cap Designs | | ■ | ■ | |
| Classifying Plant Communities on the INEL | ■ | ■ | ■ | ■ |
| Reducing Long-Term Impacts of Small Mammal Burrowing | | ■ | ■ | |
| Distribution of the Pygmy Rabbit, a Candidate T&E Species | ■ | ■ | ■ | ■ |
| Concentrations of Heavy Metals in Populations of Small Mammals | | ■ | ■ | |
| Implications of Long-Term Vegetation Changes | ■ | ■ | ■ | |
| Distribution and Status of Reptiles and Amphibians on the INEL | ■ | ■ | ■ | ■ |
| Diversity of the Ant Fauna over the INEL | ■ | ■ | ■ | ■ |
| Effectiveness of Biobarriers in Preventing Harvester Ant Excavation | | ■ | ■ | |
| Increasing Winter Forage for Wildlife near INEL Facilities | ■ | | | |
| Plutonium Distribution Among Soil Phases at the INEL | | ■ | ■ | |
| Lichens as Inexpensive Air Pollution Monitors | | ■ | ■ | |
| Snowmelt Erosion & Trench Cap Subsidence | ■ | ■ | ■ | |
| Assessing Impacts of INEL WAG Activities on Breeding Birds | ■ | ■ | ■ | ■ |
| $^{129}I$ in Effluents from the ICPP | | ■ | ■ | ■ |
| Surface Water Penetration at the Subsurface Disposal Area | | ■ | ■ | |
| Monitoring Wildlife Species of Concern | ■ | ■ | ■ | ■ |
| Effect of Plastic Liners in Evaporation Ponds | | ■ | | |
| Contaminants in Waterfowl Using Manmade Ponds | | ■ | ■ | ■ |

[1] Shaded block indicates the program identified in the column heading likely receives benefits from the research.

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

Fundamental to the Foundation's research program is a commitment to include regional and other universities in the research process. This is mutually beneficial because universities can provide specialized expertise at a reasonable cost to complement the skills of Foundation staff while taking advantage of educational and research opportunities that benefit both faculty and students. Nine University Affiliates, accounting for 33 university researchers and graduate students, plus four Foundation staff, had lead roles in research projects. Other Foundation Staff and university personnel supported different phases of the research.

Products from Foundation research are mostly information in the form of reports and publications, which provide factual and citable sources for various INEL documents (e.g. the

DOE Programmatic Spent Nuclear Fuel Management and Idaho Natioal Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement). These products provide a credible, defensible scientific basis for making informed decisions regarding INEL operations, land and natural resource stewardship, and many other topics. Because a research project is not complete until the information is published in the scientific literature, Foundation researchers are required to publish in peer reviewed journals and strongly encouraged to recast the information in less technical outlets. From April 11 through December 31, 1994, the Foundation produced, submitted or published 22 technical articles for publication in appropriate scientific journals, three Master's Theses and one Ph.D. Dissertation, two Foundation Technical Reports, four articles in the popular literature, eight articles for scientific association newsletters and the general media, and several pages in a DOE Headquarters report on National Environmental Research Parks. Three of the Principal Investigators are preparing books, or chapters in books, based on Foundation research.

Other tangible products of our research program include designs (e.g. low-level waste covers), development of scientific equipment, new research techniques, novel data analysis procedures and creative application of existing technologies in new areas.

One product in common among all the 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 the substance for a Master's thesis or Ph.D. dissertation and satisfies the research requirements for an advanced degree. Three Master's of Science and one Ph.D. degree were completed based on student participation in Foundation research.

The following summaries of individual research projects detail the scope of the project, why it is important to conduct each investigation, major accomplishments and products produced between April 11 and December 31, 1994. Some projects are in their infancy, and accomplishments such as locating a suitable study area or installing equipment are more common than the completion of products. For more mature projects, field work may be complete and products, such as technical publications and presentations, dominate.

# HONEY BEES AS SENTINELS OF ENVIRONMENTAL HAZARDS AT THE IDAHO NATIONAL ENGINEERING LABORATORY

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## ABSTRACT

We have deployed bee colonies on the Idaho National Engineering Laboratory (INEL) and its surroundings; periodically collecting and analyzing forager bees for a wide array of chemicals. From residue data, we assessed the presence of radionuclides and organics such as PCBs and mapped distributions of several inorganic elements. We summarized our findings in a series of papers, three of which were internally reviewed in 1994. We also evaluated the importance of INEL facilities in relation to the deposition patterns of contaminants such as fluoride (F), to surrounding regions. INEL facilities do not appear to be a significant contributor of F to the region, especially when compared to phosphate ore processing near Pocatello, Idaho. Bees placed near INEL nuclear testing sites accumulated small amounts of several radionuclides, a variety of inorganic elements and PCBs. However, we also found traces of PCBs in almost every bee sample analyzed, regardless of where the bees were located. When compared to the bees from the smelter region in Montana, we found dramatically different metallothionein levels, as well as depressed levels of essential elements in bees from the smelter regions.

## JUSTIFICATION

For 40 years, the Department of Energy (DOE) has conducted a wide array of activities, including the testing of nuclear materials for national defense. Now it has redirected activities toward environmental restoration. Agency goals are to bring DOE sites into compliance with environmental regulations and to reduce health and ecological risks by cleaning up contaminants. Environmental wastes often are contained (e.g., buried wastes) or follow well-defined drainage patterns, but if the sources or extent of contamination are unknown, costly sampling encompassing large regions may be required.

A more cost-effective solution is to use a mobile sampler that covers the area, samples all media and returns to a fixed location. One such sampler is the honey bee, which we have shown to be an efficient multi-media monitor of contaminant dispersion (Bromenshenk et. al. 1978, 1985, 1992). The National Research Council (1991) judged honey bees to be "excellent monitors

of air pollution", and the United States Environmental Agency (EPA) classified the use of honey bees as a Class 1, off the shelf, *in situ* assessment method (Warren-Hicks et al. 1989) for monitoring exposures to aerial and soil-born contaminants at hazardous waste sites. The bee research described here constituted part of the INEL's monitoring of its own operations and waste management.

Since 1949, the laboratory has served as an isolated area for testing nuclear reactors and support facilities, including the Idaho Chemical Processing Plant (ICPP) and its fluidized-bed, coal-fired, steam generating plant. The ICPP recovered uranium from spent fuels and solidified liquid radioactive waste for storage.

In addition to these potential anthropogenic sources of atmospheric contaminants, other industrial facilities are located in the region surrounding the INEL, and industrial wastes have been buried or disposed in ponds on the site. Much of this part of southeastern Idaho consists of basalt outcrops with few roads, sparsely distributed electrical power lines that could be used to run monitoring instruments, and little vegetation or water. Sentinel animals, such as bees, can provide averaged samples of large and remote areas. Whether honey bees, especially small nucleus colonies, could withstand these harsh conditions and serve as useful, multi-media monitors of a wide array of pollutants was the subject of our INEL studies.

We deployed nucleus colonies of bees on the INEL and sampled colonies at commercial beeyards in the area surrounding the INEL–a total of 61 locations over a period of four years. We compared these bees to those sampled (under EPA sponsorship) at 42 locations around a copper smelter in Montana. Bees were analyzed for radionuclides, fluoride, other trace elements, including heavy metals, and organics such as pentachlorobiphenyls (PCBs). The data were processed using geostatistical procedures such as kriging (Bromenshenk et al. 1985), traditional statistical tests such as F- and Student's t-tests, and multivariate techniques such as a repeated measures discriminant analysis as a means of characterizing multiple chemical exposures and population response contaminant stress.

Bees exposed to contaminants may display a wide spectrum of pathological conditions, ranging from death to behavioral dysfunctions. Of particular interest to us are biochemical perturbations that can be assessed by diagnostic biomarkers, for example, the production of metallothioneins (Cronn 1991) or acetylcholinesterase (Bromenshenk 1978).

## OBJECTIVE

Our objectives were to:

- Map chemical distributions from a variety of unique sources.
- Compare levels of contaminants in bees to levels reported for other environmental samples.

- Contrast residue concentrations in bees from the INEL with bees from other parts of the Pacific Northwest.

- Determine levels of specific biomarkers in INEL bees versus bees from industrial areas in Montana.

- Evaluate the importance of INEL facilities as contributors to regional deposition patterns of contaminants.

- Assess the feasibility of using bees as self-sustaining monitors in a semi-arid desert.

## PROJECT ACCOMPLISHMENTS

For 1994, we directed our efforts toward finalizing data analysis. In addition, improved instrumentation and additional methods were developed which overcame significant interference problems and permitted completion of the PCB analyses.

- During 1994 we completed all of the statistical analysis, drafted six articles and nearly completed the PCB re-analysis of INEL bee samples.

- Four articles have been submitted for internal review, two more are nearly complete.

  Three of the submitted articles have been through initial review. One was submitted to the Journal of Environmental Quality for consideration for publication.

- Our results suggest that facilities at the INEL intermittently release fluoride (F), affecting localized areas on the INEL and probably contributing little to the surrounding area.

  Phosphate ore processing near Pocatello, Idaho, is a recurrent F source and influences a wide area, possibly including the INEL.

- Our results further indicate that foraging bees accumulate small, often barely detectable quantities of $^{60}Co$, $^{137}Cs$ and $^{51}Cr$ near some of the nuclear testing facilities, especially colonies near waste ponds.

  Other inorganic elements, ranging from aluminum to zinc, display a variety of distribution patterns. Some appear to be related to INEL sources. Others seem to be from natural sources (e.g., artisian wells, volcanic soils), agricultural chemicals, or private industries.

- Bees located near waste ponds at the TRA and LOFT appear to have accumulated low levels of PCBs (Figure 1), and trace levels of PCBs were common in most bee samples from throughout the region, including sites in Montana.

  This is consistent with similar reports of widespread PCB accumulation by bees at many locations in Connecticut (Anderson and Wojtas 1985).

- Comparison of bees from the INEL to bees from a smelter region in Montana revealed: 1) differences in levels of metallothioneins, which were higher in smelter bees exposed to cadmium, and 2) changes in the relative values of essential elements, which were lowest in bees near the smelter.

  This provides two methods for ranking site risks to bees. One method consists of assessing the physiological condition of bees, as evidenced by production of metal-binding proteins—a relatively time-consuming and costly procedure. The other method uses depressed values of essential elements such as Cu and Zn to indicate physiological changes, which may be more cost-effective than assessing protein production. How applicable this will be for other field studies, given the complex interactions of contaminant exposure and other environmental stressors, remains to be seen.

- Our honey bee pollution monitoring research was nominated for a 1995 Computerworld Smithsonian Award.

  As part of that honor, we have been invited to submit materials for a "time capsule" for future generations to discover in the Smithsonian archives.

## PRODUCTS

Our 1994 products and their status includes the following technical reports:

- Bromenshenk, J. J., R. C. Cronn, and J. J. Nugent. Submitted. Monitoring Fluoride with Honey Bees in the Upper Snake River Plain of Idaho. Journal of Environmental Quality.

- Bromenshenk, J. J., J. L. Gudatis, and R. C. Cronn. In review. Post-Closure Assessments of Industrial Complexes with Honey Bees. Journal of Environmental Quality.

- Cronn, R. C., and J. J. Bromenshenk. In review. Radionuclide Accumulation in Honey Bees at the Idaho National Engineering Laboratory. Journal of Environmental Quality.

- Bromenshenk, J. J., G. C. Smith, and V. J. Watson. In review. Assessing Ecological Risks in Terrestrial Systems with Honey Bees. Chapter for peer-reviewed book to be published by Plenum Press.

The last paper was presented by Dr. Bromenshenk as an Invited Paper at the International Symposium on Biomonitors as Indicators of Environmental Change, June 7, 1994, Windsor, Canada.

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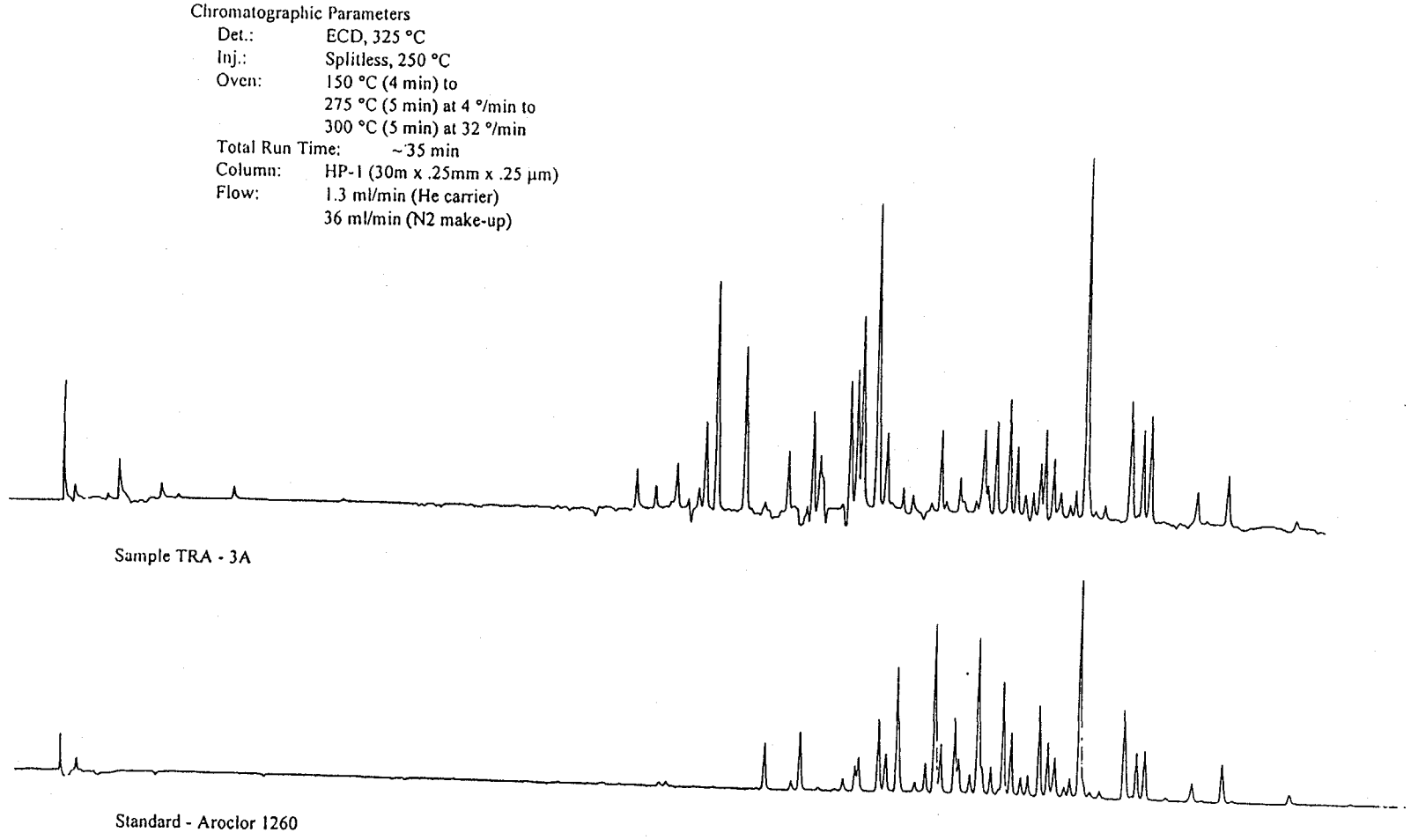


**Figure 1. Comparison of honey bee extract (top) to Aroclor 1260 standard demonstrating a strong correlation between relative peak intensities and retention times.**

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

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## ABSTRACT

Water is extremely limited on the INEL and wastewater ponds provide important feeding and resting areas for migrant birds as well as watering, feeding and reproductive sites for birds reproducing on the INEL. INEL ponds are used by a minimum of 144 bird species with peak numbers of species occurring from April through September. Mule deer, pronghorn and elk also use the ponds. The greatest numbers of bird species were found at large, nutrient rich ponds surrounded by relatively dense grass and shrub cover. Numbers of individuals within a species or species grouping were often influenced by other pond characteristics. For example, shorebirds were attracted to ponds with increased amounts of bare shoreline. We conclude that ponds on the INEL are important to a great variety of bird species as well as several large mammals and add to the diversity of wildlife on the INEL. Detailed research results from this project have been previously reported in Cieminski (1993). Manuscripts were written on invertebrate fauna of wastewater ponds, bird communities, Common Nighthawk (*Chordeiles minor*) activity at ponds, swallow activity at ponds, and mule deer (*Odocoileus hemionus*) and pronghorn (*Antilocapra americana*) use of ponds. All five of these were submitted and reviewed by Foundation staff in 1994. All papers except the mule deer and pronghorn paper were submitted and reviewed by DOE in 1994. The invertebrate paper was accepted for publication by the Great Basin Naturalist pending editing comments to be included from the Naval Reactor Facility. The manuscripts on aerial insect feeders (all species of swallows and the Common Nighthawk) and large ungulates are targeted for submission to appropriate journals or published symposia in 1995.

## JUSTIFICATION

In a cold desert ecosystem such as the INEL, water may be highly limiting to a number of wildlife species. A broad array of vertebrate species associate with wastewater ponds on the INEL. Species such as the Sora (*Porzana carolina*) and Eared Grebe (*Podiceps nigricollis*) occur during the reproductive season on man-made ponds such as the north cell of the Naval Reactors Facility (NRF) and the west pond at Argonne National Laboratory (ANL). Both of these species are dependent on wetlands with at least some emergent vegetation which the NRF and ANL ponds have available. These two ponds demonstrate the values of ponds in increasing

species richness in the desert ecosystem. Indeed, natural ponds containing water on a summer long or year round basis are almost nonexistent on or near the INEL.

Empirical and quantitative data indicate wastewater ponds on the INEL are an important and, for some species, necessary resource for wildlife on the INEL (Howe and Flake 1988, 1989). However, statistically significant, but low level radionuclide contamination has been observed in several bird species and mammals associated with radionuclide leaching ponds (Halford and Markham 1978). Although studies of animal movements (Browers 1983, Browers and Flake 1985, Connelly et al. 1988, Howe and Flake 1988, Hoskinson and Tester 1980, Laundré and Keller 1981, Reynolds 1984, Woodruff and Keller 1982) provide important information on the potential for movement of contaminants to offsite areas, little is known about wildlife use of ponds and subsequent potential exposure to contaminants. This information will be useful for DOE's Environmental Risk Assessments and will support environmental documentation and policy such as the National Environmental Policy Act and Natural Resource Damage Assessment. Information on pond characteristics in relation to wildlife use can be used in designing future ponds on the INEL to increase or decrease wildlife use.

Wildlife use of ponds on the INEL was examined. The objectives of that study were to:

- Determine daily and seasonal patterns of pond use by birds and intermediate to large mammals.

- Estimate visitation rates, and where possible, actual numbers of birds and mammals using ponds and identify the functional value of ponds for these species.

- Determine pond characteristics which are associated with use of a pond by a particular bird or mammal species.

- Provide information for predicting the wildlife potential of new ponds constructed at INEL based on pond characteristics.

Briefly summarizing, the study indicated INEL ponds had greater numbers of individual invertebrates but fewer taxa (groupings of taxonomically similar organisms such as all rotifers or all daphnia) than did natural ponds in other studies. High numbers of invertebrates may have been caused by the lack of fish predators and the high levels of nitrogen and phosphorus, particularly in ponds receiving sewage effluent. The abundance of invertebrates influenced bird use. At least 144 species of birds used the INEL ponds for a variety of purposes including resting, feeding, watering and reproduction. Large concentrations of waterfowl, shorebirds, swallows, and common nighthawks were attracted to the ponds, but concentrations of birds varied with the pond physical and biotic characteristics. Mule deer were observed at waste water ponds from June through December, but peak use was during September and October. Pronghorn were most commonly seen at the ponds in July and August although use occurred

from May through November. Ponds with more succulent forage on the periphery received the heaviest use by ungulates although they also drink the water at most ponds.

## OBJECTIVES

The objectives of this present effort were to:

- Develop and submit manuscripts for publication to appropriate journals, symposia proceedings, or as INEL publications from data previously collected on wildlife use of wastewater ponds on the INEL.

- Respond to journal reviews with appropriate editing and analysis on accepted papers through final publication stage.

## PROJECT ACCOMPLISHMENTS

Based on the results of the field work, five technical manuscript were identified and prepared.

## PRODUCTS

The products from the Calendar Year 1994 effort are five technical manuscripts in various stages of the review and publication process and two 1-hour classroom presentations.

### Manuscripts

- Cieminski, K. L. and L. D. Flake. In press. Invertebrate fauna of wastewater ponds in southeastern Idaho. Great Basin Naturalist.

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

- Cieminski, K. L., and L. D. Flake. In review. Common nighthawk diel activity patterns at desert ponds.

- Cieminski, K. L., and L. D. Flake. In review. Swallow activity patterns on desert ponds.

- Cieminski, K. L., and L. D. Flake. In review. Mule deer and pronghorn use of wastewater ponds in a cold desert.

## Presentations

- Flake, L. D. 1994. Research on the INEL concerning sage grouse, mourning doves, bird use of ponds and raptors. Classroom Presentation in Wildlife Management at South Dakota State University, Brookings, SD.

- Flake, L. D. 1994. Bird studies on the INEL. Classroom Presentation in Ornithology at South Dakota State University, Brookings, SD.

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# BREEDING AND WINTERING POPULATIONS OF RAPTORS ON THE IDAHO NATIONAL ENGINEERING

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## ABSTRACT

The raptor project involved analysis of previously collected field data, completion of a final report and thesis, and development of technical manuscripts. We developed the final report and thesis and four technical papers, two on nesting, one on wintering and one on owl occurrence. These papers were submitted to Foundation staff and DOE for review. Four papers were submitted to journals and one of these (Nest cohabitation by raptors) was accepted by the end of 1994. One additional nesting paper was submitted for DOE review at the end of December, 1994; the latter paper has since been tentatively accepted for publication. The wintering paper has been reviewed and while not rejected, is in major revision after which it will be returned to the same journal; it has a good chance for acceptance. The owl paper requires additional data collection at INEL such as collected birds, photographs, or taped calls before resubmitting. One nesting paper was presented at the annual meeting of the Raptor Research Society in Flagstaff. The results provided information beneficial to DOE-ID in meeting mandates of the National Environmental Policy Act and the Endangered Species Act, and the Secretary's commitment to responsible natural resource stewardship. Results of our studies indicated that nesting red-tailed hawks (*Buteo jamaicensis*) have increased on the INEL while Swainson's (*Buteo swainsoni*) and ferruginous hawks (*Buteo regalis*) have remained fairly stable since the mid 1970's. Nesting success for these raptors appears to be similar to that observed in other portions of their range. Of the nesting raptors, ferruginous hawks sought the most isolated nesting sites and appeared most vulnerable to human disturbance. Wintering populations have fluctuated in relation to available prey but have not shown any indication of a long-term decline since the 1970s. Current levels of activity on the INEL do not appear to have a negative effect on breeding or wintering raptor populations. The primary threat to raptors on the INEL appears to be the lack of regeneration and survival of narrowleaf cottonwood and other deciduous trees along the Big Lost River channel and along Birch Creek. We found no evidence of negative effects of INEL facility-related operations on species of special concern such as the ferruginous hawk or endangered or threatened species. Intensive sheep grazing near ferruginous hawk nests on the INEL may cause abandonment.

## JUSTIFICATION

The Idaho National Engineering Laboratory (INEL) has been identified as a National Environmental Research Park. The INEL provides an excellent field laboratory for monitoring long-term population phenomena such as may occur in raptors in relation to both natural phenomena and energy related development. Several species of owls, hawks and eagles seasonally occupy the INEL. The bald eagle (*Haliaeetus leucocephalus*) is a winter visitor that is classified as an Endangered Species. The ferruginous hawk and burrowing owl (*Athene cunicularia*) nest on the INEL and are candidates (C2 species) for federal listing as threatened or endangered species.

Birds of prey are valuable as environmental indicators by providing a warning to society in regards to persistent pesticides. Their position in the food chain dictates that persistent toxins that accumulate in smaller prey organisms will likely show up in raptors. Thus, raptors can be important as early indicators of contamination problems. Although there is no information indicating declines in raptor populations on the INEL, previous studies (Craig and Craig 1984) documented that populations of nesting and wintering raptor have fluctuated greatly.

Monitoring these species is important for DOE because such actions comply with the intent of the National Environmental Policy Act and the Department of Energy's commitment to land stewardship (U. S. DOE 1994). Further, the evidence of a stable raptor population suggests a healthy ecosystem and provides strong support for the adequacy of environmental safeguards on areas such as the INEL.

## OBJECTIVES

The objectives of this research effort were to:

- Conduct a comprehensive assessment of past and present raptor population numbers, distribution of nest sites, nest site characteristics, nesting and fledgling success, identification of priority nesting areas, and a modernization and update of the existing database on raptors of the INEL.

- Complete a master of science thesis and final report on raptor population numbers, distribution of nest sites, nest site characteristics, nesting and fledgling success, identification of priority nesting areas, and modernization and update of the existing raptor database on the INEL.

- Evaluate the status of raptors in relation to state and federal endangered or threatened species or species of special concern.

- Develop and submit manuscripts to appropriate technical journals.

- Respond to journal reviews with appropriate editing and analyses or reanalyses as necessary to ensure ultimate publication in the scientific literature.

## PROJECT ACCOMPLISHMENTS

Based on the results of the comprehensive assessment of past and present raptor population numbers, distribution of nest sites, nest site characteristics, nesting and fledgling success, identification of priority nesting areas, and a modernization and update of the existing database on raptors of the INEL, a master of science thesis and a final report were completed in 1994 as were five technical manuscripts and two popular articles.

## PRODUCTS

During Calendar Year 1994 a thesis was completed, seven manuscript topics were identified from the thesis material and prepared, and two technical presentations based on the field work were given. Three additional presentations of a semi-technical nature were also given.

### Manuscripts

- Hansen, R. W. 1994. Raptor use of the Idaho National Engineering Laboratory. MS Thesis, South Dakota State University, Brookings. 127pp.

- 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. In Press. Nest cohabitation by raptors. Journal of Raptor Research.

- 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.

- 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. In DOE review. Ecological relationships between nesting Swainson's and Red-tailed hawks in southeastern Idaho. Journal of Raptor Research.

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

- Hansen, R. W. and L. D. Flake. In Review. Prairie biologists in the desert. South Dakota Conservation Digest.

## Technical Presentations

- Hansen, R. W. 1994. Ecological relationships between nesting Swainson's and red-tailed hawks in southeastern Idaho. Platform presentation at the Annual Meeting of the Raptor Research Foundation, Flagstaff, Arizona.

- Hansen, R. W. and L. D. Flake. 1994. Nesting of three *Buteo* species on the upper Snake River Plain. Platform presentation at the Annual Meeting of the South Dakota Chapter of The Wildlife Society, Huron, SD.

## Other Presentations

- Flake, L. D. 1994. Research on the INEL concerning sage grouse, mourning doves, bird use of ponds and raptors. Classroom Presentation in Wildlife Management at South Dakota State University, Brookings, SD.

- Flake, L. D. 1994. Bird Studies on the INEL. Classroom Presentation in Ornithology at South Dakota State University, Brookings, SD.

- Hansen, R. W. 1994. Raptor studies on the Idaho National Engineering Laboratory. Seminar presented at South Dakota State University, Brookings, SD.

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Craig, T. H. and E. H. Craig. 1984. Recent changes in *Buteo* abundance in southeastern Idaho. Murrelet 65:91-93.

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# PROTECTIVE CAP/BIOBARRIER EXPERIMENT I: COMPARISON OF FOUR PROTECTIVE CAP DESIGNS FOR BURIAL OF HAZARDOUS WASTE AT THE IDAHO NATIONAL ENGINEERING LABORATORY

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## ABSTRACT

The Protective Cap/Biobarrier experiment is designed to rigorously test the performance of four protective cap configurations for precluding moisture from reaching buried wastes. The objective of the study is to recommend an effective, low cost cap that uses natural ecosystem processes to protect interred hazardous waste from moisture and minimizes long term maintenance costs. Construction of the field experiment, consisting of three replicates of four cap configurations, two vegetation types and three irrigation levels, was completed in 1993. Each plot is 16 x 24 m and is subdivided into six 8 x 8-m subplots (12 plots, 72 subplots), planted with either a monoculture of crested wheatgrass (*Agropyron desertorum*) or a native species mixture which included five shrub species, five grass species, and two forb species. The replicated experiment allows for statistical analysis. We included three 1-$m^2$ water sampling pans under each subplot which drain into monitoring caissons buried between plots, so that we can estimate drainage through the protective caps. We installed a drip irrigation system (13.2 km of tubing) and an herbivore exclosure fence (850 m), replaced dead shrubs and grasses in plots, and seeded unsuccessful seedings of crested wheatgrass and forbs in plots and adjacent disturbed areas. We collected baseline data on soil moisture and plant cover for all plots.

## JUSTIFICATION

Shallow land burial is a common method for disposing of industrial, municipal, and low-level radioactive waste. Exclusion of water from buried wastes is a primary objective in designing and managing waste disposal sites. The presence of water may result in growth of plant roots into the waste zone and the consequent transport of toxic materials to above-ground foliage. Furthermore, percolation of water through the waste zone may transport contaminants into ground water (Fisher 1986).

Various designs and recommendations for protective caps exist (Nyhan et al. 1990, Wing and Gee 1990, Anderson et al. 1991), but there have been few attempts to compare their effectiveness and long-term reliability. In addition, some highly engineered cap designs are very costly to construct, often fail to take advantage of local climatic characteristics or natural processes, and may eventually fail. Because manufactured materials are usually a critical element in these designs, the life span of the protective cap depends on the life span of the materials. In semiarid

areas, potential evapotranspiration greatly exceeds precipitation. Thus, it is theoretically possible to preclude water from reaching interred wastes by (1) providing a soil cap of sufficient thickness to store precipitation that falls while plants are dormant and (2) establishing a plant cover that depletes soil moisture reserves during the growing season. We have demonstrated the feasibility of this approach at the Idaho National Engineering Laboratory (INEL), where a protective cap of 2 m of local soil supporting a healthy stand of perennial vegetation will prevent deep drainage of water even under twice the normal precipitation (Anderson et al. 1991, 1993a). However, it is possible that burrowing by small mammals or ants may result in failure of a soil cap. Biological intrusion barriers (biobarriers) of gravel and cobble can be used to restrict burrowing, but the impacts of such barriers on soil moisture storage and plant rooting depth are unknown.

The Protective Cap/Biobarrier Experiment (PC/BE) was designed to rigorously test the efficacy of four protective cap designs. Two designs include biobarriers within the soil profile to restrict the activities of burrowing animals, a third design is 2-m of soil only, and the fourth is a configuration recommended by EPA which includes a flexible membrane liner covering compacted clay (Figure 1). The PC/BE consists of three replicates of these four cap designs, three irrigation levels, and two vegetation types in a randomized strip-split block design (Figure 2). This experiment is one of few field studies of this type to have statistical validity. The experimental plots were constructed at the INEL Experimental Field Station during the fall of 1993.

Precipitation will be augmented to simulate either above average precipitation or a change in the timing of precipitation. These simulations will show if the protective caps will perform effectively in more mesic climates, or with climate change that produces a shift in the precipitation patterns. We are testing the performance of two vegetation types to investigate soil water depletion and depth of root growth. Crested wheatgrass is commonly seeded on protective caps at the INEL, but eventually native species will also occupy the site. Therefore, it is important to explore these parameters for both vegetation types.

## OBJECTIVES

The ultimate objective of the Protective Cap/Biobarrier Experiment is to be able, within five years, to confidently recommend a protective soil cap for buried wastes at the INEL and industrial, municipal and radioactive repositories with similar climates. During the first three years we will collect baseline data, including plant establishment, rooting depths, patterns of soil water storage and depletion, and the interactions among cap design, vegetation type, and levels of irrigation. Burrowing ants and rodents will be introduced in year four, and in the fifth year we will stress the caps with excess irrigation until failure occurs (drainage through the entire cap). Results from these manipulations will enable us to predict (1) the amount of precipitation that could fall on a site before a particular cap configuration would fail, and (2) whether burrowing organisms would significantly affect cap performance under high levels of precipitation.

The specific objectives of the PC/BE are to:

- Compare the effectiveness of four protective cap designs for precluding water seepage into a buried waste zone.
- Estimate plant establishment and survival, canopy development, root distribution, and water use for each vegetation type.
- Evaluate the impact of placing biological intrusion barriers at different depths on moisture storage capacity of the soil cap.
- Examine the interaction of barrier design and vegetation type with regard to plant establishment and survival, changes in plant community composition, plant rooting depths, and patterns of soil water extraction.
- Evaluate the effectiveness of biobarriers for restricting burrowing into protective soil caps, and examine the interaction of biobarrier depth and the movement of water in soil profiles containing burrows.
- Compare costs of constructing the different barrier configurations.
- Refine recommendations for the design, construction and maintenance of protective caps at the INEL.

## PROJECT ACCOMPLISHMENTS

In 1994 our efforts were focused on completing the experimental set up for the Protective Cap/Biobarrier project and gathering baseline data.

- We installed a drip irrigation system, which involved precisely locating and installing 13.2 km (8.2 mi) of plastic irrigation tubing, headers for each plot, a buried supply line from the pump house, and instrumentation to automate the system.
- We built a fence (851 m, 2,800 ft) specially designed with a buried sheet metal barrier to exclude herbivores (except insects) and burrowing animals from the plots. The fence included two 10-ft (3.1 m) gates.
- We transplanted 1,054 shrubs and 783 grass plants onto the plots to replace those that did not survive from the initial vegetation efforts (1993).
- The areas surrounding the plots which were disturbed during construction were seeded.

- Irrigation was applied by aluminum hand lines to enhance survival of transplants and stimulate germination of seeds on plots (forbs and crested wheatgrass seeded in fall 1993) and on the disturbed areas.

- Soil moisture was measured by hydroprobe (Campbell Pacific Nuclear Corp., Martinez, CA) biweekly from 12 March through 20 October and following each irrigation application.

- Plant survival was quantified by counting all living transplants in early summer.

  Mean survival of shrubs transplanted onto the plots in December 1993 was only 55.4% and that of grasses was 65.9%.

- Canopy height, width and stem diameter were measured for all living shrubs in spring and fall to estimate growth during the summer.

- We contracted with electricians to supply electricity to caissons and instrumentation. We excavated trenches for laying the buried wire.

- Plots were periodically weeded to prevent competition between weedy species and experimental species.

- A notched rail system was installed on each caisson ladder for fall protection for personnel using the ladders.

## PRODUCTS

Between April 11 and December 31, 1994, five technical presentations and two publications related to this project were produced.

### Presentations

- Limbach, W. E., J. E. Anderson, and S. A. Hardegree. 1994. Seed-priming enhanced emergence of thickspike seedings at cool temperatures. Presentation, 1994 Annual Meeting of the Society of Range Management, Colorado Springs, CO.

- Anderson, J. E. 1994. Evapotranspiration in cold deserts: applications to hazardous waste management. Seminar at University of Nevada Las Vegas.

- Limbach, W. E., T. D. Ratzlaff, J. E. Anderson, T. D. Reynolds, and J. W. Laundré. 1994. Design and implementation of the protective cap experiment at the Idaho National Engineering Laboratory. Presentation, 33rd Hanford Symposium on Health and Environment - In Situ Remediation: Scientific basis for current and future technologies, Pasco, Washington.

- Ratzlaff, T. D. 1994. Soil water dynamics in sagebrush steppe habitats. Poster presentation, Annual Meeting of the Idaho Academy of Sciences, Idaho State University.

- Limbach, W. E. 1994. Seed priming enhanced emergence of thickspike wheatgrass seedlings at cool temperatures. Presentation, Annual Meeting of the Idaho Academy of Sciences, Idaho State University.

### Publications

- Anderson, J. E., R. S. Nowak, K. E. Rasmuson, and N. L. Toft. In press. Gas exchange and resource-use efficiency of *Leymus cinereus* (Poaceae): Diurnal and seasonal responses to naturally declining soil moisture. American Journal of Botany.

- Limbach, W. E., T. D. Ratzlaff, J. E. Anderson, T. D. Reynolds, and J. W. Laundré. 1994. Design and implementation of the protective cap experiment at the Idaho National Engineering Laboratory. Pages 359-378 *in* G. W. Gee and N. R. Wing, eds., Proceedings of the 33rd Hanford Symposium on Health and Environment - In Situ Remediation: Scientific basis for current and future technologies, Pasco, Washington.

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Anderson, J. E., T. D. Ratzlaff, and W. E. Limbach. 1993b. Evapotranspiration as related to waste management areas: FY 1993 Progress Report. Idaho National Engineering Laboratory Radioecology and Ecology Program.

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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. U. S. Geological Survey Circular 973.

Nyhan, J. W., T. E. Hakonson, and B. J. Drennon. 1990. A water balance study of two landfill cover designs for semi-arid regions. Journal of Environmental Quality 19:281-288.

Wing, N. R., and G. W. Gee. 1990. Protective barrier development: overview. Pages 147-151 *in*: R. H. Gray, ed., Proceedings of the twenty-eighth Hanford symposium on health and the environment, environmental monitoring, restoration, and assessment: what have we learned? Pacific Northwest Laboratory, Richland, Washington.

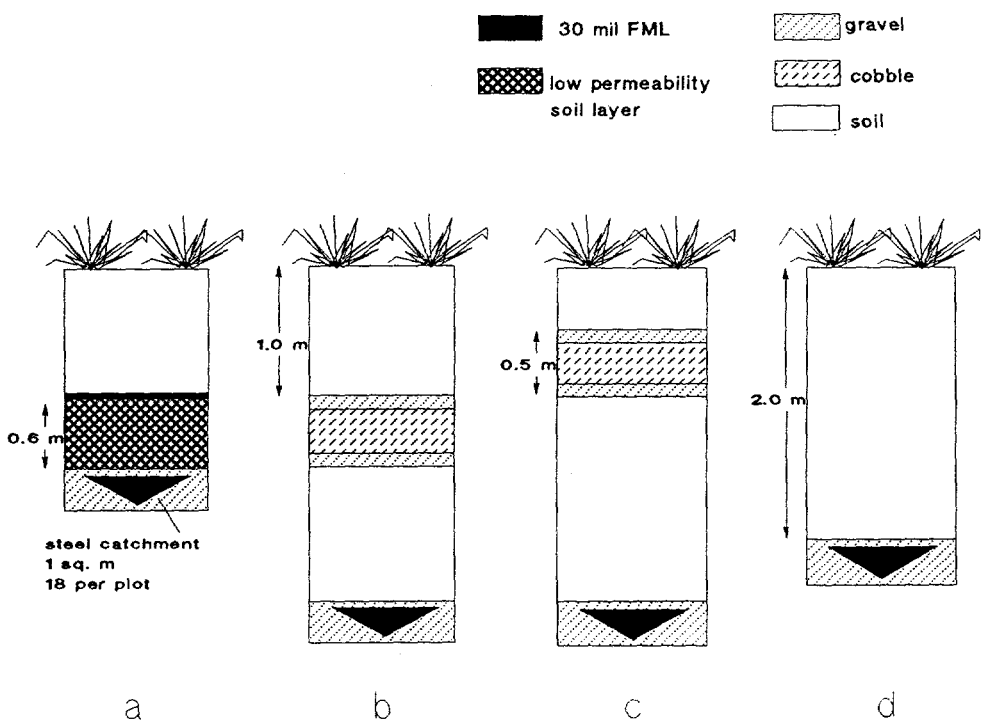


**Figure 1. Schematic design (not to scale) of the four cap configurations for the Protective Cap/Biobarrier Experiment at the Idaho National Engineering Laboratory. Configuration a is a design recommended by the Environmental Protection Agency (FML = flexible membrane liner), b and c include a biointrusion barier at 1 m and 0.5 m, respectively, below the soil surface, and d consists of 2 m of soil only. Steel catchment pans collect drainage from the bottom of each plot**

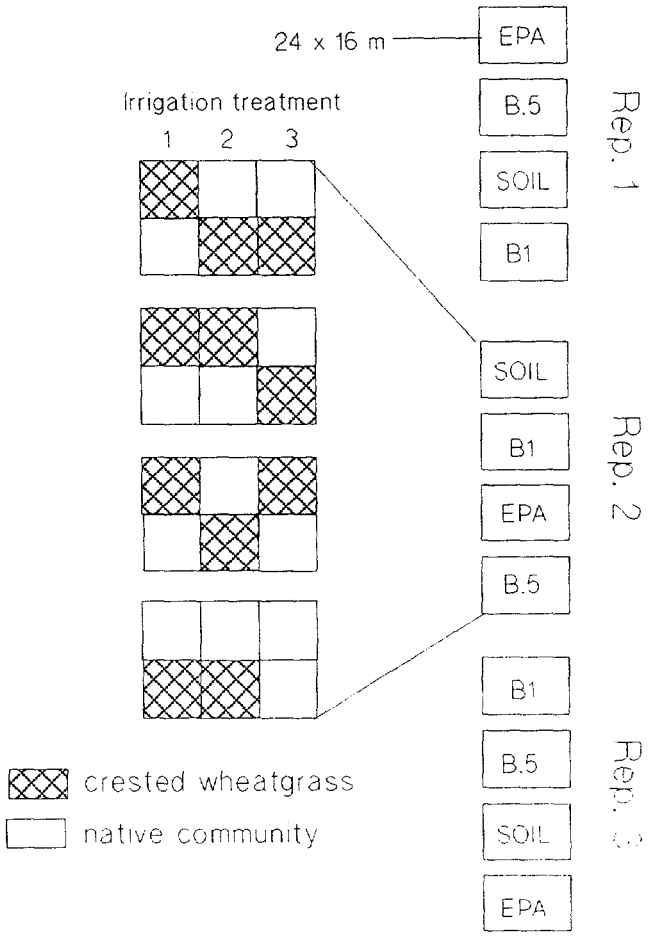


**Figure 2. Schematic of the experimental design (not to scale) of the Protective Cap/Biobarrier Experiment at the Idaho National Engineering Laboratory. The design is a three-way factorial, strip-split plot, with levels of irrigation as the strip factor, cap design as the split-plot factor, and vegetation as the subplot factor. The design includes four cap configurations: EPA (recommended by the Environmental Protectin Agency), B.5 (gravel-cobble biobarrier at 0.5 m below the surface, B1 (gravel-cobble biobarrier 1 m below the surface), and soil (2 m of lakebed soil only), three irrigatin treatments, two vegetation types, and three complete replications.**

# PROTECTIVE CAP/BIOBARRIER EXPERIMENT II: A COMPARISON OF WATER USE BY ANNUAL AND PERENNIAL SPECIES ON SIMULATED WASTE BURIAL PLOTS AT THE IDAHO NATIONAL ENGINEERING LABORATORY

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## ABSTRACT

Plants in arid regions, such as the Idaho National Engineering Laboratory (INEL), use all the available soil water during a growing season because potential evapotranspiration far exceeds precipitation. Thus, a cover of perennial vegetation can be used effectively to preclude drainage through soil caps covering buried wastes. However, cheatgrass (*Bromus tectorum*) and other exotic annuals have replaced native perennial species in many sagebrush steppes in the Intermountain West. The presence of invasive annual species poses a risk to the integrity of protective soil caps because annuals may not extract all of the plant-available soil moisture during a growing season. A comparison of water use by annual and perennial species on simulated waste burial plots in 1993 and 1994 indicated that annual species may not use water as effectively from the entire soil profile as do perennials. Our data suggest that the likely result of the replacement of perennial species by annuals on a protective soil cap would be drainage of water through the protective cap and into the waste zone.

## JUSTIFICATION

In arid regions, the potential for water loss by evapotranspiration (the sum of evaporation from leaf and other surfaces) is far greater than the amount of water that falls as precipitation, and plants in these areas typically use all of the available water in the soil. Thus, if a soil cap protecting buried wastes is vegetated with plants that use all of the stored moisture each growing season, and is sufficiently deep to store precipitation received while vegetation is dormant, then no water will drain through the soil and into the wastes. Our studies at the Idaho National Engineering Laboratory (INEL) have demonstrated that a cover of perennial plants on waste burial plots will use all available soil moisture in a 2.2-m protective soil cap during a growing season, precluding drainage into the waste zone (Anderson et al. 1993).

However, the integrity of native perennial communities in the Intermountain West is threatened by the invasion of exotic annual species, especially cheatgrass (*Bromus tectorum*). Cheatgrass is a short lived, facultative (capable of functioning under varying environmental conditions) winter annual that has converted much sagebrush steppe into annual grasslands. It is present in many areas of the INEL, including areas near the Radioactive Waste Management Complex. Research by Cline et al. (1977) indicated that cheatgrass may not use all the available soil water from

depths greater that 0.8 m. Thus, the establishment of cheatgrass on protective soil caps could reduce the effective water storage capacity of the soil, resulting in eventual moisture intrusion into the waste zone.

To examine soil moisture dynamics in a stand of cheatgrass, we broadcast-seeded cheatgrass onto two simulated waste burial trench plots in the fall of 1992 to compare its water use with that of Wyoming sagebrush (*Artemisia tridentata* subsp. *wyomingensis*), crested wheatgrass (*Agropyron desertorum*) and Great Basin wildrye (*Leymus cinereus*). These perennial species will use all of the plant-available water in a 2.2-m soil profile, even during a very wet growing season (Anderson et al. 1993). Although precipitation during the winter and spring was ample, emergence of cheatgrass on the experimental plots in the spring of 1993 was poor and the plots became occupied by dense stands of various annual species, dominated by Jim Hill mustard (*Sisymbrium altissimum*), another aggressive alien. Soil moisture data from the 1993 growing season indicated that the lower limit of extraction (LLE, the limit to which plants can extract water from a soil) for these annuals may be higher than that for the perennial species (Figure 1a). This has serious implications for waste management because the effective water storage capacity of a protective soil cap vegetated with annuals may be considerably lower than that of one with perennials. However, additional data are needed to confirm these results and to determine whether patterns of water extraction are similar for different species of annuals. Observing vegetation dynamics in these plots over several years will provide valuable information on the long-term effects of occupation of a buried waste site by annual species. Cheatgrass is a major component of the annual species on these plots, but its annual density fluctuates with soil moisture content.

## PROJECT ACCOMPLISHMENTS

- We monitored soil moisture on plots vegetated by annual species and plots vegetated with monocultures of Wyoming big sagebrush, crested wheatgrass, and Great Basin wildrye during the 1994 growing season.

  In the top 1 m of soil, the annual species extracted soil moisture to a volumetric content of about 10% (equivalent to the LLE for the perennial species), but below 1 m soil moisture was about 12% at the end of the growing season. The perennial species extracted water to the LLE from the entire profile (Figure 1b). The dominant species on the annual plots in 1994 was Russian thistle (*Salsola kali*) but cheatgrass was also abundant; other species were scarce. The observed difference in soil water depletion between years may have resulted from the difference in precipitation (136% of average in 1993, and 72% of average in 1994) or composition of annual species. Additional studies are needed to determine whether the LLE differs among annual species, and to examine the longevity of the other annual species in competition with cheatgrass. A buried waste area that has been subjected to disturbance will demonstrate similar vegetation dynamics.

## PRODUCTS

No manuscripts or presentions resulted from this study in 1994.

## LITERATURE CITED

Anderson, J. E., R. S. Nowak, T. D. Ratzlaff, and O. D. Markham. 1993. Managing soil moisture on waste burial sites in arid regions. Journal of Environmental Quality 22:62-69.

Cline, J. F., D. W. Uresk, and W. H. Rickard. 1977. Comparison of soil water used by a sagebrush-bunchgrass and a cheatgrass community. Journal of Range Mangement 30:199-201.

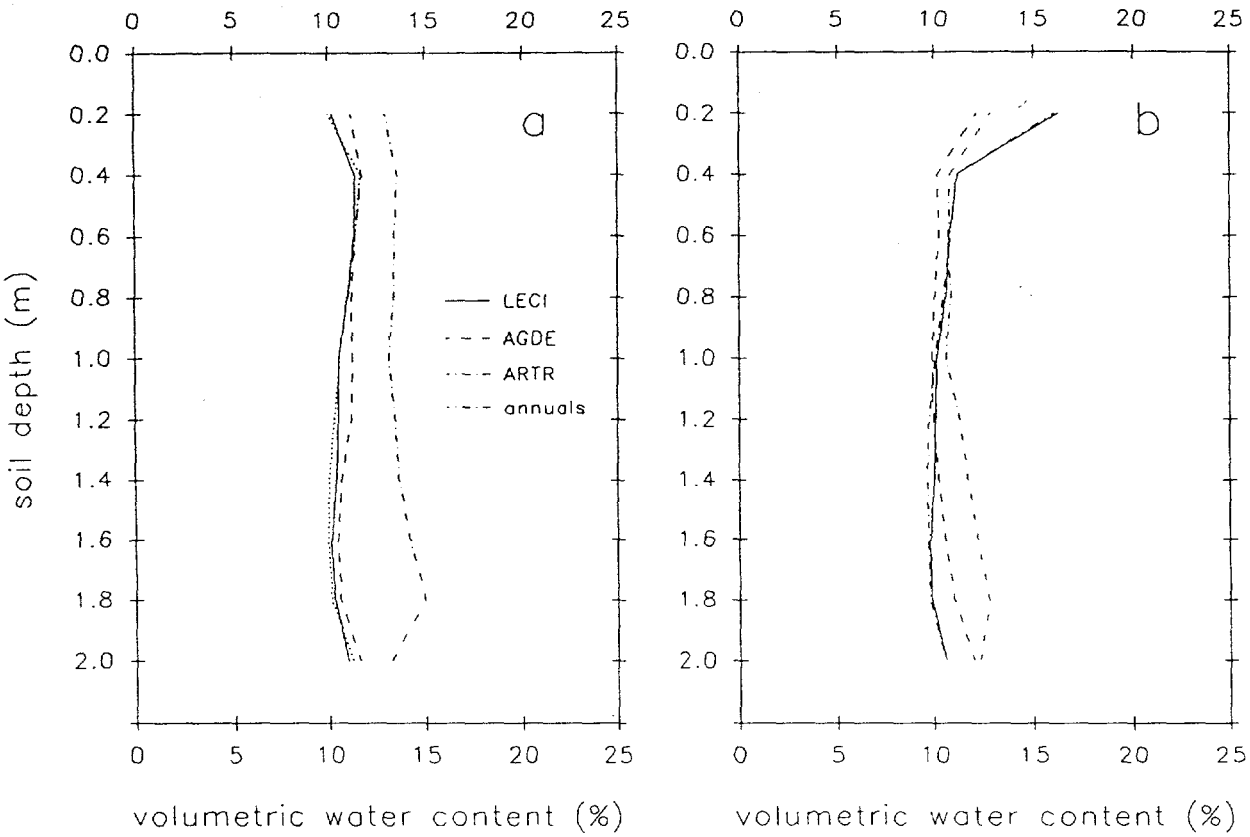


**Figure 1. Soil moisture profiles on September 8, 1993 (a) and October 11, 1994 (b), for *Lemus cinereus* (LECI), *Agropyron desertorum* (AGDE), *Artemisia tridentata* ssp. *wyomingensis* (ARTR), and mixed annual species. Species were grown on simulated waste burial trench plots (2.4 m of homogeneous soil). LECI, AGDE, and ARTR were grown in monoculture.**

# PROTECTIVE CAP/BIOBARRIER EXPERIMENT III: THE EFFECT OF VEGETATION HEIGHT ON SNOW ACCUMULATION AND SOIL WATER RECHARGE IN CRESTED WHEATGRASS AT THE IDAHO NATIONAL ENGINEERING LABORATORY

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## ABSTRACT

Maintenance of interred waste sites at the INEL includes routine mowing of grasses to discourage deep accumulations of snow. However, to maintain a healthy vegetal cover on buried waste sites in semiarid and arid climates, it may be necessary to leave grasses unmowed to prevent removal of snow by wind. We measured snow depth during winter and soil moisture during the growing season in mowed and unmowed crested wheatgrass (*Agropyron desertorum*) stands from 1990-1994. Consistently, the unmowed plot accumulated more snow and subsequently had more soil moisture in the spring. In spite of the difference at the beginning of the growing season, soil moisture was similar by early summer. Plant cover was similar between treatments, but biomass in the unmowed plot was greater than in the mowed plot in 1994. Plants with greater biomass have a greater capacity for transpiration, and hence, soil water depletion during the growing season. This study may provide evidence that mowing vegetation on waste management areas in this climate is unnecessary.

## JUSTIFICATION

Interred waste sites are routinely mowed to discourage deep accumulations of snow which may result in water infiltration that exceeds the moisture storage capacity of a protective cap, especially when coupled with high spring rainfall. However, in semiarid climates, it may be important to manage the waste cap so that enough snow accumulates to provide sufficient water to establish and maintain a healthy stand of plants. In areas where grasses have been mowed, snow is lost by wind and the plants may not receive enough water to maintain vigor. Our previous studies (Anderson et al. 1993) demonstrated that crested wheatgrass (*Agropyron desertorum*) will use all the available water during the growing season, even when precipitation is augmented to above record amounts. Thus, if the soil of a protective cap is sufficiently deep to store moisture received, accumulation of snow to the height of the mature vegetation should not result in deep drainage but will help to maintain a vigorous stand.

To explore the relationship between vegetation height and snow accumulation, we established a pair of adjacent 50x100 m plots in an extensive crested wheatgrass stand on the INEL. One plot has been mowed each successive November since 1990, and snow depth and stored soil moisture were estimated in each plot (n=15 per treatment).

## OBJECTIVES

The objectives of the snow depth study are to:

- Determine the relationships between snow depth and vegetation height, snow water content, and soil water content.

- Examine the combined effects of annual mowing and soil water recharge on plant cover and biomass.

## PROJECT ACCOMPLISHMENTS

- Snow depth was measured on 13 January and 15 February 1994 and was greater in the unmowed plot for both sampling dates.

- Soil moisture content was measured during the growing season (Figure 1).

  Soil moisture recharge was greater in the unmowed plot on 19 April, but soil moisture content was similar in mowed and unmowed plots on 25 May and thereafter (Figure 1).

- We measured vegetal cover, tussock width, and dry weight of current year standing crop in mowed and unmowed plots in July.

  Cover and tussock width were similar between treatments, but current year standing crop was greater in the unmown plot than in the mowed plot (76.6 vs 56.9 g $m^{-2}$, respectively, P=0.027).

## PRODUCTS

A single presentation resulted from this research in Calendar Year 1994:

- Ratzlaff, T. D. 1994. Soil water dynamics in sagebrush steppe habitats. Poster presentation. Idaho Academy of Sciences meetings, Idaho State University, Pocatello.

## LITERATURE CITED

Anderson, J. E., R. S. Nowak, T. D. Ratzlaff, and O. D. Markham. 1993. Managing soil moisture on waste burial sites in arid regions. Journal of Environmental Quality 22:62-69.

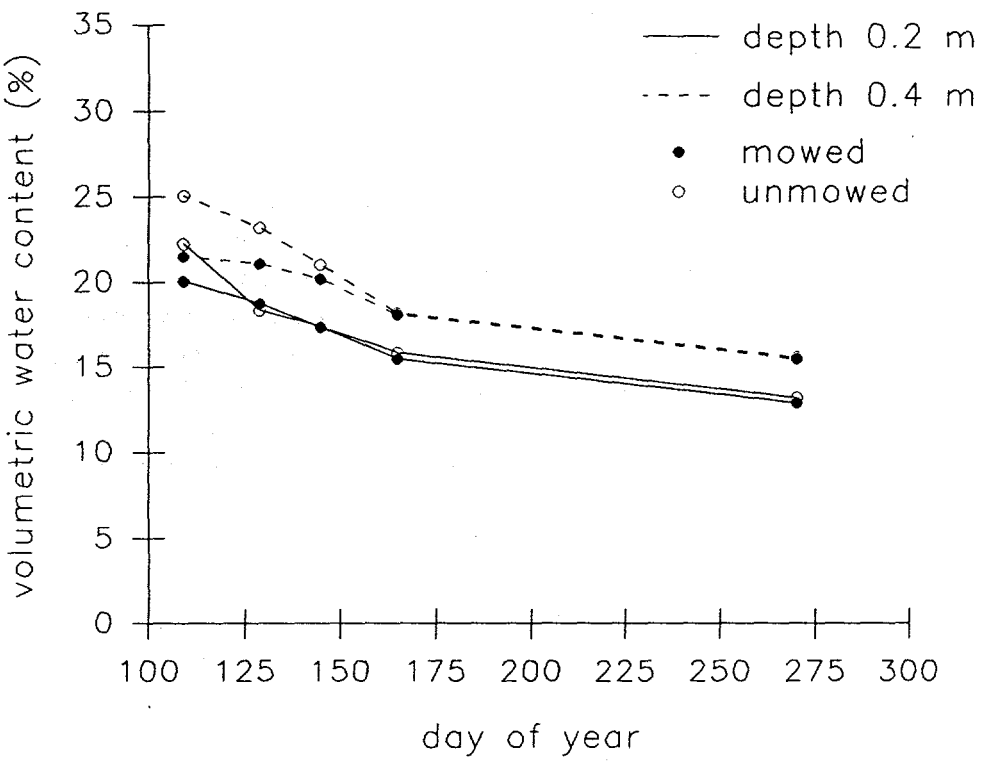


**Figure 1. Soil moisture at 0.2- and 0.4-m depths in mowed and unmowed *Agropyron desertorum* plots during the 1994 growing season.**

# MITIGATING LONG TERM IMPACTS OF SMALL MAMMAL BURROWING ON THE CLOSURE OF HAZARDOUS WASTE AREAS

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## ABSTRACT

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 waste areas and continues to be a concern regarding future closure of current waste areas. The objective of this study is to determine the effectiveness of three types of material (biobarriers) in preventing the burrowing of small mammals into waste areas. The three materials are (1) 10 cm cobble, (2) chipped roofing gravel, and (3) a mixture of gravel and cobble. Townsend's ground squirrels (*Spermophilus townsendii*) and Ord's kangaroo rat (*Dipodomys ordii*) were introduced into enclosures containing 50-cm thick layers of these materials overlaid by native soil. An additional objective was to determine if creating such a biobarrier in the presence of burrowing mammals might alter soil moisture patterns and compromise the integrity of the waste cap. After two years, there is still no evidence that the test animals have burrowed through the biobarrier layers. Ambient moisture patterns during the last two years have not provided a critical test of the impact of small mammal burrows above a biobarrier layer on soil moisture patterns.

## JUSTIFICATION

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. Studies of burrow depths on the INEL have demonstrated that small mammals can potentially burrow deep enough to reach waste material within many currently closed waste areas (Reynolds and Wakkinen 1987, Laundré and Reynolds 1993). Work published by other INEL workers have also demonstrated that small mammal burrowing has contributed to the upward transport of waste to the surface of waste areas (Arthur and Markham 1983). Consequently, considerable effort is being expended on ways to mitigate the transport of waste by burrowing mammals and developing accurate risk assessments of the long-term impact of small mammals on hazardous waste areas.

A protective cap/biobarrier experiment has begun on the INEL. The project's goal to test the effectiveness of several cover designs for use in waste areas throughout the arid and semi-arid west. Incorporated into the designs to be tested are biobarriers of either gravel and cobble. These biobarriers are designed to test prevention of burrowing mammals and insects from penetrating the trench cap and to act as a capillary break to limit the movement of water into the

waste zone. With reference to the first property, little data are available on whether the proposed material will act as an effective biobarrier to burrowing mammals. An effort to test the effectiveness of the proposed biobarrier material was initiated. The experimental design consists of 24 circular enclosures. Six of the enclosures function as controls; the remaining 18 contain various treatments of two barrier materials as described in the objectives section. Ground squirrels (*Spermophilus townsendii*) and kangaroo rats (*Dipodomys ordii*) were released into the 24 enclosures in the summer of 1992. During FY93 and FY94 the enclosures were monitored to determine if the animals have dug through the biobarrier material. The enclosures will continue to be monitored during FY95.

Relative to water movement, the effectiveness of abrupt soil texture changes (capillary breaks) in stopping downward water movement is well documented. However, it is unknown what impact burrowing mammals may have on the effectiveness of a capillary break. From 1984-92, there has been a study of the effects of small mammal burrows on soil water dynamics on the INEL. Data collected indicate that burrows increase the amount of water that enters the soil and the depth to which it can penetrate, especially during spring recharge (Laundré 1993). The test area for this previous research contains a naturally occurring capillary break. If a burrow extends to or through the capillary break, increased water penetration may compromise the break's effectiveness. One of the objectives of the current research is to predict the impact of mammal burrows on the water storage effectiveness of a soil profile above this capillary break. From previously collected data, regression equations have been developed that predict the extent of water infiltration from burrows (Laundré 1993). These equations should be usable to predict the impact of burrows on the water holding capacity above a capillary break. However, winter precipitation (Nov-Feb) during the study years was at or below average ($\leq$5.5 cm water). As of 1992, data were still lacking from the INEL on the effects of burrows on water infiltration during spring recharge from above normal winter precipitation. Failure of a capillary break is most likely to occur at these higher precipitation amounts especially if followed by a rapid spring snow melt. Data from years of this worst case scenario of above normal precipitation and rapid snow melt are needed to validate the regression equations developed.

The enclosures used to test the different biobarriers will provide an additional test of the impact of burrows on water storage capacity of soils and data to help validate the regression equations previously developed. Each enclosure consists of 50 cm of the biobarrier material overlain by 50 cm of soil (lakebed material used for waste disposal) and planted with sufficient vegetation to dry the soil profile annually. The ground squirrels and kangaroo rats have constructed several burrows per enclosure in the soil. The enclosures are designed to catch adequate snow to provide sufficient moisture to fill the 50-cm layer of soil above the capillary break in the absence of burrows. The ability of the soil profiles containing burrows to hold the prescribed amount of moisture will be compared to six control enclosures identical to the biobarrier enclosures but lacking small mammals.

The results of this work will help determine the feasibility of using biobarriers to prevent small mammals from burrowing into waste areas. If the biobarriers tested prove effective, they would

be valuable to the Department of Energy's own hazardous waste management efforts. This work would also be an integral part of the Department of Energy's commitment to technology transfer of waste management advances to private sector industrial and municipal waste management organizations.

## 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 are being 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 INEL (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.

## PROJECT ACCOMPLISHMENTS

Project accomplishments for the Calendar Year 1994 included:

- Monitor burrowing activity of animals in the enclosures.

  As of the fall of 1994, there is no evidence that either ground squirrels or kangaroo rats have penetrated the biobarrier material.

- Sample soil moisture above and below the biobarriers during the spring recharge.

  Soil moisture in the 50 cm of soil above the biobarriers was significantly greater than for soil controls. For the 90 cm of soil below the biobarrier depth, no differences were found among barrier types and soil controls.

## PRODUCTS

One manuscript, appearing in a late issue of a 1993 volume, was published in the technical literature during Calendar Year 1994:

Laundré, J. W. and T. D. Reynolds. 1993. Effects of soil structure on burrow characteristics of five small mammal species. Great Basin Naturalist 53:358-366.

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# ASSESSING THE POTENTIAL IMPACT OF A CANDIDATE THREATENED AND ENDANGERED RABBIT SPECIES ON INEL OPERATIONS

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## ABSTRACT

The pygmy rabbit (*Brachylagus idahoensis*) is currently under consideration for threatened and endangered status (C-2). If the pygmy rabbit becomes listed as a threatened and endangered (T&E) species, expensive mitigation actions for current operations and future developments on the INEL may be mandated. Costly mitigation actions can be avoided if INEL managers have an understanding of the status, distribution, and habitat needs of the pygmy rabbit on the INEL. This research is designed to provide the Department of Energy with the information necessary to avoid these potentially costly actions. The work will provide INEL personnel with an assessment of the current status of the pygmy rabbit on the INEL and develop a habitat suitability index (HSI) that would be a valid predictor of possible occurrence of pygmy rabbits on proposed development sites. The study is in its first year. Techniques and logistics are in the process of being refined. Previously known burrow sites are being relocated and several new burrow sites are being found. Ten pygmy rabbits will be radiocollared in order to obtain the location of foraging areas. Vegetation, soil, and topographic features around burrow systems and foraging areas will be measured. A habitat suitability index will be calculated based on all the variables that were measured. On a larger scale, a GIS spatial analysis of the INEL site will be conducted to identify all possible areas that contain the appropriate vegetation types likely to support pygmy rabbits. Based on this analysis, a map will be produced of likely pygmy rabbit locations on the INEL.

## JUSTIFICATION

The pygmy rabbit historically has had a limited distribution within the sagebrush community in the intermountain west. The conversion of sagebrush lands to human dominated uses has contributed recently to reduced pygmy rabbit populations and it is currently a C-2 species: under consideration as a candidate for threatened and endangered status. One of the last large protected areas where pygmy rabbits are found is the INEL Site. As a C-2 species, the pygmy rabbit should be treated as a candidate for threatened and endangered status in complying with National Environmental Policy Act (NEPA) regulations. Such compliance could have major, costly implications to current operations and future development at the INEL. Operations or developments that might impact rabbit habitat would have to be curtailed or modified extensively to provide mitigation actions. To comply with such regulations, INEL personnel need information on the pygmy rabbit's distribution and abundance. Knowing the status of this species

on the INEL would help determine if T&E designation is justified. There is limited current information available on the pygmy rabbit's status on the INEL. Understanding its distribution and habitat needs would help INEL managers formulate plans that would avoid costly mitigations. Knowledge of habitat needs would enable a rapid and inexpensive assessment of an area under consideration for development as to its potential suitability for pygmy rabbits. Such an assessment of habitat or habitat suitability index (HSI) also is lacking for the INEL. Data in these two areas will give Site personnel the information needed to determine the potential impact the pygmy rabbit might have on future Site development and help them minimize the cost of meeting NEPA regulations regarding this species. Furthermore, data from this and other studies may lead to the removal of this species from consideration for T&E status which, in turn, would also translate into future savings for DOE-ID.

The only prior studies of pygmy rabbits on the INEL were a population dynamics analysis (Wilde 1978) and a study of reproduction (Fisher 1979). Wilde's work documented that pygmy rabbits dig their burrows in definable clusters of varying numbers of burrows (burrowing sites), presumably in patches of desirable habitat. However, neither study addressed the distribution of rabbits on the INEL nor the habitat characteristics associated with rabbit "burrowing sites". In general, the pygmy rabbit is a relatively unstudied species. The only other recent study of this species was conducted on the U.S. Sheep Experiment Station near Dubois, Idaho (Green 1978). This study primarily documented rabbit diet but did assess vegetation at six burrowing sites (Green and Flinders 1980). Based on the limited sample size, Green and Flinders found pygmy rabbits preferred areas with greater woody cover and shrub height than randomly selected areas. However this information was not used to develop any predictive capability as to where pygmy rabbit colonies might be found.

Currently, the lack of information on pygmy rabbit abundance and distribution on the INEL could be a major hinderance to compliance with NEPA regulations, specifically Section 7 consultation with Fish and Wildlife Service personnel. Data from this current study would provide the information necessary for compliance and avoid possible costly delays. If the pygmy rabbit is listed as a threatened and endangered species, it may mandate expensive mitigation costs associated with potential future development. These mitigation costs could be avoided by incorporating the information this study will provide INEL managers. The general decline in pygmy rabbit numbers could also be of concern to Native Americans who traditionally hunted this species. Its preservation could be viewed as important to maintaining their traditional values and ways. Consequently, any INEL activities that might impact pygmy rabbit distribution and abundance could come under the scrutiny of tribal leaders. INEL personnel could address any concerns raised if data on abundance and distribution and a method of assessing the impacts of INEL Site development were available.

## OBJECTIVES

This research is designed to provide an assessment of the current status of the pygmy rabbit on the INEL and develop a habitat suitability index (HSI) that would be a valid predictor of possible

occurrence of pygmy rabbits on proposed development sites. Specific objectives of the study are to:

- Locate at least 10 pygmy rabbit burrowing sites.

  Efforts are being made to locate burrowing sites from as wide a distribution on the Site as possible.

- Capture and fit 10 rabbits with radio collars.

- Locate forage areas of the radiocollared animals.

  Foraging areas will be determined by relocating collared animals periodically over 24-hour periods.

- Assess habitat of burrows and foraging areas.

  Habitat characteristics to be measured include density and height of tall and short shrubs, topographic characteristics, and soil texture.

- Calculate a habitat suitability index.

  This index will be calculated as the first principal component of the variables for vegetation height, soil composition, and topographic complexity.

- Combine habitat information with Geographical Information System (GIS) vegetation files of the INEL to develop a predictive index of possible pygmy rabbit locations.

- Use the habitat suitability index to predict all possible sites of pygmy rabbit locations on the INEL.

- Determine reliability of habitat suitability index.

  Thirty sites predicted to have rabbits will be selected and the occurrence/nonoccurrence of rabbits at the sites will be determined.

- Based on above analyses, produce a map of likely pygmy rabbit locations on the INEL.

## PROJECT ACCOMPLISHMENTS

Accomplishments during the period April 11-December 31, 1994 included:

- Night-lighting and snow covered road surveys were conducted for pygmy rabbits.

  Sixty percent of the INEL roads were driven and surveyed for pygmy rabbits.

- One of the two sites used by Wilde (1978) was relocated.
- Twenty new pygmy rabbit burrowing sites have been located.
- Traps were set on nine evenings resulting in a total of 73 trap nights.
- Two pygmy rabbits were captured.
- Vegetation was measured at one burrowing site.
- Telemetry equipment was tested, traps were modified, and a handling bag was constructed.
- An extensive literature search on pygmy rabbits was conducted.

## PRODUCTS

There are no products at this time because this was the first year of the project.

## LITERATURE CITED

Fisher, J. S. 1979. Reproduction in the pygmy rabbit in southeastern Idaho. Unpublished thesis, Idaho State University, Pocatello. 32 pp.

Green, J. S. 1978. Pygmy rabbit and coyote investigations in southeastern Idaho. Unpublished dissertation, Brigham Young University, Provo, Utah. 88 pp.

Green, J. S. and J. T. Flinders. 1980. Habitat and dietary relationships of the pygmy rabbit. Journal of Range Management 33:136-142.

Wilde, D. B. 1978. A population analysis of the pygmy rabbit (*Sylvilagus idahoensis*) on the INEL site. Unpublished dissertation, Idaho State University, Pocatello. 172 pp.

# HEAVY METALS IN SMALL MAMMAL POPULATIONS AT THE IDAHO NATIONAL ENGINEERING LABORATORY

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## ABSTRACT

The Environmental Protection Agency (EPA), under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), requires that all Superfund sites perform both human health and ecological risk assessments. Little field data exist for ecological risk assessments on the INEL and elsewhere, particularly regarding levels of heavy metals in, and effects of heavy metals on, wild animal populations. The objective of this research was to determine contamination levels of small mammals exposed to heavy metals in the environment at the Idaho National Engineering Laboratory. Inductively coupled plasma techniques were used to evaluate the level of contamination in soil, plant food species and three species of small mammals: *Peromyscus maniculatus*, deer mouse; *Dipodomys ordi*, Ord's kangaroo rat; and *Tamias minimus*, least chipmunk. Preliminary data indicated detectable levels of lead, chromium and cadmium in populations of small mammals on control and experimental grids. Soils from the experimental grid had significantly higher concentrations of lead and chromium than the control grid.

## JUSTIFICATION

This research addresses the general mission of the DOE Environmental Restoration Program by assessing the extent of harmful substances (heavy metals), identifying contamination levels, and impacts on natural populations of small mammals.

Many areas of the United States are currently contaminated with heavy metals. High levels of contamination are often the result of earlier land use practices (Elfving et al. 1979), industrialization (Fleming et al. 1979), or even areas of heavy automobile traffic (Goldsmith et al. 1976, Goldsmith and Scanlon 1977). Contamination levels and areas of contamination may be increasing on a national level. There is a lack of information on the effects of heavy metal exposure on the dynamics of natural populations of animals (McBee and Bickham 1990). This research focuses on the availability and toxicity of chromium and lead to populations of small mammals resident on a contaminated area of the INEL. These elements are known to be toxic to small mammals and are found in abnormally high concentrations in some soils at the INEL (Eshelman unpub. data). Small mammals fit the criteria for use as biomonitors suggested by Jenkins (1981): common, geographically widespread, and easily collected. These animals also occur naturally on both contaminated and uncontaminated sites and are also large enough to

provide multiple tissue samples for analysis. Additionally, although each of these three species consumes plant material, each feeds on different portions and species of plants. Because of their different feeding habits, some species of small mammals may be more at risk than others under the same general level of contamination in the environment.

Heavy metals can become concentrated in plants growing on contaminated sites (Arthur et al. 1992) which can then be used as food by local populations of small mammals. Use of food sources contaminated with heavy metals can cause death of individuals (Mason et al. 1986; Fleming et al. 1979) and as a result, may severely impact local populations and animals higher up the food chain.

An experimental grid for long term monitoring of populations has been established in an area of known contamination and a control grid is located approximately 700 m away in a natural vegetation community on the Idaho National Engineering Laboratory. Preliminary soil analyses have indicated that levels of lead and chromium are significantly higher within the experimental grid than within the control grid. Both grids support populations of deer mice, Ord's kangaroo rat and least chipmunk. Animals on the experimental grid are exposed to levels of lead in the surface soil as high as 122 parts per million (ppm) and levels of chromium as high as 52 ppm. There is currently a great need for information on population-level effects of environmental contamination on naturally occurring populations (McBee and Bickham, 1990). Results from the this research will begin to fill the recognized gap in our knowledge of natural system responses to environmental contamination.

## OBJECTIVE

The objective of this study is to test hypotheses dealing with the effects of *in situ* concentrations of heavy metals on resident populations of small mammals. The near-term objective is to determine if there are detectable differences in field levels of heavy metal (lead, chromium, or cadmium) concentrations in:

- Soils of the experimental or control grids.
- Plants that occupy the grids.
- Small mammals that reside on the grids.

The long-term objectives associated with this study address the fitness of individuals exposed to *in situ* levels of heavy metals on the control and experimental grids and will consist of laboratory experiments to compare:

- Growth rate between animals raised on a diet containing in heavy metals and a standard diet.
- Reproductive output between animals raised on a diet containing heavy metals and a standard diet.
- Survival of young from animals with and without heavy metals in their diet.

Young mammals often accumulate heavy metals faster than adults (Bacher, 1985; Fleming et al., 1979). Combined with the fact that young can obtain metals from the mother's milk, this accumulation may influence life expectancy or reproduction of contaminated individuals and therefore influence the dynamics of exposed populations. Experiments addressing these hypotheses will be performed in the laboratory.

## PROJECT ACCOMPLISHMENTS

Accomplishments during calendar year 1994 were divided between field work and laboratory activities.

- Because of the construction of the new water treatment plant for the central facilities area and resultant disturbance to the previous control tagging grid, a new control grid was established. As this grid was to serve as the new control grid, soil samples and vegetation analyses were performed.

- A second set of samples was taken from the experimental grid so that within-year comparisons of contamination and vegetation composition could be determined. It was found that the two control grids had similar vegetation components and distributions. Soil samples also showed similar levels of contamination.

- A set of soil samples (60) from the new control grid were collected for analysis. These samples and 29 samples from the experimental grid were prepared and sent to the University of Minnesota Research Analytical Laboratory for analysis for heavy metal concentrations.

- An analysis was performed on the data of heavy metal concentration from the preliminary study conducted during the summer of 1993. Results from this study were obtained in FY 1994. The experimental grid had significantly higher values for lead and chromium, but not cadmium in the soils.

  These analyses indicated that there was a significant difference in lead (control mean = 38 ppm, experimental mean = 61 ppm, surface soils; two factor ANOVA $F=11.72$, $df = 1,54$, $p << 0.01$) and chromium (control mean = 31.3 ppm, experimental mean = 36.5 ppm at surface $F = 8.42$, $df = 1,54$, $p<<0.05$) between the control and experimental grids. Cadmium was not significantly different between the two grids ($p= 0.06$).

- A total of 4200 trap nights for small mammals was conducted during the summer and early fall seasons.

  This resulted in 1085 captures of 438 individuals (224 from experimental and 214 from control grid). Of these animals a total of 10 *Peromyscus maniculatus*, 5 *Dipodomys*

*ordii,* and 5 *Tamias minimus* were removed from each grid for stomach content analysis and for analysis of heavy metals contained in the tissues of the animals. These analyses are ongoing. The increased sample sizes obtained this year will significantly raise our understanding of heavy metal concentrations of animal tissues.

- Tissue samples of animals from a preliminary study (five deer mice from each grid) were obtained in Calendar Year 1994. These analyses indicated that detectable levels of heavy metals occur in the animals at the INEL.

- Samples of the vegetation from each grid were collected and are currently being processed for shipment to and analysis of heavy metals at the University of Minnesota Research Analytical Laboratory. The vegetation samples will also provide a reference collection of slides to compare plant tissue to the plant tissue found in the stomachs of the animals collected from each grid.

## PRODUCTS

No publications or other products resulted from this project between April 11 and December 31, 1994 .

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# FACTORS THAT AFFECT THE DISTRIBUTION OF CHEATGRASS AT THE IDAHO NATIONAL ENGINEERING LABORATORY

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## ABSTRACT

Cheatgrass *(Bromus tectorum)*, an aggressive alien grass, has invaded many habitats at the Idaho National Engineering Laboratory (INEL). Establishment of cheatgrass threatens the biodiversity of the INEL, increases risk of wildfire, threatens wildlife habitat for a large number of game animals, decreases forage for domestic livestock, and threatens the integrity of protective covers on waste management sites. Thus, it is important to understand factors that may limit or enhance its establishment. Data from our field sites at the INEL indicate that soil salinity, soil surface characteristics, and the availability of nitrogen and phosphorus in the soil may limit its distribution. We conducted a greenhouse study to assess the effects of soil salinity on growth and productivity of cheatgrass. Relative growth rate, specific leaf and stem area, and leaf and tiller production were reduced by increased soil salinity. Photosynthetic rates, stomatal conductance, intercellular $CO_2$, and leaf water potential were also negatively correlated with salinity. A field experiment indicated that roots of cheatgrass could conduct water through a dry layer of soil, and examination of root anatomy showed vessel structure that appeared to be adapted to function effectively under stressful conditions.

## JUSTIFICATION

Invasion by alien plants poses one of the greatest threats to the integrity and biodiversity of many ecosystems in the western United States (Soule' 1990). Cheatgrass (*Bromus tectorum*), an aggressive annual grass, not only threatens the integrity of natural plant communities at the Idaho National Engineering Laboratory (INEL), it may also increase the risk of wildfire and impair the efficacy of protective covers on hazardous waste burial sites. Because cheatgrass often replaces native species where it becomes established, its increasing abundance may impact winter range for many game animals and forage for domestic livestock on the INEL.

Cheatgrass is the most common alien plant in the sagebrush steppes of the Intermountain West (Mack 1981). Its range increased exponentially after introduction to the region in the 1890's, undoubtedly facilitated by disturbances such as livestock grazing, fire or cultivation (Klemmedson and Smith 1964, Mack 1981). However, it was recognized early that cheatgrass could establish and persist in rather pristine rangelands (Daubenmire 1942, Hull and Pechanec 1947, Hulbert 1955). Because of its opportunistic response to fire (Klemmedson and Smith 1964, Young and Evans 1978) and the tenacity with which it holds a site once established

(Daubenmire 1942, Hulbert 1955), its invasion often results in conversion of communities dominated by native perennials to stable annual grasslands.

Cheatgrass was documented in the earliest vegetation samples taken at the INEL in 1950, but at that time its distribution was limited to the extreme southern and eastern edges of the area. However, by 1975 its distribution had increased to include much of the southern two-thirds of the INEL, and this occurred in the absence of major disturbances such as livestock grazing or fire. This encroachment is of concern for three reasons. First, the INEL is an important reservoir of the genetic diversity of the flora and fauna of the sagebrush steppe region; few other protected areas of sagebrush steppe exist. Extensive loss of native steppe habitat at the INEL would threaten the survival of many plant and animal species. The second concern is that increased abundance of cheatgrass increases the potential for devastating fires, which could damage facilities directly or create smoke and dust that could damage air monitoring or filtering equipment. Cheatgrass matures early in the season and is extremely flammable when cured; dense stands have greatly increased the fire frequency of sagebrush rangelands (Klemmedson and Smith 1964, Whisenant 1990). Finally, should cheatgrass displace perennial species on protective soil covers over buried hazardous wastes, reduced evapotranspiration might result in failure of the cover. Perennial species can remove water from deep in a soil profile (>2 m, at the INEL), maintaining adequate soil water storage to preclude drainage into the waste zone (Anderson et al. 1993). However, research at Hanford indicated that cheatgrass may use little water from depths greater than 0.8 m (Cline et al. 1977). Thus, if cheatgrass were to replace perennial species on waste burial sites, water might accumulate deep in the profile and eventually percolate into the waste zone.

Our studies have shown that cheatgrass has invaded some habitats but not others at the INEL. Data from field plots indicated that soil salinity, soil surface characteristics, and the availability of nitrogen and phosphorus in the soil may limit its distribution. Understanding the mechanisms through which these factors operate would allow us to identify areas at risk of invasion by cheatgrass and to develop management strategies to protect diverse natural communities or prevent establishment of this annual grass on the protective covers of waste burial sites.

This study was supported by a fellowship from the Department of Energy's Experimental Program to Stimulate Competitive Research (EPSCoR).

## OBJECTIVES

The ultimate goals of this study are (1) to determine potential biotic and abiotic factors that limit the distribution of cheatgrass in different habitats at the INEL by identifying factors that influence its establishment and persistence and (2) to develop a mechanistic understanding of factors that may affect its establishment and persistence by studying physiological and growth responses to environmental stresses.

Specifically, we addressed six hypotheses during 1994.

- Environmental factors such as soil salinity, soil crust formation and water availability negatively affect anatomical characteristics of cheatgrass roots, resulting in reduced water conduction and water leakage to the surrounding soil.

- Dry soil crusts reduce root growth of cheatgrass seedlings and the capacity of roots to conduct water from deeper in the soil profile. This will result in either reduced total plant growth or seedling death.

- Growth and photosynthesis of cheatgrass plants decrease sharply in response to increasing levels of soil salinity.

- Cheatgrass plants grown in the field exhibit higher rates of photosynthesis than those that have been reported for greenhouse grown plants.

- Cheatgrass growth and photosynthesis decrease in response to incremental decreases in soil phosphorus (P) and nitrogen (N) availability, and responses are more sensitive to reductions in P than N. Efficient nutrient use results in high growth rates.

- Biomass allocation to shoots and roots are altered with different combinations of P and N availability.

## PROJECT ACCOMPLISHMENTS

We conducted six experiments to investigate factors that may enhance or preclude cheatgrass establishment and persistence.

- We examined the direct effects of four levels of soil salinity on growth of cheatgrass seedlings in the greenhouse.

  Average leaf area, stem area and plant dry weight were higher for control plants than for those in all three of the salt-added treatments, and both leaf area and dry weight were negatively correlated with salinity level six weeks after treatments began. Photosynthetic rates were reduced by 18% and 41% in the medium and high salinity treatments, respectively, primarily due to stomatal closure.

- We investigated the effects of soil surface drying and soil crust formation on biomass allocation, root anatomy and morphology, and water relations of cheatgrass.

  Root biomass was reduced in the dry zone compared to that at the same depth of well watered plants. However, once seedlings established a root system, shallow roots did conduct water through the zone of severely desiccated soil.

- We collected root samples from the salinity and soil drying experiments to investigate the hypothesis that soil salinity, soil crust formation and water stress might negatively affect endodermis formation, xylem diameter or the rate of tissue differentiation.

  Root anatomy showed vessel structure that appeared to be adapted to function effectively under stressful conditions.

- We examined the effects of two levels of N and three levels of P on the physiology, growth and biomass allocation of cheatgrass in large PVC pots in the field.

  Photosynthetic measurements indicated that nutrient availability has a large effect on photosynthetic capacity of this species. Unfortunately, insect infestations and other unforeseen problems resulted in some questionable growth data. This experiment will be repeated in the greenhouse in 1995.

- We measured photosynthesis and leaf water potentials of cheatgrass plants growing at two field locations (one well-watered and one water-stressed).

  Most reported photosynthetic rates for cheatgrass are surprisingly low for a fast growing annual, but few studies have measured gas exchange of plants growing under natural conditions in the field. Analyses of these data are in progress, but preliminary results indicate that photosynthetic rates of field-grown plants can also be quite modest.

- We continued to follow emergence, growth and reproduction of cheatgrass on four study sites at the INEL that were established in the fall of 1991 (see Rasmuson 1993).

  Because 1994 was a very dry growing season, there was little recruitment on any plot in the spring. However, germination occurred on all plots following fall rains in September, demonstrating that cheatgrass can maintain a persistent seed reserve in the soil.

## PRODUCTS

A single presentation based on this research was given during the period from April 11-December 31, 1994.

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# MAPPING THE DISTRIBUTION OF CHEATGRASS ON THE IDAHO NATIONAL ENGINEERING LABORATORY

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## ABSTRACT

Cheatgrass is an invasive exotic weed species with a colonizing strategy typical of many noxious weeds. The various amendments to the Federal Noxious Weed Act charge federal agencies with a duty for responsible weed management. We investigated the use of multi-spectral video images collected from low-level flights to map the distribution of cheatgrass (*Bromus tectorum*) at the Idaho National Engineering Laboratory (INEL). Images were collected from areas where cheatgrass was known to occur at the INEL in 1993 and near Malta, Idaho, in 1993 and 1994. The imagery, a series of sequential still frames, was referenced to the UTM coordinates of known locations measured with a Magellan Global Positioning System (GPS) receiver. The frames were then "stitched" together by a computer program to form one large mosaic image. Finally, the imagery was classified into spectrally distinct classes using a maximum likelihood classification algorithm. Our results indicate that cheatgrass cover can be accurately detected and mapped on areas where its ground cover is 30% or greater. In addition, the classified imagery can be used to identify areas of potential cheatgrass occupation, such as disturbances due to fire or intensive grazing. Thus, low-level imagery may be a valuable tool for monitoring the extent of cheatgrass dominance and for identifying potential areas of invasion in cold desert ecosystems. Low-level videography was also used to determine the area and boundaries of a 20,000-acre (ca. 8100 ha) fire that occurred at the INEL in July 1994.

## JUSTIFICATION

Cheatgrass (*Bromus tectorum*) is the most ubiquitous alien plant in the sagebrush steppes of the Intermountain West (Mack 1981). Its range increased exponentially after its introduction to the region in the 1890s. This rapid expansion was facilitated by disturbances such as livestock grazing, but it was recognized early that cheatgrass could invade and persist in undisturbed rangelands as well (Daubenmire 1942, Hull and Pechanec 1947, Hulbert 1955). Because of its opportunistic response to fire (Klemmedson and Smith 1964, Young and Evans 1978) and the tenacity with which it holds a site once established (Daubenmire 1942, Hulbert 1955), its invasion often results in conversion of communities dominated by native perennials to stable annual grasslands.

Cheatgrass was documented in the earliest vegetation samples taken at the INEL in 1950, but at that time its distribution was limited to the extreme southern and eastern edges of the area.

However, by 1975 its distribution had increased to include much of the southern two-thirds of the INEL, and this occurred in the absence of major disturbances such as livestock grazing or fire. This expansion is of concern because cheatgrass not only threatens the integrity of natural plant communities, it also increases the risk of catastrophic wildfires and may impair the efficacy of protective covers on hazardous waste burial sites. Therefore, accurate and timely data are needed to monitor its distribution.

Because invasion by cheatgrass has often resulted in the conversion of shrub steppe to communities dominated by annuals, and because cheatgrass changes color to a distinctive wine-red as the plants mature, it seemed that it should be possible to discriminate areas where it was abundant from the surrounding vegetation by remote sensing. If that were the case, it would be possible to rapidly survey large tracts of rangeland during this color phase. We chose to explore the use of video images from low-altitude flights because at the INEL patches of cheatgrass rarely attain sufficient size to be detected on satellite imagery.

A remotely sensed image consists of thousands of individual picture elements known as pixels. Each pixel records the intensity of reflected radiation from a given area on the surface of the earth. Each pixel in a Landsat image represents an area 30 x 30 m on the ground. A pixel from our imagery, taken from fixed-wing aircraft at an altitude of 1,981 m, represents an area 2.75 x 2.75 m. This results in a significant decrease in the number and diversity of objects contributing to the reflectance recorded by an individual pixel. The sensors used to record pixel brightness typically are filtered to measure only a very narrow portion of the electromagnetic spectrum. Plants (Gates et al. 1965) and soils (Huete and Jackson 1987) have very different spectral characteristics, particularly at red and near-infrared (NIR) wavelengths. Bare soil generally dominates images from arid rangelands (Tueller 1987, Huete and Jackson 1987, Wilson and Tueller 1987, Satterwhite and Henley 1987). With smaller pixels, the probability that vegetation will be the dominant feature in an individual pixel increases. Thus, it should be possible to detect much smaller target entities such as small patches of cheatgrass.

In 1993, we contracted with Intermountain Technologies of Pocatello, Idaho, to collect multi-spectral video images from flights at 1,981 m above ground level at three target wavelengths: 650 nm (red), 750 nm (NIR) and 8-12 $\mu$m (thermal). In 1993, videography was collected at the INEL along a 46-km transect beginning just south of Big Southern Butte and ending about 2 km north of the Experimental Field Station. Additional videography was taken from a transect covering about 40 $km^2$ on the east face of the Jim Sage Mountains, 10 km southwest of Malta, Idaho. Spectral signatures for areas having varying amounts of cheatgrass were developed for the INEL and Malta sites. The Malta site was re-sampled in 1994 to assess the accuracy of cheatgrass spectral signatures developed from the 1993 imagery. No imagery was collected at the INEL during 1994 because cheatgrass densities were very low as a consequence of drought conditions.

In early July 1994, a wildfire burned about 20,000 acres (ca. 8100 ha.) along the west edge of the INEL in an area called Deadman Flats. Personnel from the Bureau of Land Management

designated this the Butte City Fire and mapped the extent of the fire by sketching the boundaries on USGS 7.5" topographic maps from an aircraft. Inspection of these maps during ground reconnaissance visits to the area showed that the maps were inaccurate. A more precise map of the burn was required to update our INEL Geographic Information System database, so we took advantage of the opportunity to assess the potential for using videography to accurately delineate the boundaries and estimate the size of burned areas. We collected multispectral videography from flights over the area on 12 July. This imagery will provide a permanent record of the aerial extent and boundaries of this fire scar for future vegetation work in that area.

## OBJECTIVES

The objective of this study is to evaluate the potential for using videography from low altitude flights as a remote sensing tool for monitoring the distribution of cheatgrass, the aerial extent of fires, or other changes in vegetation or site characteristics in semiarid rangelands.

## PROJECT ACCOMPLISHMENTS

- Multispectral video images were collected from flights at 1,981 m at the Jim Sage study site near Malta, Idaho.

  The images were referenced to the UTM coordinates of known locations measured with a Magellan Global Positioning System receiver. Individual frames of the images were "stitched" together by computer to form one large mosaic image. The imagery was classified into spectrally distinct classes using a maximum likelihood classification algorithm (Bolstand and Lillesand 1991).

- Spectral reflectances of soils, cheatgrass and other key plant species were measured with a ground-based spectroradiometer.

  This information was used to facilitate interpretation of spectral classes and improve discrimination of cheatgrass in the imagery. These data enabled us to improve the detection threshold for cheatgrass from about 40% ground cover to nearly 30%.

- Cheatgrass spectral signatures developed from INEL imagery were used to classify the imagery collected at Malta to determine whether signatures developed in one area can be used to map cheatgrass distributions in other areas.

  The accuracy of the Malta site classification dropped by 20% to 30% when INEL signatures were used, which probably reflects differences in the soil background. Thus, it may not be feasible to use cover class signatures developed at one site to accurately map cheatgrass distributions in other areas. Our work indicates that moderately dense, more or less continuous patches of cheatgrass can be readily mapped using low-altitude, multi-spectral video imagery. The imagery must be collected while cheatgrass is in the

wine-red color stage, and it may be necessary to develop signatures from "ground truthing" at the imaged site.

- Multispectral video images were collected from flights over the area burned by the Butte City Fire. GPS locations were obtained from numerous landmarks on the periphery of the fire scar so that the images could be referenced to known UTM coordinates. Individual frames were stitched together using computer image processing (91 frames at each of three wavelengths) to form composite images of the fire scar.

  It should be possible to map disturbances caused by fire or heavy grazing that would provide habitat for cheatgrass colonization. Imagery from the thermal wavelengths clearly delineated the extent of the burned area. Mapping of burned areas by low-altitude videography is accurate, but numerous ground fixes are necessary to accurately position the feature spatially. For large areas, image processing and stitching individual frames together is time intensive. It would be more cost and time effective to use either Landsat or Spot satellite imagery to map similar large features. These products are referenced to UTM coordinates and only one image would be required. The resolution of satellite imagery is sufficient for mapping burned areas this large, but unburned patches within the burned area smaller than 400 $m^2$ to 900 $m^2$ (for Spot and Landsat images, respectively) would fall below the detection limits.

## PRODUCTS

Two presentations and two tangible products resulted from this project during Calendar Year 1994:

### Presentations

- Bowlin, T. R. 1994. Low altitude multi-spectral video mapping of vegetation in arid rangelands. Invited Classroom Presentation, Advanced Science Class, Malad High School, Malad, ID.

- Bowlin, T. R. 1994. Remote Sensing for resource monitoring in arid rangelands. Invited Classroom Presentation, Advanced Science Class, Malad High School, Malad, ID.

### Tangibles

- Multi-spectral video maps of the Butte City Burn.

- Graphic analyses of elk distribution for Foundation Affiliate at the University of Idaho.

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

# THE DISTRIBUTION AND STATUS OF AMPHIBIANS AND REPTILES ON THE INEL: IMPLICATIONS FOR FUTURE SITE DEVELOPMENT AND ENVIRONMENTAL RESTORATION OPERATIONS

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## ABSTRACT

To determine changes in the distribution and abundance of amphibians and reptiles on the Idaho National Engineering Laboratory (INEL) site, we repeated a herpetofaunal survey conducted by Sehman and Linder in 1975. In 1994, we revisited 18 of the original survey sites and recorded the number of species and the number of individuals observed at each site. Our survey results indicate: (1) In contrast to 1975, no Spadefoot Toads (*Spea intermontana)* were observed or heard in 1994, presumably because of an absence of water for breeding; the long-term persistence of this species on the INEL may be in jeopardy. (2) Three of the four lizard species apparently have declined in distribution and abundance. (3) Four snake species on the INEL generally appear to have maintained similar distribution patterns and abundances. All of the species of snakes on the INEL occurred at fewer sites in 1994 than in 1975, but these differences were not statistically significant. Similarly, fewer individuals of all four species of snakes were seen in 1994 than in 1975; these differences were statistically significant for garter snakes and rattlesnakes.

In addition to the 1994 survey, we continued the snake population monitoring program initiated in 1989 at Cinder Butte and extended it to two more sites. The monitoring program has already resulted in the detection of a new species for the INEL, the Racer (*Coluber constrictor*). Ten snake denning areas were located; the data for these sites will be used to develop a Geographic Information System (GIS) model to predict potential snake hibernacula on the INEL. All known amphibian and reptile locality information for the INEL are being entered into a computerized database that will be used to describe the distribution of these animals on the site.

## JUSTIFICATION

The goal of the proposed research is to determine the distribution and population trends of amphibians and reptiles on the Idaho National Engineering Laboratory site. This information is important to the Department of Energy for several reasons, including: (1) identifying and managing populations of sensitive species; (2) meeting NEPA requirements regarding the siting of future developments; (3) avoiding potentially dangerous snake-human interactions; (4)

monitoring environmental health and change; and (5) providing a foundation for future research into the ecological importance of these species.

## OBJECTIVES

The encompassing goal of this project was to provide DOE-ID with a comprehensive assessment of the status of amphibians and reptiles on the INEL, particularly those that are classified as sensitive or unique species. There were four short-term objectives with which to meet the goal:

- Resurvey all of the sampling sites examined by Sehman and Linder in 1975.
- Compare current and past surveys to determine possible changes in distribution and population status.
- Continue snake population monitoring program at Cinder Butte and extend it to two other den sites on the INEL.
- Enter all previous and current information on species distributions and abundances into a Geographic Information System and produce dot-distribution maps.

## PROJECT ACCOMPLISHMENTS

Field activities dominated the April 11- December 31, 1994, period.

- Surveys were repeated and multi-year comparisons were made at 18 locations for which data from 1975 were available (Figures. 1 & 2).

  Although Spadefoot toads (*Spea intermontana)* were found at several sites along the Big Lost River and Sinks in 1975, no Spadefoot toads were observed or heard in 1994, presumably because of the absence of water for breeding. No free water was available for breeding in 1994 due to upstream water demands from the Big Lost River and low winter precipitation. To our knowledge, spadefoots have only had opportunity to breed once (1993) in the past nine years and that may not have been succesful. Consequently, given the estimated 15-year maximum life span of this species, its fate on the INEL is precarious.

  An apparent decline in three out of four lizard species has occurred on the INEL. In 1994, we only found Leopard Lizards (*Gambelia wislizenii*) at one of the two sites where they were found in 1975; only four lizards were observed in 1994 compared to 15 in 1975. Of all the lizard species, Short-horned Lizards (*Phrynosoma douglassii*) appear to have declined the most. They were found at only one site in 1994 versus 13 sites in 1975.

Furthermore, only one horned lizard was observed in 1994 versus 13 in 1975. Although Sagebrush Lizards (*Sceloporus graciosus*) appear to have persisted at most of the locations where they were present in 1975, the total number of sagebrush lizards observed in 1994 was only 14 compared to 38 in 1975. Sagebrush lizards have recently been classified by the U. S. Fish and Wildlife Service as a C2 species. A longer term study is required to determine if these apparent decreases in lizard distribution and abundance are due to natural causes (e.g., drought) and/or anthropogenic causes (e.g., pesticides or habitat destruction), and whether these declines are within normal multi-year population variation. It is possible that lizard populations are experiencing unexplained population declines similar to those experienced by amphibian populations in the Western United States.

In contrast to lizards, snakes on the INEL generally appear to have maintained similar distribution patterns and abundances. Although all four snake species on the INEL were found at fewer sites in 1994 than in 1975, these differences were not statistically significant. Significantly fewer Western Terrestrial Garter Snakes (*Thamnophis elegans*) and Western Rattlesnakes (*Crotalus viridis*) were observed in 1994 than in 1975. However, a mark/recapture study conducted from 1989-1993 did not indicate that the large population of rattlesnakes at Cinder Butte had declined since 1975 (Sehman, 1977; V. Cobb, unpublished data).

- The snake population monitoring program was continued at Cinder Butte and extended to two more sites, Crater Butte and Rattlesnake Cave.

  Funnel traps and drift fences were set up near three hibernacula: Cinder Butte, Crater Butte, and Rattlesnake Cave. This effort at Crater Butte produced a new species record for the INEL, the Racer (*Coluber constrictor*).

- Ten snake denning areas were located and will be used to develop a statistical and Geographical Information System model to predict potential snake hibernacula on the INEL using topography, geology and vegetation as independent variables.

- All of the survey information from 1994 and 1975 was entered into a computerized database which will be imported into a Geographical Information System and used to produce dot-distribution maps for the reptiles and amphibians of the INEL. These data will be used in a related project to test and refine Gap analysis models (Scott et al., 1993).

## PRODUCTS

Two publications and two additional products from this research were produced between April 11 and December 31, 1994.

## Publications

- Cobb, V. A. 1994. Rattling around on the Snake River Plain. Idaho Wildlife 14:10-13.

- Cobb, V. A. 1994. The ecology of pregnancy in free-ranging Great Basin Rattlesnakes (*Crotalus viridis lutosus*). Unpublished dissertation, Idaho State University, Pocatello. 82 pp.

## Other Products

- A computerized database of INEL amphibian and reptile records was established.

- Portions of this research were featured in the May, 1994, Public Broadcasting System telecast "Incredible Idaho."

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Scott, J. , et al. 1993. Gap analysis: a geographic approach to protection of biological diversity. Wildlife Monographs No. 123. 41 pp.

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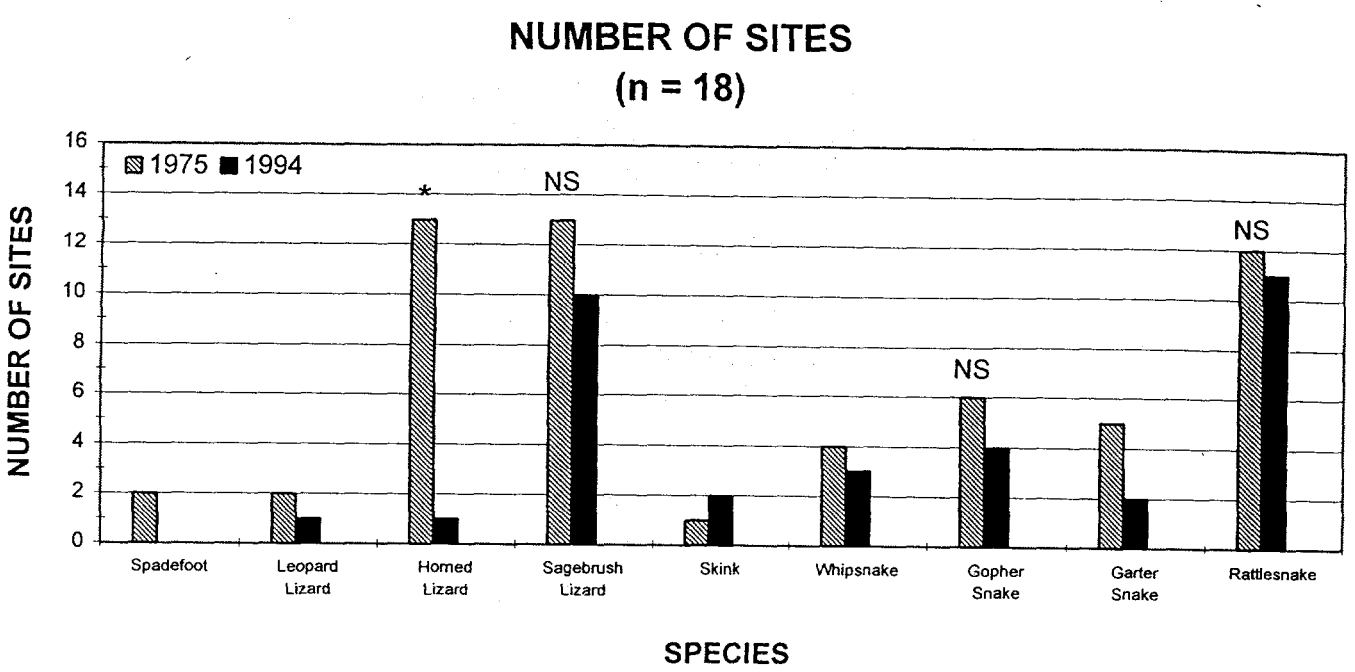


**Figure 1. The number of sites at which each species of amphibian or reptile was found in 1975 and 1994. The total number of sites surveyed was 18. If enough sites with a species occurred, we performed a chi-square analysis. The results are indicated above the bars (NS = not significant, * = significant at the 0.05 level).**

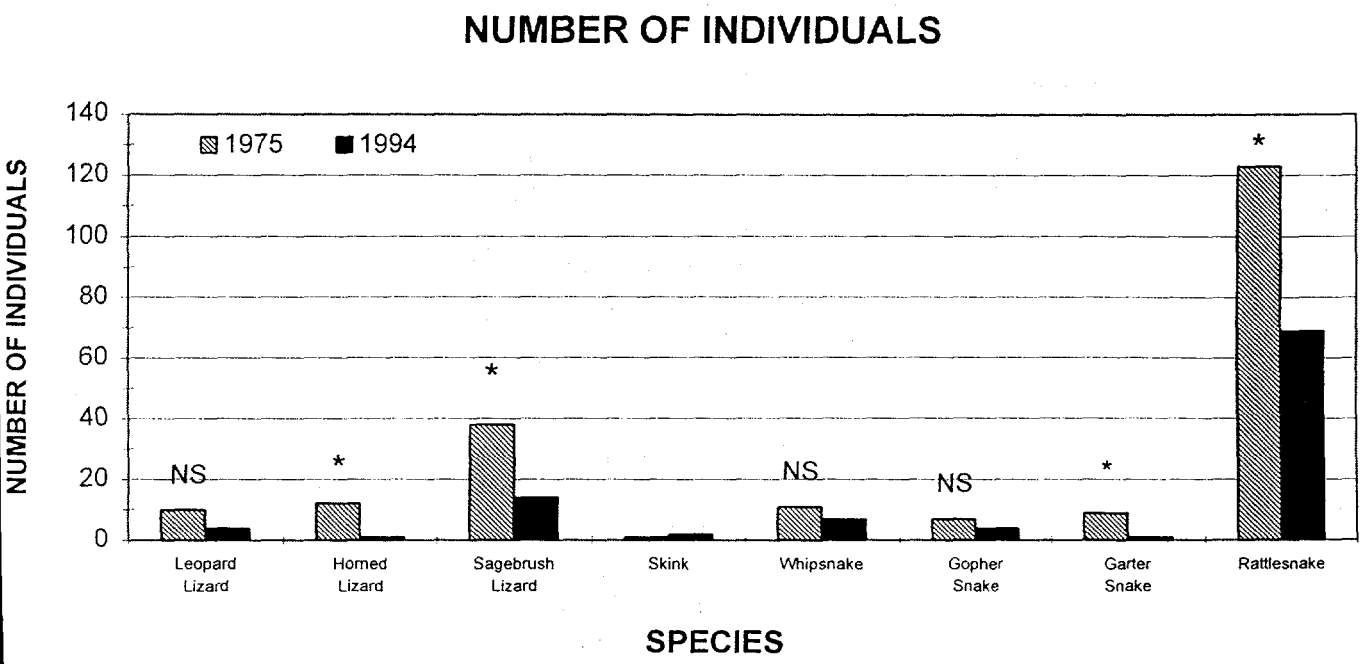


**Figure 2. The number of individuals of each species of reptile observed in 1975 and 1994. The total number of sites surveyed was 18. If enough individuals were observed, we performed a chi-square analysis. The results are indicated above the bars (NS = not significant, * = significant at the 0.05 level).**

# DIVERSITY OF THE ANT FAUNA OVER THE IDAHO NATIONAL ENGINEERING LABORATORY: IMPLICATIONS FOR WASTE MANAGEMENT

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## ABSTRACT

Early work at the Idaho National Engineering Laboratory (INEL) identified 22 species of ants. Our initial assessment of the ants on the INEL reveals that there are many more species, including at least one new to science. We are now building a baseline understanding of the INEL ant fauna, its diversity and abundance. Ultimately, we will produce an annotated checklist of the ants of the INEL. We met our objectives (curate historical collections, begin verification of determinations, collect additional sites during the spring and fall, and initiate computerization of data) for this first year of work. We began curation of historical collections by pinning and labeling over 2,000 ant specimens. We are working with various experts to identify and verify some of the ant specimens collected. We collected additional specimens at the INEL during 1994. We initiated computerization of the data by constructing database programs and by entering over 13,000 ant specimens. We announced this project in three scientific newsletters and at least five newspapers. A poster about the project in currently on display at the O. J. Smith Museum of Natural History, Albertson College of Idaho. One scientific publication resulted, in part, from this work in 1994.

## JUSTIFICATION

Ants are an important ubiquitous component of the semi-arid land ecosystem. The biomass of ants can exceed the collective biomass of all vertebrates in arid land ecosystems. They contribute to soil processes and energy cycling. Some species can significantly alter soil moisture and water infiltration characteristics, and can unearth buried wastes and contaminated soils. Others can change vegetation patterns and thereby affect hazardous waste storage areas. Knowledge of the species composition and distribution over an area is important for long-term waste management decisions, as well as comprehensive land stewardship.

We have been collecting ants at the Idaho National Engineering Laboratory since 1986. We have made many important collections and observations since that time. Our current work has made it possible to continue the curation process and begin data entry.

## OBJECTIVES

The overall project objective is to provide DOE-ID with a complete description of the ant fauna of the INEL. There were four primary objectives of the April 11 - December 31, 1994 work plan:

- Curate historical collections.
- Begin verification of determinations.
- Collect additional sites during the spring and fall.
- Initiate computerization of data.

## PROJECT ACCOMPLISHMENTS

### Curate Historical Collections

- Technicians were trained for curatorial tasks.

  Several reference texts were purchased which will aid with ant identification and help us determine the ecological role of the ants collected. A protocol was established for curation of ant specimens by technicians.

- INEL maps were foam-core mounted for use in displaying ant collection localities.
- Ants previously pinned and labeled were placed into new California Academy of Science (CAS) insect cabinets at the O. J. Smith Museum.
- A backlog of pinned ants were labeled and placed into the collection.
- We began curation of the historical collections we made at the INEL.

  Several hundred field vials of ants were sorted and labeled. More than 2,000 individual ant specimens were pointed and labeled. These specimens will be deposited in the entomological collections at the Orma J. Smith Museum of Natural History, Albertson College of Idaho, Caldwell; the William F. Barr Entomological Museum, University of Idaho, Moscow; and with individual taxonomic specialists working on the material.

## Begin Verification of Determinations

- Efforts were made to locate the original ant collection made on the INEL in the 1960s and verify species identification.

  We visited Dr. Richard W. Baumann (Monte L. Bean Life Sciences Museum, Entomology Department, Brigham Young University, Provo, UT). We examined the ant collection (pinned and alcohol), but were unable to locate the specimens collected during the 1960s at INEL (known as the National Reactor Testing Station at that time)(Allred 1968 and Allred and Cole 1971).

  We contacted the primary author of the original ant checklist (Dr. Donald M. Allred, now retired) to see if he knew where the specimens were located. He replied that they had not been pinned and should be in the alcohol collection. Dr. Baumann and his assistants will continue to search for the material and send it to us if and when it is found. We contacted Roy Snelling at the Los Angeles County Museum to see if any of the material might be with the Arthur C. Cole collection that the Museum acquired. Dr. Cole was the junior author of the 1971 checklist.

- We contacted specialists for verifying or identifying several taxonomically difficult ant species found on the INEL.

  We are awaiting verifications of identifications of ants in the genera *Formica* and *Myrmica* sent to Dr. Andre Francoeur, Universite du Quebec, Chicoutimi, Quebec, Canada this past spring. Dr. Francoeur is the North American expert on these genera. We will send him the additional specimens we curated this summer. Dr. Francoeur will be describing a new species of *Myrmica* (discovered on the INEL) in the future (Jackson *et al.* 1991). We will provide biological and ecological information to the paper.

  We received a letter from Dr. Edward O. Wilson (Harvard University) that their curatorial assistant, Stefan Cover, will examine the ants of the genus *Lasius* from our INEL collections. We have mailed a box of specimens for identification or verification.

## Collect Additional Sites During Spring and Fall

- Fifty-six additional ant collections were made at the INEL on 14-15 July at locations on the INEL not previously collected.

- An INEL site visit was made in July to introduce the research technician to the Site and to our collection methods.

- We also photographed the area on the west side of the INEL recently burned and made some ant collections and observations there.

- General ant collections were also made in conjunction with June and September trips to the INEL associated with the Protective Cap/Biobarrier Experiment.

### Initiate Computerization of Data

- We have been working on the development of a museum management system for over five years. With our participation in the Entomological Collection Network, our designs have been able to address concerns common across the discipline and incorporate the emerging national and international standards.

- During this year a structure was finalized and the User Entry Interface developed to facilitate the cataloging of INEL ants. The system and program are still under development. Thus, its application to the INEL ant survey project will serve as an excellent test and tool for refinement.

- The system was constructed to permit a variety of output data summaries which will enhance the information obtained from the INEL survey. Specimen localities in latitude and longitude permit easy development of distribution information and mapping for any specified taxonomic category. Summaries can be generated of the number of individuals collected from various locations, seasons, ecological habitats and /or by specific collection methods or collectors. Using the database in its present form, preliminary cataloging has demonstrated that a technician will be able to access around 75+ specimens per hour once they have been curated and labeled. We have now entered approximately 4,800 records accounting for over 13,000 individual ant specimens.

## PRODUCTS

One publication and several media-related products resulted from our work from April 11 through December 31, 1995.

### Publication

- Merickel, F. W., and W. H. Clark. 1994. *Tetramorium caespitum* (Linnaeus) and *Liometopum luctuosum* W. M. Wheeler (Hymenoptera: Formicidae): New state records for Idaho and Oregon, with notes on their natural history. Pan-Pacific Entomologist 70:148-158.

## Other

- A poster showing some aspects of this project is now on display at the Orma J. Smith Museum of Natural History, Albertson College of Idaho, Caldwell.

- News notices were published in three newsletters: *The Retort*, *Idaho Entomology Group Newsletter*, and *Entomological Society of America Newsletter*.

- Five articles concerning the ant species discovered through this research appeared in Idaho newspapers.

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# STUDIES ON THE EFFECTIVENESS OF BIOBARRIERS TO PREVENT HARVESTER ANT EXCAVATION

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## ABSTRACT

Harvester ants in the genus *Pogonomyrmex* are known to excavate subterranean nests to depths greater than 2 m. They have been shown to concentrate radioactive materials in their mounds and may bring waste materials to the surface. In addition, their excavations have been shown to influence soil water balance with further potential to redistribute buried waste materials. Thus, they pose a threat to the integrity of shallow, subsurface waste closures and a barrier to their penetration is desirable. In the laboratory, two soil particle sizes were compared for their utility in blocking vertical penetration by ants. No ants breached a 25-cm thickness of gravel incorporated 25 cm below the surface of laboratory nesting soil profiles. However, they did pass through similar layers of cobble and a cobble-gravel mix. Presently various thicknesses of the gravel layer are being tested for their efficacy. Treatment thicknesses of 3 cm, 6 cm and 9 cm have failed to stop *Pogonomyrmex salinus* excavation. Testing of 12-cm, 15- cm and 18-cm thicknesses is underway.

## JUSTIFICATION

Buried contaminants at the Idaho National Engineering Laboratory (INEL) could be exhumed due to animal activity. Among the organisms capable of moving buried waste are ants. Ants are numerous and taxonomically diverse in this area (Allred and Cole 1971; Blom and Clark, unpublished data), and harvester ants (*Pogonomyrmex salinus* Olsen) are widespread over the INEL (Blom et al. 1991a).

*Pogonomyrmex salinus* galleries can be extensive. Near vertical tunnels, ca. 5 mm in diameter, have been found as deep as 1.8 m on the INEL. Plate-like chambers radiate from the vertical tunnels (Lavigne 1969, Blom 1990). Ant excavation of these tunnels and chambers could bring radioactive waste to the surface. It is known that they can concentrate radioactive materials in their mounds if the colony is located on or near a site with contaminated soil (Blom 1990, Blom et al. 1991b). Ant mounds and galleries are also likely to influence water infiltration (Blom et al. 1994, Blom and Johnson unpublished data), which in turn could affect redistribution of buried radioactive materials. Thus, in designing a cap for shallow waste disposal, incorporation of a layer resistant to ant excavation would be extremely beneficial.

Results from our research show that both the cobble and cobble-gravel mix failed to stop the ant excavation, though during the length of the trial (ca. 6 months), the 25-cm thickness of gravel prevented the ants from digging beyond the 25-cm to 50-cm section. The biobarrier thickness of a gravel layer needed to stop the ants is unknown.

## OBJECTIVE

During the period April 11 - December 31, 1994, a two phase (laboratory and field) testing of barrier materials under consideration for potential use at a shallow land burial site was continued with the following principal objectives:

- Complete the laboratory test of potential gravel layer thicknesses initiated in 1993.
- Initiate laboratory tests of gravel layer thicknesses from 12 cm to 18 cm.
- Transfer mature colonies to the Protective Cap/Biobarrier Experiment after initial tests are completed.
- Refine methods for moving harvester ant field colonies in preparation for transfers to be made to the biobarrier demonstration site.

## PROJECT ACCOMPLISHMENTS

Only the first two objectives were addressed. Preparation of the Protective Cap/Biobarrier Experiment was not completed this year, and it does not seem likely that it will be ready for ant colonies until 1997 or 1998 (Objective 3). With the drought in 1994 (resulting in weakened ant colonies) and delay of the closure project completion, the field refinement of colony transfers (Objective 4) was postponed for a more suitable time.

### Objective 1: Complete Laboratory Testing of Potential Gravel Layer Thicknesses Initiated in 1993

- Twelve cylindrical laboratory 'ant farms' were constructed using 8-inch diameter PVC pipe (schedule 40) and plexiglass (Lexan, 1/4 inch).

  A 1-m high soil column for ant nest excavation was assembled using four 25-cm-long sections of the PVC pipe (Figure 1). A 75-cm x 75-cm x 50-cm plexiglass arena provides an area for the ants to construct their stereotypic mound; feeding and foraging needs may also be accommodated with the arena.

- Lake bed sediments collected south of the Radioactive Waste Management Area on the INEL were used in the ant farm sections. Columns were packed from the base upward. Three layer thicknesses, 3 cm, 6 cm and 9 cm, of a subangular rock ranging from 1.8 cm

to 2.7 cm were tested in the 25-cm to 50-cm depth section (Figure 1). Each of these treatments was replicated three times along with a control, containing only lakebed soils. A tracer layer of colored aquarium gravel (Conga Roc®) was placed at the bottom of each soil section. Four colors were used (gray, yellow, green and pink), being randomly assigned to particular depths within each column.

- Ants for the laboratory structures were collected from 12 harvester ant colonies on the INEL and introduced into the experimental chambers.

- Trials for gravel thickness of 3 cm, 6 cm and 9 cm were completed in 1994.

Two of the three colonies with 3-cm thick gravel exhumed tracer below the barrier level. Two of these colonies excavated to the 100-cm depth. Two colonies penetrated the 6-cm gravel barrier, going deeper than tracer exhumation indicated (100 and 75 cm respectively). Only one colony breached the 9-cm test barrier, going to 100 cm in its excavation. In both the 6-cm and 9-cm treatment blocks, ant penetration below the barrier did not appear extensive, usually represented by a single tunnel terminating in a small chamber.

### Objective 2: Initiate Laboratory Tests of Gravel Layer Thicknesses from 12 cm to 18 cm

- Eighteen field colonies were excavated to arrive at the minimal numbers needed for eight experimental nests.

- While the cool, wet conditions of early to mid season may have caused a reduction in harvester ant colony strength during 1993, the severe drought of 1994 seems to have further reduced worker numbers. Fortunately, individuals from several colonies could be combined to create cohorts of nearly 2,000 workers to be added to the laboratory nests structures.

- Trials of 12-cm to 18-cm gravel thicknesses were initiated using eight artificial nest structures.

## PRODUCTS

One manuscript was published in the technical literature and one presentation describing the research was given at a technical meeting during the April 11 - December 31 period:

### Presentation

Blom, P. E., and J. B. Johnson. 1994. An 'ant farm' for laboratory colonies of *Pogonomyrmex salinus* (Hymenoptera: Formicidae). Idaho Academy of Science Annual Meeting, Pocatello.

### Publication

Blom, P. E., J. B. Johnson, B. Shafii, and J. Hammel. 1994. Soil water movement related to distance from three *Pogonomyrmex salinus* (Hymenoptera: Formicidae) nests in southeastern Idaho. Journal of Arid Environments 26:241-255.

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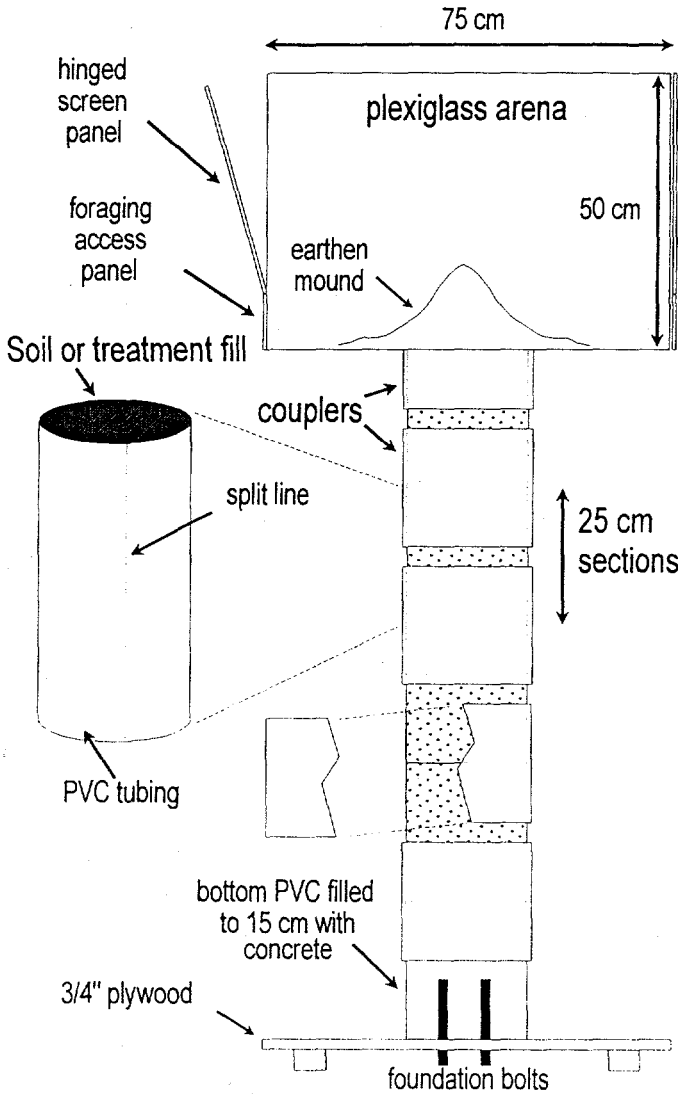


**Figure 1: Schematic of the 'ant farm' used in testing of potential biobarriers for the exclusion of harvester ants during nest excavation.**

# HABITAT USE AND MOVEMENT PATTERNS OF MULE DEER ON THE INEL

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## ABSTRACT

The increased visibility of mule deer (*Odocoileus hemionus*) near INEL facility complexes, particularly during severe winters, has heightened the awareness of, and concerns for, deer on the INEL. Concomitantly, the need for effective management alternatives based on population dynamics, habitat use and movement patterns has been emphasized The objective of this study is to determine those and other ecological aspects of the mule deer population on the INEL. On- and off-site depredation problems, on-site forage requirements, and improvement of winter habitat, with existing water sources (e.g. overland waste water application) and the use of prescribed fire, will be examined. Additionally, the feasibility of establishing green strips for fire protection and forage production will be addressed. During 1994, a graduate student was selected to conduct the field investigations. Radio-transmitter collars were purchased and competitive bidding was initiated for capturing deer.

## JUSTIFICATION

Although little is known about mule deer numbers, distribution and movements on the INEL, there is an indication that deer concentrate near CFA and other facilities at different times of the year. The recent severe winter of 1992-93 demonstrated the hardships facing the INEL mule deer population when many animals were witnessed near the facilities and roadways. Deer wintering at CFA generally elicit an emotional response from site workers and constitute a public relations issue. These same deer often cause significant damage to ornamental plantings and other landscaping efforts. There is also concern about the possible depredation on surrounding croplands, again a notable public relations issue. In addition, various land management activities, such as prescribed burning as a fire management tool, may influence mule deer seasonal distribution and habitat use. There is a general interest on the behalf of DOE management, as well as various stakeholder groups, to provide adequate winter forage for mule deer and other big game on the INEL. Successful management of the deer on the INEL is impossible without a basic understanding of habitat use and needs throughout the year. Information from this project can serve not only the INEL but other agencies that manage deer herds in similar habitats. Conclusions derived from this undertaking will allow INEL to better understand on-site mule deer populations and their needs.

## OBJECTIVE

The primary objective of this study is to determine the movement patterns, densities and habitat use by mule deer (*Odocoileus hemionus*) on the INEL. The actual field work associated with this project has just begun. Sampling regimes, experimental design and data collection procedures are being implemented in a manner to determine:

- Habitat use related to domestic livestock grazing, patch size of habitat and type of habitat.
- Selective preference in homogeneous habitat between non-treated and land-surface wastewater application areas.
- Seasonal movements of mule deer on the INEL.
- Depredation on croplands adjacent to INEL.
- Mule deer densities on INEL.
- Function and feasibility of green strip establishment.
- Effects of prescribed burns on big game habitat use on the INEL.

## PROJECT ACCOMPLISHMENTS

This project was initially proposed in the spring of 1994, using 20 radio-collared deer as study animals. The primary accomplishments for this project during Calendar Year 1994 were:

- Twenty radio-transmitter collars for deer were purchased.
- A graduate student from the University of Idaho, Moscow, was selected to conduct the field research.
- After the competitive bid process, a contract was awarded for the deer capture operation.

  The capture, initially scheduled to take place 24 October 1994, to mark resident deer was delayed until January 1995. The delay resulted from an unforeseen incompatibility with Idaho Department of Fish and Game animal capture policy. Upon resolution the bid was opened and summarily awarded to a Boise, Idaho, based company.

## PRODUCTS

No physical products were produced during the April 11, 1994 to Dec. 31 1994 period. However, of note is the selection of a research assistant responsible for the field work for the study, access of computer software/hardware necessary to analyze pertinent data, and procurement of essential equipment and supplies. Logistic requirements regarding animal capture and personnel prerequisites were also arranged during this period.

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

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## ABSTRACT

The use of total transuranic concentrations as a criterion to assess the potential risk of contaminated soil implies that all forms of these radionuclides have an equal impact on man and his environment. The degree of ecological mobility and bioavailability of these elements are known to be limited and that the above assumption is unrealistic. The goal of this project is to study the association of plutonium in six different chemical and mineralogical soil phases as a function of depth in the soil profiles using sequential extraction experiments. One hundred soil samples were collected from five locations near the Subsurface Disposal Area (SDA) at the Idaho National Engineering Laboratory (INEL). Each location was sampled to 30-cm soil depth in 3-cm layers. All soil samples were dried, mixed and screened through a 0.5-mm mesh. Ten-gram aliquots were selected for Pu analysis and for the sequential extraction experiments. Post extraction readsorption is being tested by tracer experiments. From this information, the relative environmental impact of the different chemical and physical forms of Pu will be assessed.

## JUSTIFICATION

From 1954 through 1970, transuranic waste from the Rocky Flats Plant was shipped to the Idaho National Engineering Laboratory (INEL) site. Markham et al. (1978) reported that 21,000 Ci of $^{239}$Pu and 570 Ci of $^{238}$Pu were buried beneath the SDA at the INEL Radioactive Waste Management Complex (RWMC). In 1994, the upper bound of the inventories of $^{238}$Pu and $^{239}$Pu in the SDA were estimated to be 6,700 Ci and 87,000 Ci, respectively (pers. comm., R.L. VanHorn, Lockheed Idaho Technologies Co.) The majority of this waste was buried in pits in the SDA. After the pits were filled, they were leveled to grade by covering the waste with approximately 1.0 m of soil. Additional soil, as much as 1.0 m in some locations, was added in the early 1980's to contour much of the SDA and promote runoff.

Soil samples collected near the SDA indicated Pu contamination outside the SDA perimeter (Markham et al. 1978). Maximum concentrations in surface soil (0-4 cm) occurred in the drainage depression near the perimeter of the SDA. Surface water runoff and wind transport appear to be the primary mechanisms which transported these radionuclides out of the SDA.

Although knowledge about the total concentrations of these contaminants in the soil matrix are important in appraising the potential hazard, this is not sufficient data to assess potential transport and movement in soil and water. In order to better understand the availability and mechanisms of Pu transport in the environment, a sequential extraction experiment of soil from around the SDA will be conducted. Improved understanding of transuranic association in soil phases will aid in the performance of reliable ecological and human health risk assessments and can help establish tenable and defendable cleanup standards based on the actual mobility of these radionuclides in the environment. This provides factual data for scientific purposes by an independent, scientifically-established group, and should enhance the public acceptability and credibility of the resulting information.

This work addresses some of the ecological risk and impact assessment requirements of RCRA/CERCLA and NEPA programs at INEL. These programs are in need of site specific environmental research to support decisions and documentation for the remediation and restoration programs. Additionally, this project will provide for the training of a graduate student in health physics and radioecology. Such training supports the needs stated by the Department of Energy for the long-range environmental restoration goals.

## OBJECTIVES

The objectives of this project are to:

- Determine the extent of vertical migration of Pu isotopes in soil profiles from the SDA.
- Study the association of these radionuclides in six important chemical and mineralogical soil phases controlling their transport in soils and seep waters. The soil fractions obtained by sequential extraction are the soluble, exchangeable, carbonate, organic, sesquioxides and silicate.
- Assess the degree of post-extraction readsorption using radiotracers including $^{234}$Th and $^{237}$Np.

## PROJECT ACCOMPLISHMENTS

- A part time hourly student was hired to order supplies and to assist in conducting the analysis.
- A sampling protocol and procedure was prepared.
- A radiation project description per campus regulations was written for this contract.
- One hundred soil samples were collected from five locations near the SDA in October. Each location was sampled to 30-cm soil depth in 3-cm layers.

- Gamma spectroscopy measurement was also conducted on all field samples. All samples were transported to Colorado State University.

- We started the preliminary sample pretreatment including drying, grinding and sieving. This sample preparation is about 80% complete.

- Preliminary work is underway using $^{234}Th$ and $^{237}Np$ tracers to assess the degree of post-extraction readsorption for the soil sequential extraction. Preliminary results suggest that post-extraction readsorption contribution is minor, hence Pu partitioning among the different soil phases can be evaluated with a high degree of accuracy using the proposed sequential extraction scheme.

## PRODUCTS

Some results from the radiotracer study were presented at a technical interchange meeting held October 18-19, 1994 in Fort Collins, Colorado, organized by NASA/DOE contractors to discuss the environmental pathways of Pu resulting from accidents during the launch of space vehicles.

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# LICHENS AS BIOMONITORS OF AIR POLLUTION AT THE INEL

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## ABSTRACT

In previous work, lichens were used as air quality biomonitors at the INEL. The electrolyte leakage test has demonstrated that in an arid or semiarid climate, lichens are injured most when moist from early morning dew. Damage to lichen tissues, attributable to air pollution from the ICPP, was discovered up to 10 km from the plant. Energy Dispersive Spectroscopy (EDS) has been employed to assay concentration of polluting elements, and regression formulas which convert EDS data into concentration in ppm are included in a manuscript which was completed in November, reviewed by DOE and submitted to *Science*. A study to determine the utility of lichens and EDS to monitor transuranic element pollution around the RWMC and ICPP was begun in the summer of 1994. No data are yet available.

## JUSTIFICATION

Since the beginning of the Industrial Revolution in the late eighteenth century, the abundance of some kinds of plants has been decreasing in urban areas and near factories and smelters. This reduction is generally attributed to toxic gases in smokestack effluents. Especially pronounced is the change in the lichen vegetation, for of all living things, lichens are the most sensitive to air pollution. However, millions of dollars of crop damage each year is also caused by atmospheric pollution (Darley et al. 1966), and deteriorating air quality is now recognized as a major cause of human health deterioration in most industrialized areas of the world (Lave and Seskin 1970, Gore 1992, Nordhaus 1992, Edwards and Ludwig 1994).

Most lichens are excellent indicators of pollution because they are especially sensitive to toxic gases, *e.g.,* sulphur dioxide, nitrogen oxides, ozone, carbon monoxide, hydrogen fluoride and peroxyacyl nitrates. Species that are relatively tolerant, compared to other lichens, are also valuable indicators; from the combination of sensitive and tolerant species present, an air quality index can be constructed to identify the level of pollution in an area.

To help persons studying air quality identify problem areas more quickly, an electrolyte leakage test (Pearson 1980, 1985) was developed and used to measure degree of injury to lichens from air pollution in laboratory and field tests at several locations in Europe (Pearson and Henriksson 1981, Pearson and Rodgers 1982). Between 1984 and 1994, it was used to evaluate injury from pollutants given off by the Idaho Chemical Processing Plant (ICPP) at the INEL (Rope and Pearson 1990, Pearson and Rope 1987, Pearson in review). Damage to lichen tissues, attributable to air pollution from the ICPP, was discovered up to 10 km from the plant. The

greatest damage occurred at distances greater than 2 km and along the nightime downwind transect.

Fields and St. Clair (1984) applied the electrolyte leakage test to lichens in western United States and compared it with other measures of injury; they reported several advantages over the other measures. These advantages include the following:

- It enables the researcher to detect injury within a few weeks.
- It does not require special or expensive equipment but can be performed with simple, easily available equipment (conductivity meter and distilled water).
- It does not require special skills to perform; students can do the testing.
- It is environmentally friendly; pieces of thallus weighing less than 100 mg are large enough for the test whereas other tests may require grams.

Lichens are also valuable as pollution indicators because they accumulate heavy metals and other polluting elements in their tissues (*e.g.,* Burkitt et al. 1972, Garty 1987, Hale and Lawrey 1985, Nash and Sommerfield 1981, Rope and Pearson 1990, Steines and Krog 1977). In order to more readily identify the chemical elements given off by a point source of pollution, I developed a microchemical assay method in which concentration of elements is calculated from thin, free-hand sections of lichen tissue examined by SEM (scanning electron microscopy) and EDS (energy dispersive spectroscopy). Studies at the INEL have shown that the method correlates with traditional macrochemical methods, is less expensive, and is environmentally friendly, requiring only micrograms of lichen material.

By testing additional species of lichens and additional types of pollution, we can improve the effectiveness of both the electrolyte leakage and SEM/EDS methods. We learned in 1994, for example, that *Lecanora melanophthalma* was better than *Letharia vulpina* for early detection of polluting elements. We are currently testing the SEM/EDS method for transuranic elements. If it is effective, it will be much cheaper than current alpha spectrometric methods for detecting transuranics. As we study the decay products of transuranic elements with SEM/EDS, we hope to find "markers" that will enable us to measure any radionuclides released from the RWMC or the ICPP even if we do not measure TRUs directly.

## OBJECTIVES

The objectives of these studies at the INEL are to:

- Develop an inexpensive microassay method for TRU which is environmentally friendly and can be used to screen samples prior to running more expensive and accurate complete alpha spectroscopy assays.

- Assess the relative value of lichens compared to other plants as bioindicators of transuranic elements in the environment.

- Differentiate between stack emissions and windblown dust as carriers of TRU pollution.

- Establish baseline data for comparison of past and present levels and rates of TRU pollution with each other and with future levels and rates.

- Continue to refine the techniques of using lichens as biomonitors for toxic gases and trace elements.

- Use lichens to monitor the pollution status, especially of transuranic elements, of the area surrounding the Radioactive Waste Management Complex.

- Continue to monitor for toxic gases and trace elements around ICPP.

- Publish the results of our findings so that they may be of benefit to others, *viz.*, to scientists engaged in air quality research, environmental protection and conservation, or lichen physiology, and to the general public.

## PROJECT ACCOMPLISHMENTS

Research in 1994 focused on all of these objectives and most accomplishments were related to transplanting non-contaminated lichens to areas of the INEL. Transplant lichens were collected from three sites in the Little Lost River Valley where the probability of air contamination originating at the INEL should be very near zero according to our analyses of wind patterns and topographic maps:

- Sufficient *Letharia vulpina*, *Lecanora melanophthalma*, and *Psora globifera* were collected from non-contaminated, offsite areas for 500 transplant specimens.

- Half of the *Letharia* and half of the *Lecanora* were transplanted to 16 experimental sites surrounding the ICPP. The remainder, plus the *Psora* specimens, were transplanted to 13 sites in the vicinity of the RWMC.

- Two 200-mg specimens of *Lecanora melanophthalma* transplants from the potentially most contaminated RWMC site, and one from 5 km NE of it were sent to Colorado State University (CSU) for $\alpha$-spectroscopic analysis. A specimen from the pollution-free Little Lost River collection site was also submitted.

- Seven specimens of *Psora globifera*, average size 15 g, were collected from near the RWMC and sent to CSU for α-spec analysis. An additional specimen from the Little Lost River collection site was included.

- Nine specimens from the RWMC area were analyzed by EDS.

- After 7½ weeks, specimens of both *Lecanora melanophthalma* and *Letharia vulpina* were harvested from the 16 transplant sites surrounding the ICPP and analyzed by the electrolyte leakage test and EDS.

- All 1994 data are currently being analyzed. However, regression analysis of 1984 and 1993 macrochemical assays *versus* SEM/EDS analysis of the same lichens collected from the same sites demonstrated that the concentration for most elements can be accurately estimated from EDS data with a relatively high correlation coefficient and low standard error of estimate. Analysis of variance showed statistically significant differences among transects, between tissues, and between species with *Lecanora melanophthalma* superior to *Letharia vulpina* for air quality biomonitoring at the INEL.

- I identified and/or confirmed the identity of an additional 17 difficult-to-identify lichen specimens for the INEL herbarium, and tabulated the location of all 100 specimens now in the herbarium in reference to direction and distance from the ICPP.

## PRODUCTS

One manuscript and three presentations resulted from this research during the period from April 11 through December 31, 1994.

### Presentations

- Pearson, L. C. 1994. Using lichens to monitor air pollution. Invited classroom presentation in Agronomy, Ricks College, Rexburg, ID.

- Pearson, L. C. 1994. Results of monitoring air pollution with lichens and other plants. Invited classroom presentations (2), General Studies, Ricks College, Rexburg, ID.

### Publication

- Pearson, L. C. In review. Biomonitoring air quality with lichens and energy dispersive spectroscopy reveals surprising patterns of atmospheric pollution in a semi-arid environment. Science.

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# SOIL SUBSIDENCE AND SNOWMELT EROSION ON WASTE DISPOSAL SITES

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## ABSTRACT

Soil moisture flux through physical barriers to low-level nuclear waste and subsequent environmental exposure are of great concern to waste management personnel. Surface erosion and subsidence of soil barriers, and atmospheric contamination is also of concern. The recently installed Protective Cap/Biobarrier Experiment at the Idaho National Engineering Laboratory (INEL), which includes four waste covers, was instrumented with soil moisture flux detectors. Diagrams of the location of time domain reflectometry (TDR) probes, installed at various depths for the assessment of vertical water flow in two replications of the four biobarrier treatments, were prepared. We investigated potential techniques, and began the development of a statistically valid sampling scheme, to accurately measure and compare soil subsidence on the PC/BE plots. We are conducting a companion study of soil erosion from simulated waste burial trench caps generated by snowmelt runoff. At that study site meteorological factors which contribute to rapid snowmelt and the presence and extent of soil frost are continuously monitored and telemetered to Utah State University. This fully automated study site was established at the INEL, near EBR-1, to define existing meteorological and soil conditions contributing to snowmelt erosion on nine simulated waste burial trench caps maintaining three different surface cover treatments. Data files were then transferred to the VAX computer system at Utah State University for storage and subsequent analysis.

## JUSTIFICATION

Low level radioactive wastes are interred beneath a shallow mantle of soil at the Subsurface Disposal Area. Disposal sites must be designed to withstand the normal geomorphological processes which 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 or shrink-swell cycles, and soil settling after internment (Cooke et al. 1973). The impact of these processes varies from year to year, according to the climatic patterns specific to the area. Although our investigations on soil settling and erosion are related to waste management and designed to complement other Foundation research, between April 11 and December 31, 1994, these research efforts were conducted without funding from DOE-ID.

## Soil Subsidence on the Protective Cap/Biobarrier Experiment Plots

Among the major environmental exposure hazards in waste disposal areas, soil settling has received less attention than wind and water erosion, infiltration, and percolation. However, subsidence can occur in widely scattered situations and, in terms of ground engineering, might be considered one of the most insidious of threats. Subsidence is a common occurrence at some INEL waste disposal areas. Styles of soil settling vary greatly. In this study we will be investigating and comparing exogenic processes, including instantaneous surface collapses and more longer-term movements among the four cover designs, three irrigation treatments, and two vegetation schemes recently established at the Protective Cap/Biobarrier Experiment (PC/BE). Natural soils are rarely uniform enough to allow perfectly even settlement after construction (Waltham 1989). Volume reductions after the "swell" that accompanies construction are common, particularly when soils contain a significant content of shrink-swell clay minerals (e.g., montmorillonite). Montmorillonitic clays have excessive compressibility and a free-swelling capability that can result in a varied surface topography. Different precipitation patterns, as simulated by the PC/BE, may have different effects on the shrink-swell activity, and any resultant soil settling can lead to surface depressions. These depressions can promote water infiltration and deep percolation, and increase the potential for surface contamination, biotic intrusion, and radiation exposure. Data are needed at the PC/BE to determine the potential effects of various biobarriers, vegetation, and precipitation treatments on subsidence and erosion.

## Erosion from Waste Burial Sites

Conventional management of shallow land burial sites within the sagebrush-steppe at INEL involves some degree of damage to the native vegetation. Goff et al. (1993), working at the EBR-1 study site at INEL, showed that removal of all vegetation cover, canopy, and litter causes potentially serious increases in soil loss when subjected to intensive rainfall, simulated to match summer thunderstorms. Removal of the canopy cover alone had less of an effect, but an effect that the authors claim might grow in magnitude over time as surface protection from raindrop impact and structural characteristics begin to break down. Lakebed sediments, used as trench cap soils, appear to have some inherent erodibility protection due to greater cohesiveness of these clay loams when compared with native sandy loam soils (Goff et al. 1994). Under this same summer thunderstorm regime, Goff et al. (1992) found hydraulic roughness to be greater on trench caps planted to bunchgrass than sodgrass, re-emphasizing the role of vegetal cover in obstructing overland flow and thereby reducing accelerated erosion. We believe that summer thunderstorms do not represent the greatest potential hazard to trench cap integrity from the erosive power of overland flow. The average annual precipitation for the INEL is 224 mm (median 242 mm) (Clawson et al. 1989). Snowfall contributes approximately 45% or 101 mm to this amount. Precipitation during the months of December and January alone, account for 25% of the annual average (Bent 1988). The erosive potential of overland flow is greater during the spring snowmelt period due to a lack of actively growing plants. Dormant plants coupled with the potential for saturated surface soils over frozen subsoils, provide the characteristics necessary for significant erosion from waste burial sites. Soil erosion induced by snowmelt runoff is

dependent upon several factors. The rate at which snowmelt is delivered to the soil surface is determined by energy fluxes into the snowpack as well as the physical composition of the snowpack itself. The condition of the soil surface will also determine the course of descending meltwater at the soil-snow interface. Soil beneath a deep snowpack might remain in an unfrozen state throughout the winter, allowing water to infiltrate into the soil matrix. However, soil erosion is most severe during periods of rain and rapid snowmelt on partially thawed, weakly structured soils (e.g., lakebed sediment soils at INEL) (Zuzel et al. 1982, Papendick et al. 1983). Blackburn et al. (1990) found soil infiltration capacity and interrill erosion to be significantly influenced by freezing and thawing cycles during snowmelt on a sagebrush-steppe site in Idaho.

Waste disposal areas on the INEL are located within a sagebrush-steppe ecosystem where snowpacks are variable. The soil surface is influenced to a great degree by air temperature. Low temperatures prior to snowfall can result in a frozen soil surface that is resistant to infiltration and thereby promotes overland flow. Freeze-thaw and shrink-swell cycles can disrupt soil surface structures and make them more susceptible to erosion. Repeated freeze-thaw events can saturate the soil surface with water that is drawn upward from underlying horizons during each cycle. Surface soil aggregates can also break down during this process, increasing their susceptibility to erosion (Blackburn et al. 1990). Hart and Loomis (1982) reported that soil loss on bare mountain plots in northern Utah is more dependent upon the rate of snowmelt than the total volume of runoff. Sudden periods of high-intensity snowmelt produced by increased temperature rain-on-snow events can result in severe erosion (Zuzel et al. 1982). To accurately predict the impact of snowmelt erosion, it is necessary to measure the physical condition of the local snowpack as well as the energy fluxes incident upon it. Properties of the soil surface and near surface layers also need to be monitored during the same period. These measurements can be used to accurately characterize the processes of snowmelt infiltration, runoff and erosion on simulated waste burial sites at INEL. These data are needed to assess the long-term effectiveness of various cap designs at shallow-land waste disposal sites.

## OBJECTIVES

Our objectives in relation to the Protective Cap/Biobarrier Experiment were to:

- Provide Idaho State University researchers with diagrams and other support regarding the installation of the Time Domain Reflectometry (TDR) system and associated electronics.
- Select an accurate, precise, reliable and economic methodology for multi-year measurement of soil subsidence at the PC/BE.
- Develop a statistically valid sampling scheme with which to compare soil settling among the various PC/BE study plots.

We are using the existing erosion plots near EBR-1 to study the effects of snowmelt erosion on simulated waste burial trench caps. Our 1994 objectives for that effort were to:

- Document the natural deposition of snow and redistribution mechanisms associated with available snowmelt volumes.

- Determine the controls on snowmelt (radiative versus turbulent exchange) and the mechanisms associated with the snow ripening process.

- Determine the process of melt infiltration, three-dimensional flow paths, and subsequent runoff production.

- Determine the volume of runoff and sediment production from waste burial trench caps associated with extreme snowfall events.

- Develop a simplified physically-based component model to describe the snow deposition/melt/runoff processes that interact with surface cover treatments and are meaningful to the INEL experimental site.

- Complete the installation of time domain reflectometry (TDR) wave guides and cables according to specifications, including the purchase of cable testing equipment (wave guide readers) used to interface wave guides and data acquisition devices and calibrate the system.

## PROJECT ACCOMPLISHMENTS

In support of the Protective Cap/Biobarrier Experiment we:

- Evaluated the various methodologies for measureing soil subsidence and, along with other PC/BE researchers, determined that tachometry (laser electronic distance measurement) would not only provide accurate measurements at a reasonable cost, but would not interfere with other PC/BE research efforts.

- Began the development of a sampling scheme for monitoring soil settling that would provide meaningful and statistically valid results related to the various biobarrier, vegetation, and irrigation treatments at the PC/BE.

- Provided information to PC/BE researchers on time domain reflectometry probe locations, installation, and electronics.

During 1994, we upgraded the existing erosion plots near EBR-1 with state-of-the-science instrumentation and electronic capabilities. This instrumentation will compliment a meteorological tower at the site, installed prior to 1994.

- A total of 54 soil moisture probes (wave guides) were installed within the plots to monitor soil water volume snowmelt infiltration and detect the presence of soil frost.

The soil moisture probes utilize the principles of time domain reflectometry (TDR). The probe configuration is based upon information obtained from laboratory tests conducted at Utah State University and Los Alamos National Laboratory.

- We developed a program to measure soil water volume as well as record the electronic signal produced by the soil moisture probe.

  Measurements of soil water volume can be obtained from a graph of the electronic signal. This program will allow us to manually verify measurements of soil water volume to insure accuracy.

- Five snow pillows were set at various locations around the erosion plots to measure snow water equivalent.

  The snow pillows are installed at the soil surface and measure the weight of snow as it accumulates on the instrument. This measurement can be directly correlated to water content.

- Temperature probes were installed at 10-cm increments from 1 m below to 1.1 m above the soil surface.

  Two heat flux plates were installed near the temperature probes at 10 cm below the soil surface to monitor change in thermal energy.

- Nine snow depth sensors were installed (one at each plot) to measure snow accumulation and ablation.

- We designed and manufactured instruments to measure snowmelt runoff and subsequently installed them in the runoff collection tanks at each plot.

  All instruments were connected to data collection units (data loggers). The data loggers were then wired to a radio frequency (RF) modem. The use of an RF modem allows us to collect data from Logan, Utah, by remotely accessing the site through a phone modem located at EBR-1 and a second RF modem. The data loggers used at the study site allow for real-time monitoring of all instruments at the study site.

  We field tested the instrument network with a laptop computer at the study site and from Logan, Utah with a PC located in our laboratory.

- We established an automated data retrieval system by combining computer software and DOS script files. This system automatically retrieves all data collected at the study site during the previous 24 hours. Data files are then labeled with the current date and sent to the VAX computer network at Utah State University for storage and future analysis.

- We prepared the surface cover of appropriate plots and cleaned all runoff collection troughs and tanks prior to snowfall.

## PRODUCTS

This study is in the data collection phase. No publications were produced during 1994. One presentation and two tangible products were produced between April 11 and December 31, 1994.

### Presentation

- Duffin, E. C. 1994. Progress of snowmelt erosion study: 1993-1994 field season. Research review. Environmental Science and Research Foundation. Idaho Falls, ID.

### Tangibles

- DOS script files were developed and merged with existing software to allow automatic data collection.

- Electronic gauges which measure the level of runoff produced by snowmelt were designed and manufactured.

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# BREEDING BIRD SURVEYS ON THE INEL

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## ABSTRACT

Birds have long been used as indicators of environmental stresses. Bird populations reflect ecosystem conditions and, as such, can be used to monitor and assess impacts to the environment from INEL operations. Thirteen breeding bird survey routes, consisting of over 450 established annual observation points, were previously established on the INEL. Data from historical surveys on the INEL were entered into a computer database, validated, and reformatted for analysis. A biostatistician was selected to conduct the analyses and prepare a summary manuscript for publication. Preliminary analysis suggests breeding bird populations around facility complexes may generally have greater avian diversity than populations in remote areas. More species not generally associated with the sagebrush-steppe (e.g. waterfowl and shorebirds) were recorded near facility complexes. Data from the 1994 surveys did not appear substantially different than earlier years.

## JUSTIFICATION

Bird populations are accurate biological indicators of environmental quality, quickly responding to changes in the environment. Bird surveys conducted annually during the breeding season provide the best data for making comparisons among different areas or between years. Recognizing this, the U.S. Fish and Wildlife Service coordinates a nationwide Breeding Bird Survey effort each year. Long-term data, such as that available from these surveys, can be used to track changes that take place over time and to compare impacts to bird populations in areas of different land use management or development. Over 200 species of bird have been observed on the INEL (Reynolds et al., 1986; R. G. Mitchell, unpub. data). Sixty of these have been observed during the breeding season. Several of these (e.g. Brewer's sparrow, sage grouse, sage sparrow and sage thrasher) are considered sagebrush obligates: dependant on relatively large expanses of unfragmented sagebrush habitat for successful nesting (Braun et al., 1976).

Thirteen breeding bird survey routes are established on the INEL. Some routes on the INEL are, by design, near to facility complexes while others are distant from any developments (Figure 1). The five routes in remote areas of the INEL serve as controls against which to compare

results from the eight routes around the facilities. Breeding bird surveys were conducted on these routes from 1985-1991. Annual surveys not only provide data for assessing changes in bird populations, but also provide information on individual species of special concern, such as Threatened, Endangered, or Candidate species. In addition, survey data are useful for CERCLA compliance, including specific Waste Area Group ecological risk assessments, and also support National Environmental Policy Act requirements.

## OBJECTIVE

The primary objective of this effort is to annually provide accurate data on breeding bird populations with which to assess and document environmental impacts from INEL operations.

Specific objectives for 1994 were to:

- Conduct the annual survey along established routes near to and distant from INEL facilities.

- Initiate preparation of a manuscript analyzing and summarizing the existing historic data.

## PROJECT ACCOMPLISHMENTS

The accomplishments for April 11 - December 1994 were substantial for this project.

- We located an experienced, local bird watcher, with a scientific background, to conduct the 1994 Breeding Bird Surveys on the INEL.

  A biology teacher from Shelly High School was assigned to the Foundation through the Academic Affairs TRAC (Teacher Research Assistance) Program at no cost to the Foundation.

- Survey points along the established historical Breeding Bird Survey routes were relocated and, as needed, reidentified.

- Breeding Bird Surveys were conducted in June 1994 along all 13 established routes.

  More species generally associated with water (e.g. shore birds, waterfowl) were observed on routes near facilities than on routes in remote areas of the INEL.

- Results of the surveys were transcribed and submitted to the U.S. Fish and Wildlife Service.

- A descriptive summary of historic survey results was drafted.

This was a preliminary effort to organize more than 30,000 observations into a meaningful format for subsequent rigorous statistical analysis. Because a computer glitch destroyed the integrity of the historic (1985-91) database, the process of reconstructing and verifying the historical data was initiated.

- A biometrician, with experience in analyzing field data for birds, was located. This University Affiliate was invited to, and subsequently did, submit a proposal to analyze the data in an aggressive and creative manner and produce a meaningful summary document. Preliminary analysis suggests that overall there is more variability in bird populations from year to year than among routes. Additional analyses and interpretation are in progress.

## PRODUCTS

There were three products from this effort between April 11 and December 31, 1994:

- A corrected database for the 1985-1991 Breeding Bird Surveys.
- A qualitative description of the 1985-1991 Breeding Bird Surveys.
- Field data from the 1994 Breeding Bird Survey routes.

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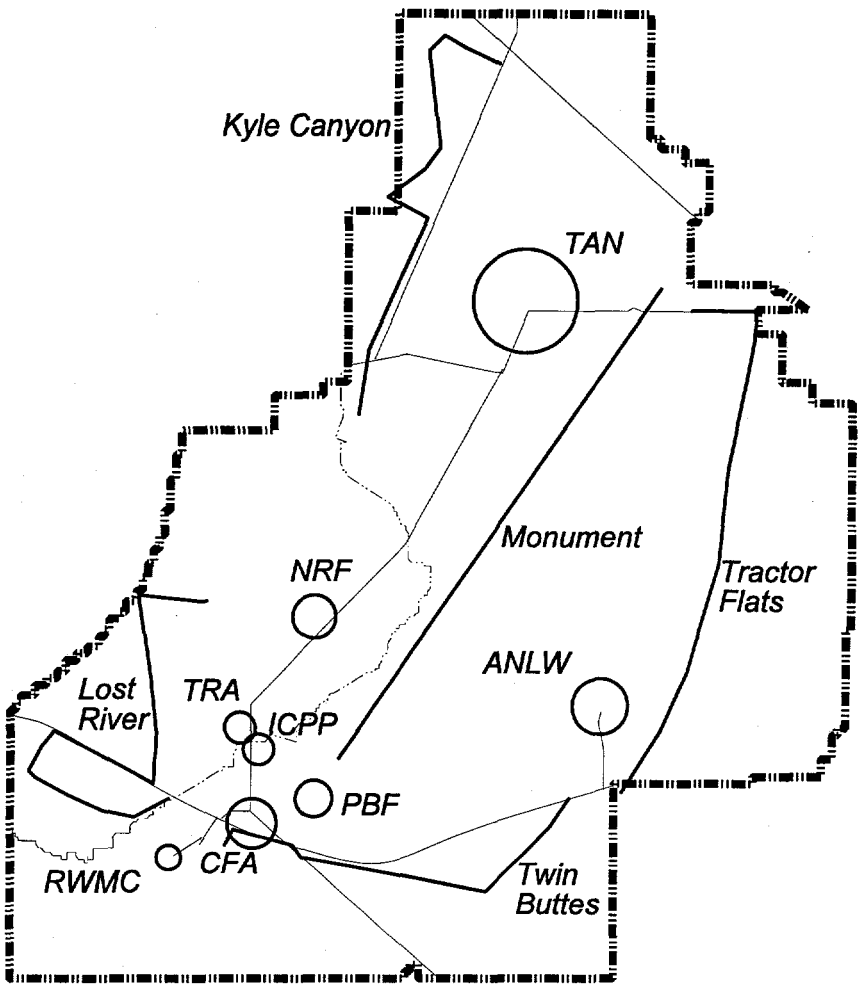


**Figure 1. Breeding bird survey routes on the INEL. Routes represented by a circle encompass facility complexes; others serve as controls for analyses.**

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

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## ABSTRACT

Research is being conducted to determine the fate of radionuclides released as liquid effluent to two double-lined evaporation ponds at the Test Reactor Area on the INEL. Although much information is available describing the fate of radionuclides placed in percolation ponds, there is no information currently available on radionuclide behavior in evaporation ponds. 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. Special emphasis is placed on determining potential radionuclide transport from the ponds, especially transport to humans via waterfowl which have spent time on the ponds. Because this project is in its early stages, analysis of data has not been completed. The total activity of radionuclides in the effluent released to the ponds during 1994 was about 43 curies, 98% of which was tritium. The remainder of the activity was largely from $^{60}Co$, $^{137}Cs$ and $^{51}Cr$. Inventories of gamma emitting radionuclides, tritium, strontium, and transuranics are being determined through time from samples taken on a regular basis. Collections of the various pond components began in August of 1994. Dose to humans or wildlife using the ponds is being determined by measuring exposure rates at multiple locations on and around the ponds with thermoluminescent dosimeters put in place August of 1994. The process of obtaining permission to collect waterfowl on the INEL was completed late in the year. Daily observations were made throughout 1994 in order to determine waterfowl use of the ponds. Twelve waterfowl were collected in 1994, all from the Ft. Hall area and will be used as control samples. Over 44 species of birds were identified using the ponds in 1994, 15 of which were waterfowl.

## JUSTIFICATION

Two lined ponds were constructed during the summer of 1993 to replace percolation ponds at the Test Reactor Area (TRA). Many studies were conducted over the lifetime of the percolation ponds (Morris 1994) and much was learned about radionuclide cycling in, and transport from, such ponds. Radionuclides tended to become bound with the sediments of the percolation ponds (Ibrahim and Culp 1989, Millard 1986) such that the potential for transport of large amounts of radioactivity was limited and, thus, the potential for doses to humans was small. In contrast, little is known about radionuclide cycling in a lined pond system. With very little sediment present, at least initially, radionuclide behavior will likely be different than in a non-lined

percolation pond. Without sediment, radionuclides may be more available (i.e. in the water column) to waterfowl and other birds, thereby increasing the likelihood of transport of contaminants from the pond and potentially to humans. Also, radionuclides remaining in the water column will have less shielding and, thus, may result in higher exposure rates. Because the central concept in hazardous waste management is to keep waste isolated from the environment and humans, the question of whether lined-pond systems have a greater potential for environmental exposure than percolation ponds must be answered.

Understanding the behavior of radionuclides in a lined pond system is also important for other reasons. The environmental assessment for the lined ponds (U.S. Department of Energy 1991) indicated that studies of waterfowl using the pond will be initiated to determine whether they constitute a significant pathway of contaminants to humans. Second, waterfowl are protected under the Migratory Bird Treaty Act so information on the effects of lined ponds on waterfowl is needed. Also, the use of lined evaporative ponds is likely to increase due to public concerns for the Snake River Plain Aquifer. Already other percolation ponds are being replaced by lined evaporation ponds (e.g. at the TAN facility) so knowledge of radionuclide behavior in them is essential. These data can also be used in support of Ecological Risk Assessment. The analysis of the potential radiation dose to humans from migrating waterfowl will be included in the Annual Site Environmental Report as mandated by DOE Order 5400.1.

## OBJECTIVES

In order to determine the fate of radionuclides in lined ponds, this project has the following objectives:

- 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.

  Regular observations will allow us to determine visitation rates to, and residence times on, the ponds for waterfowl.

  Waterfowl will be collected and radionuclide concentrations determined for both whole body and the edible fraction. Dose to both the duck and the person potentially consuming it will be based on these analyses.

- Determine the transport of radionuclides from the ponds by vectors other than waterfowl.

  Both barn swallows and mourning doves use the ponds regularly. Both species will be collected and analyzed to determine the magnitude of transport from the ponds via these birds.

Tumbleweeds are known to blow into the ponds, become contaminated, then blow out. Wind-blown vegetation is being collected to quantify this.

- Determine radionuclide cycling in the ponds through time.

  This involves sampling of several components of the pond system, including, but not limited to, water, suspended materials, sediment, vegetation, waterfowl and other species. Samples are examined for gamma-emitting radioactivity with a subset being analyzed for transuranic activity. Samples are being collected at least once every month in order to document any temporal changes.

- Create a dynamic model of radionuclide cycling in the pond system to be used to estimate future potential radiation doses to waterfowl and the humans who might eat them.

- Determine whether the pond liner has changed the potential for dose to waterfowl and humans as compared to the previously used percolation pond system.

## PROJECT ACCOMPLISHMENTS

Major project accomplishments for April 11- December, 1994 included:

- Observation data were collected throughout the year to determine visitation rates and residence times for waterfowl.

  Daily visits were made at randomly selected times and the number and species of birds using the ponds were recorded. Over 44 species of birds, including 15 species of waterfowl, used the ponds. According to research conducted from April 1989 through October 1991 (Cieminski 1993), a total of 68 species of birds were observed at the now reclaimed TRA percolation ponds. Our data indicate that, in regard to bird species richness, the TRA evaporation ponds rank 12th out of 22 waste ponds on the INEL.

- Sample collection of pond components began in August 1994.

  During 1994, 70 samples were taken from the ponds and surrounding area. Of these, 10 were water samples, 12 were sediment, 4 were seston and 44 were vegetation. Of the vegetation, all samples were tumbleweeds, 41 of which were taken from the area surrounding the ponds (outside of the marked contamination area).

- Activity levels of gamma-emitting radionuclides as well as for strontium and transuranics in water, sediment and wind blown vegetation samples were obtained.

- Samples of wind blown vegetation were collected from around the pond perimeter in order to quantify transport from the system by this pathway.

- Eighteen dosimeters were also put in place on the two pond during August.

  These will be used to determine exposure rates from penetrating radiation at various locations on the ponds as well as along the shore. Dosimeters will be replaced quarterly. Quantifying exposure rates will let us know doses to birds spending time at various locations on the ponds. Higher exposures mean higher doses and, therefore, higher chances of detrimental effects.

- Permission was received on December 7 to collect waterfowl from the ponds.

  In order to ensure that facility management, security, and all employees associated with the ponds on the INEL were properly notified of our waterfowl collection activities. A document describing our plans was sent to over 32 people for signature. LITCO ES&H, public relations, and employee concerns personnel became involved and it was agreed that collections would take place only after employees were notified in the INEL News. Since this process was initiated late in the year, we could not print our waterfowl collection plans until the January 10, 1995 edition. Therefore, we did not collect any waterfowl on the INEL in 1994. We did, however, collect 12 waterfowl from remote locations south of the INEL as control samples.

- Sediment collection pans were placed on the bottom of the ponds.

  The sediment collection pans are being used to measure sedimentation rates in the ponds. Because sediment plays a central role in radionuclide cycling, accurate estimates of amounts are needed. Also, sedimentation rates are needed in order to determine how much pond volume will be lost to sedimentation over a given time period.

- Water quality measurements were taken monthly.

  Water quality measurements included pH, conductivity, temperature and dissolved oxygen. These measurements are being used to help characterize the pond system.

## PRODUCTS

Because this project is only in the early stages, no publications have been produced. We have, however, established our sampling methodologies and are continuing to collect quality data to meet project objectives.

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# IODINE-129 EFFLUENTS FROM THE ICPP: LONG-TERM CONCENTRATIONS IN ANIMAL THYROIDS AND VEGETATION ON AND OFF THE INEL

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## ABSTRACT

Previous investigations have shown $^{129}I$ concentration and $^{129/127}I$ ratios to be elevated in environmental media both on and near the INEL. The method of transport and the long-term trends have not been determined. This study analyzes $^{129}I$ concentration and $^{129/127}I$ ratios in sagebrush (*Artemisia tridentata*) and mule deer (*Odocoileus hemionus)* and pronghorn (*Antilocapra americana*) thyroids to increase our understanding of the mode of transport of $^{129}I$ off-site, the long-term trends in $^{129}I$ contamination of the environment, and its potential dose to big game animals. An analysis contractor has been selected and some samples have been shipped.

## JUSTIFICATION

The Idaho Chemical Processing Plant (ICPP) began processing radioactive waste in 1953. As part of plant operations, approximately 3.7 GBq $y^{-1}$ (0.1 Ci $y^{-1}$) (U.S. Energy Research and Development Administration 1977) of $^{129}I$ was released to the atmosphere until October 1988, when the waste calciner was shut down for renovation. Much of this $^{129}I$ became incorporated into the ecosystem on and surrounding the Idaho National Engineering Laboratory.

Previous studies have reported above background levels of $^{129}I$ on the INEL in several environmental media including vegetation (McGiff 1985), waterfowl tissues (Halford and Markham 1984), rabbit thyroids (Fraley et al. 1982) and mule deer thyroids (Markham et al. 1983). Concentrations in vegetation decrease with distance from the ICPP. However, ratios of $^{129}I$ to the stable nuclide of iodine, $^{127}I$, in mule deer harvested at Craters of the Moon National Monument and Monida Pass were 12 to 15 times background ratios, indicating that contamination from the INEL has been carried to those locations, probably by wind. None of the past studies have occurred over a sufficient period of time to determine the long-term trends in $^{129}I$ contamination on and off the INEL. In particular, current data do not allow estimates of long-term trends in $^{129}I$ contamination after the ICPP is shut down.

While $^{129}I$ in the environment is not expected to present a significant radiological health risk, it does present a significant public relations risk, principally because of its 16-million year half-life. In the public mind, long half-life is associated with extreme hazard. In addition, although the

total dose was small, $^{129}I$ was responsible for 92.1% of the dose to the maximally exposed individual in 1993 (Mitchell 1994). Because of its long half-life, and because some of its chemical forms readily bond to organic materials, $^{129}I$ is expected to become a permanent component of the environment, continuously cycling through the food chain and delivering radiation dose to humans and non-human organisms. In order to enable us to respond to public concerns, as well as to adequately assess human and ecological risks, it is necessary for us to understand the patterns and mechanisms of $^{129}I$ cycling in the sagebrush steppe. It is also important that we understand the long-term consequences of $^{129}I$ contamination for human and environmental health.

Finally, iodine is an essential element in human nutrition and scientists have invested a great deal of effort in studying its cycling in the environment (Hanson 1963, Kocher 1979). Iodine-129 serves as an analog for stable iodine and our work here will help increase the level of understanding of that system.

For all these reasons, our overall goal is to understand $^{129}I$ cycling in this system. However, it will be of immediate benefit to DOE to determine the extent of the environmental contamination and to demonstrate its low level of hazard to the environment. The current project objectives reflect that short-term goal.

## OBJECTIVES

There are two primary objectives to this study:

- Determine whether $^{129/127}I$ ratios are elevated (relative to world-wide background) in sagebrush collected at Craters of the Moon National Monument, Monida Pass and various on-site locations.

  Sagebrush samples collected when the calciner was running will be analyzed by accelerator mass spectroscopy (AMS), a new, highly sensitive technique which will provide information about both the concentration and isotopic ratio of $^{129}I$ and $^{127}I$. This will allow us to determine the extent to which emissions from the ICPP have contaminated the environment, both on and off the INEL. Elevated ratios at the off-site locations will indicate that $^{129}I$ has been carried from the ICPP to those locations by wind, enhancing our understanding of the mechanisms of iodine movement in the environment.

  Later samples, collected long after the calciner stopped operating, will be analyzed to determine the extent to which $^{129}I$ has become a permanent component of the environment.

  Locating areas with fairly high levels of contamination in the sagebrush, relative to the surrounding areas, will also identify fruitful sites for later study of $^{129}I$ cycling in the environment. All of this information will later be integrated into a comprehensive model

of iodine cycling in the sagebrush steppe. This model will enable us to more accurately predict doses to humans and non-human biota.

- Analyze pronghorn and mule deer thyroids, collected on- and off-site over approximately the past 20 years, for $^{129}I$ concentration and $^{129/127}I$ ratio.

  These samples also will be analyzed by AMS. Because these samples were collected over a long period of time, they will allow us to determine long-term trends in $^{129}I$ contamination, including the trends to be expected when the ICPP is shut down. Understanding these trends are important for an assessment of the human and ecological risks posed by INEL activities. These data will also be incorporated into a model of iodine cycling. In addition, we will estimate the thyroid doses delivered to the animals from $^{129}I$, enabling us to determine part of the long-term consequences of environmental contamination by $^{129}I$.

## PROJECT ACCOMPLISHMENTS

Efforts related to analysis of thyroid and vegetation samples dominated the accomplishments on this project during April - December 1994.

- We selected a new contractor for performing the analyses.

  The new contractor, Isotrace Laboratory at the University of Toronto, uses Accelerator Mass Spectroscopy, a new, highly sensitive technique. The technique allows the detection of natural, environmental levels of $^{129}I$ in all media.

  Isotrace Laboratory was selected from among three laboratories able to perform the analysis on the basis of recommendations by other users and their university connection. Because Isotrace is a university affiliate and a full collaborator on this study, they perform analyses at lower cost than they would if we were seeking work on a production basis.

- We contracted for custom prepared analytical standards.

  Iodine-129-in-animal-tissue standards were prepared by Analytics, Inc. using aqueous $^{129}I$ reference material obtained from the National Institute of Standards and Technology. The standards were shipped directly to Isotrace for their analysis. Isotrace will analyze them as blind samples and report results to us along with results from the sample thyroids. Results from these standards will be compared to their known values, reported to us by Analytics, Inc., as a quality control measure. Error in these measurements will be used to determine error in the sample measurements.

- We shipped 63 mule deer and pronghorn samples to Isotrace for analysis.

These samples are currently under analysis. However, preliminary results indicate that some $^{129}I/^{127}I$ ratios were up to two orders of magnitude higher than expected based on results from other regions of the country (Soldat et al. 1973, Brauer et al. 1973). Because of the high results, Isotrace's procedures required them to shut down the analysis, decontaminate their laboratory and dilute the samples. They have completed this and will shortly begin analyses again.

## PRODUCTS

Because no data have yet been produced from this project, no products have been completed.

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# SURFACE WATER PENETRATION AT THE SUBSURFACE DISPOSAL AREA

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## ABSTRACT

Various EPA and DOE regulations require that shallow-land burial sites for low-level radioactive wastes be effective for at least 100 years. Primary to the success of a waste management site is the capability to keep wastes isolated from water. At the Idaho National Engineering Laboratory, most of the annual soil moisture recharge results from precipitation that occurs during the months when plants are dormant (September - March). Changes in management strategies at the Subsurface Disposal Area (SDA) have resulted in differences in soil covers and thickness, land contours, vegetation types, and proximity of buried wastes to roads and ditches throughout the disposal area. Each of these factors influences soil moisture dynamics in the protective soil caps. Since 1988, we have measured soil moisture, mostly during the late winter, early summer and fall, at 20-cm intervals to depths of 1.6 m on seven study sites within the SDA. Throughout that period precipitation during the non-growing season ranged from 40% to 124% of normal (116.42 mm; 4.58 in). Soil moisture recharge was generally $\leq 40$ cm deep for all areas and all years, except for 1989 and 1993 when moisture in some study plots reached depths of 1.0 m and 1.4 m, respectively. This depth is greater than the thickness of the soil cover over portions of the SDA.

## JUSTIFICATION

Effectively managing hazardous wastes at shallow-land burial sites requires managing the annual influx of moisture into the soil to preclude drainage into the waste zone ( Fisher 1986, Nativ 1991). This is particularly important for waste management sites, such as the Subsurface Disposal Area (SDA) at the Idaho National Engineering Laboratory (INEL), that overlie a significant aquifer. In much of the semi-arid west, including the INEL, the most significant recharge of water into the soil often results from melting snow and spring rains (Anderson et al. 1993). The soil recharge dynamics are influenced not only by the amount and timing of precipitation, but by soil type, vegetative cover and topographic features. For example, soils high in silt or clay have a much higher water holding capacity, and consequently lower hydraulic conductivity, than soils with a greater sand content; soils lacking vegetation are likely to have

more moisture that penetrates deeper than vegetated soils (Anderson 1993); and a sloping soil surface directs surface water elsewhere and presumably reduces infiltration.

The Subsurface Disposal Area (SDA) at the Idaho National Engineering Laboratory (INEL) Radioactive Waste Management Complex (RWMC) has received contaminated wastes for shallow-land burial since the 1950's. Early disposal practices were primitive by today's standards, and did not fully isolate wastes from the environment. Since that time different waste management strategies have been implemented. Perennial grasses have been planted over much of the SDA to reduce erosion. A high clay-content soil from a nearby playa has been added to the original soil cover in many areas to reduce infiltration, correct for soil settling (subsidence) and provide a thicker soil barrier to burrowing animals. Drainage ditches and contoured soil covers have been established to promote runoff and reduce the consequences of flooding events. The impacts of these practices on soil water dynamics, including infiltration, are unknown.

Other Foundation research has shown that 1.6 m of the high-clay playa soil is sufficient to store the maximum amount of precipitation ever recorded on the INEL during the non-growing season, and that a vigorous stand of plants will withdraw all that moisture during the following growing season (Anderson et al. 1993). Not all wastes at the SDA are under a soil mantle as thick as 1.6 m. Any waste management strategy that affects that balance between moisture input and moisture withdrawal may allow water to reach the waste. It is possible that contouring the soil cover may diminish soil moisture recharge which subsequently decreases the vigor of the vegetation cover. This could ultimately reduce the ability of plants to withdraw moisture from the soil cover and result in an increased potential for infiltration into the waste zone. Results of this long-term study will provide information on the impacts of different waste management strategies on annual and multi-annual soil water dynamics and infiltration depths, which will be useful to DOE-ID for making informed waste management decisions to meet regulatory targets.

## OBJECTIVE

This study has two related long-term objectives:

- Monitor and compare the fluctuations in annual and multi-annual soil moisture content in the soil profiles of the seven areas within the SDA likely affected by different management strategies.

  Study areas included: (1)an area covered with high clay-content soil that was leveled, but not contoured, and planted with crested wheatgrass (*Agropyron desertorum*); (2) the same treatment but adjacent to a roadway where drainage ditches and road maintenance likely influence infiltration; (3) a level area covered with high clay-content soil and allowed to revegetate naturally; (4) the top of a domed contoured area; (5) the lowest edge of the contoured area; (6) a level area where grasses were planted in deep native soils; and (7) an area where grasses were planted in shallow soils (ca. 40 cm) over a basalt shelf.

- Monitor and compare the maximum annual depth of moisture infiltration into soils at the same seven areas.

  Up to six neutron hydroprobe access tubes, to depths of 1.6 m, were located in each of the seven study areas at the SDA. Moisture measurements were taken at 20-cm depth increments. Our sampling efforts have been concentrated during the winter and early spring, when soil moisture is most dynamic, although we generally take a late fall reading.

Specific objectives for 1994 included:

- Take moisture measurements during the spring and early summer, and at the end of the growing season in the fall.

- Begin a comprehensive data analysis for all years with which to prepare a report summarizing the results, to date, of the project in 1995.

## PROJECT ACCOMPLISHMENTS

- Soil moisture measurements were taken seven times during the year, starting in March and ending in November.

  Below normal precipitation during the 1993-94 winter resulted in soil moisture recharge to depths $\leq$ 40 cm for all plots except one near a drainage ditch, in which infiltration reached 60 cm.

- Multi-year data analysis and comparisons were initiated.

  Maximum recharge depths were identified. Soil moisture recharge was generally $\leq$ 40 cm deep for all areas and all years, except for 1989 and 1993 when some study plots were wetted to 1.0 and 1.4 m respectively.

  Volumetric soil moisture profiles were generated for all plots and sample dates. Seasonal total moisture content for each plot was determined and bar graphs summarizing spring and fall soil moisture since 1988 were prepared for each study plot (Figure 1).

## PRODUCTS

No manuscripts were related to this research were prepared during 1994. A summary document is in preparation for 1995. Although no technical presentations addressed this research exclusively, the study was described during several presentations summarizing waste management research on the INEL.

## LITERATURE CITED

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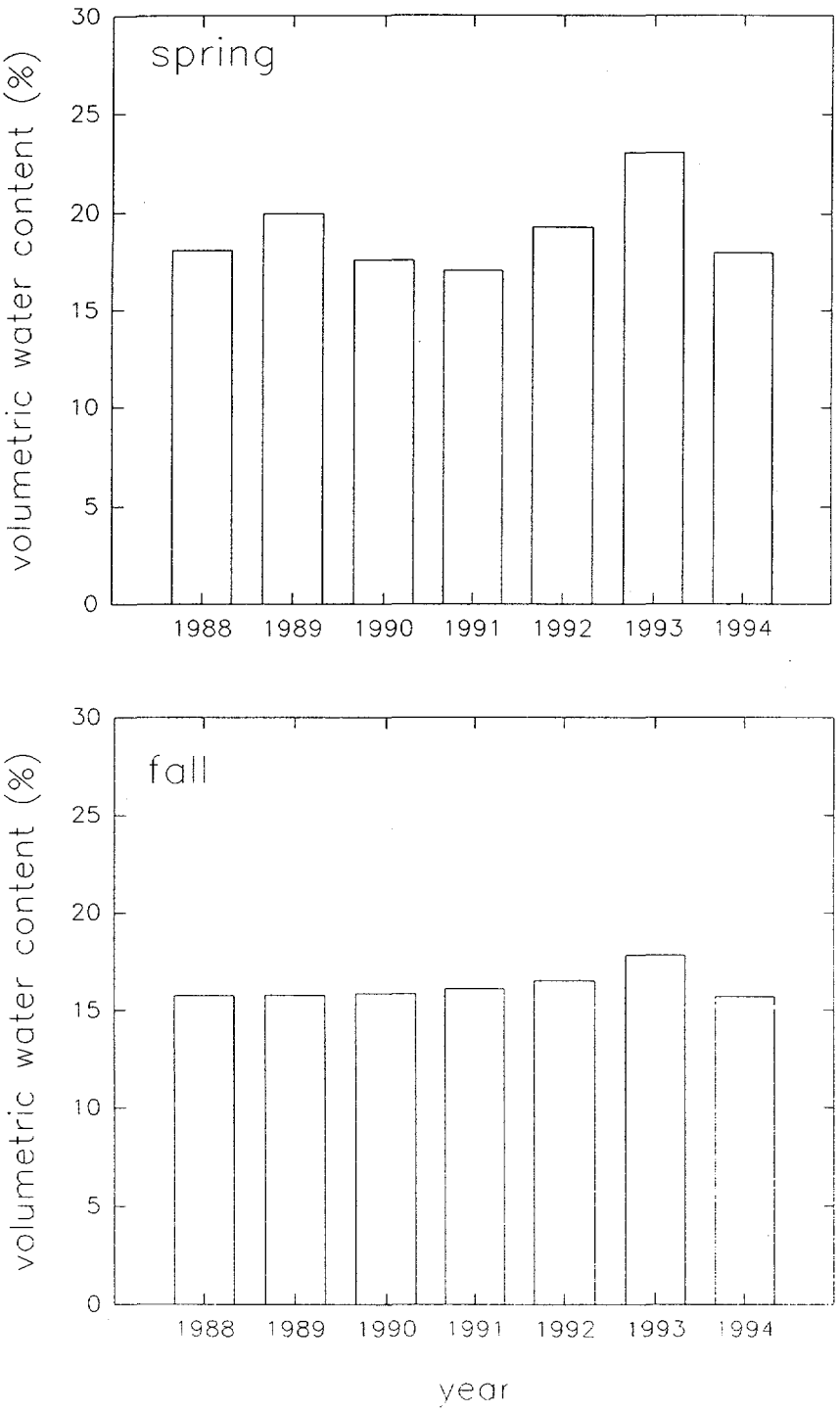


**Figure 1. Spring and fall total volumetric water content (%) for Plot T at the Subsurface Disposal Area (SDA) on the Idaho National Engineering Laboratory, 1988-1994. Plot T is one of seven plots at the SDA in which surface water penetration is measured.**

# MONITORING WILDLIFE SPECIES OF SPECIAL CONCERN

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## ABSTRACT

Certain wildlife species of public, economic and regulatory concern are regularly monitored to determine densities and locations on the INEL. During 1994, surveys were conducted for elk, pronghorn, and various birds of prey including endangered species, such as bald eagles. Data were also collected for future monitoring of sage grouse populations. Survey results showed below average numbers of both bald and golden eagles while there was a fairly large increase in the number of rough-legged hawks counted on the INEL. The number of elk observed on site continued to rise during 1994 and may soon be reaching levels experienced in the late 1980s when depredation on adjoining agricultural lands became a problem. Summer pronghorn numbers appear to have significantly declined from numbers observed five years ago and is likely a result of the particularly harsh winter of 1992-1993 and very dry conditions in subsequent years. The observed fluctuations in bird of prey numbers are thought to be due to natural variations while increases in elk numbers are due to continued immigration and reproduction.

## JUSTIFICATION

The INEL is a very important habitat for many wildlife species. It is an especially important winter habitat for pronghorn and sage grouse. Under certain conditions, up to 30 % of Idaho's entire population of pronghorn have wintered on the INEL. Some pronghorn migrate from SW Montana to winter on the INEL. Furthermore, hunting of game species which spend time on the INEL is common and sharp reductions in game populations are quickly noticed by the public. Without data to determine population trends, the DOE leaves itself defenseless against accusations of INEL activities causing detrimental effects on wildlife species or increased depredation of crops near the INEL. Changes in habitat use can have equally negative repercussions. For example, during the drought in the late 1980s, the INEL was involved in a serious public relations problem with adjacent landowners, politicians and sportsman groups over depredation by pronghorn and elk. Fortunately, some data were available to refute statements against the INEL and provide potential solutions to the problem. In order to reduce these problems, 200 elk were captured and removed from the INEL in 1993, thereby greatly reducing the number of elk on site. During 1994, however, elk numbers appeared to be once again increasing, meaning potential depredation problems in the future and more public relations problems for the INEL. Understanding big game use of the INEL will help make management decisions that could benefit habitat utilization and reduce animal stress and crop depredation.

Supplying movement and density data to land and game management agencies and to the public will also be beneficial to public relations with the INEL.

For the past 12 years Foundation employees have participated in the U.S. Department of the Interior, National Biological Service's Midwinter Bald Eagle Survey. A large portion of the area covered during the survey includes the INEL and not only are eagles counted, but all birds of prey are identified and recorded. During the 1994 survey, no bald eagles and 6 golden eagles were observed on the INEL. The long-term yearly averages are about 2 and 11 for bald and golden eagles, respectively. The number of northern shrikes observed on the INEL was slightly lower, with 2 shrikes observed compared with 3 for the long-term average. Because year to year variability is high, the lower than average numbers recorded in 1994 are believed to be due only to natural variation. One species showing a marked increase was the rough-legged hawk with 164 being observed compared with a long-term average of 50. Again, year to year variability is high. Continual monitoring of species of concern provides data necessary for compliance with the National Environmental Policy Act (NEPA) and for making informed management decisions regarding the environmental protection.

The National Environmental Policy Act, mandated in 40 CFR 1500-1508, is "the basic national charter for the protection of the environment (40 CFR § 1500.1)." Knowledge of critical habitat is essential for supporting the NEPA process. There are currently seven species on the INEL under consideration for listing as threatened or endangered species. These are the ferruginous hawk, pygmy rabbit, burrowing owl, long-eared bat, small-footed bat, Townsend's big-eared bat and the sagebrush lizard. By understanding these species use of the INEL, informed decisions can be made about the impact of certain actions on them and other wildlife. This is especially important for the threatened and endangered species as section 7 of the Endangered Species Act requires consultation with the U.S. Fish and Wildlife Service to determine the impact of projects on threatened and endangered species. These monitoring efforts along with specific research on certain species described elsewhere in this document (e.g. research on pygmy rabbits) provide the data necessary to determine these impacts.

Another monitoring project, just in its beginning phase, was initiated to determine relative sage grouse densities on the INEL. In recent years concern has been expressed by federal and state wildlife managers in Montana and Idaho over apparent decreases in grouse numbers in southwest Montana and the upper Snake River Plain, Idaho. Whether grouse populations on the INEL are also declining is unknown. Monitoring sage grouse on the INEL complements an ongoing interstate (Montana and Idaho) grouse study. Grouse surveys will further benefit DOE-ID by providing data for the NEPA process and by demonstrating to the public DOE's continued commitment to responsible stewardship of natural resources.

## OBJECTIVES

Monitoring various wildlife species of concern on the INEL is done to satisfy the following objectives:

- Determine the densities of sage grouse, elk, deer, pronghorn and other wildlife species on the INEL.

  Data will be available to determine population trends, thereby providing information which can be used to refute accusations of INEL caused detrimental effects or to prove beneficial effects.

  Data will also be used to support the NEPA process and to help make management decisions to reduce animal stress (e.g. as a result of critical habitat loss or reduced resource availability) and crop depredation.

- Monitor the number of game animals inhabiting the INEL which potentially depredate crops adjacent the INEL.

  This will provide DOE-ID with information to allow managers to anticipate depredation problems and implement proactive measures to resolve public concerns.

  Data will be used to help game management agencies make decisions prior to major depredation problems (as in the late 1980s) thereby saving the INEL from major public relations problems and the high cost of another animal relocation project as was conducted in the early 1990s.

## PROJECT ACCOMPLISHMENTS

For this project, major accomplishments included:

- Conducting two aerial surveys for big game on the INEL.

  The first survey was completed in February 1994 to determine winter populations of elk and pronghorn while the second survey was in late July to determine summer pronghorn populations. A total of 1085 pronghorn antelope and 51 elk were observed during the winter survey. The pronghorn population during the summer was estimated with 95% confidence to be $1044 \pm 544$ individuals.

  All data obtained from big game surveys were supplied to DOE-ID managers and the Idaho Department of Fish and Game, region 6, regional biologist.

- Conducting the INEL area portion of the National Biological Service Mid-winter Bald Eagle Count.

This provided data on eagle and other bird of prey numbers on and around the site which was supplied to the National Biological Service. A total of 6 golden eagles, 4 prairie falcons, 164 rough-legged hawks, 2 red-tailed hawks, 35 ravens, 2 northern shrikes, 2 American kestrels and 22 short-eared owls were observed on the INEL during the min-winter eagle count.

- collecting data on historic sage grouse lek locations to be used in establishing annual spring lek surveys to monitor sage grouse population.

## PRODUCTS

Products produced in this project during 1994 were data which was reported to area game management agencies as well as to DOE land managers on the INEL.

# TRACE ELEMENTS AND ORGANICS IN SURFACE SOILS AT THE SUBSURFACE DISPOSAL AREA

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## ABSTRACT

Samples of soil excavated by small mammals and adjacent, non-excavated soils were collected previously from the Subsurface Disposal Area and analyzed for trace elements and organic pesticides. Although several trace elements were found in higher concentrations at the SDA than in background areas, all fell within the ranges found naturally throughout the region (Rope et al. 1988). Over all transects, Hg was found at higher concentrations in non-excavated soils than in excavated soils, possibly as a result of industrial operations at SDA. The organic pesticide Aldrin was found in soils excavated by small mammals at the SDA in concentrations of up to 18 $\mu g\ kg^{-1}$. It was not found in non-excavated soils. In order to explain the presence of Aldrin in these samples, further samples were collected from the Big Lost River spreading areas south of the SDA. These samples will be analyzed in FY-1995.

## JUSTIFICATION

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

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 that of small mammals bringing contaminants to the surface in soil excavated by their burrowing. This contaminated soil would then be available for dispersal by wind.

Radionuclide transport by biota has been well investigated at the SDA. Arthur and Markham (1982) estimated that 270 $kBq\ y^{-1}$ of radioactivity was exported from the SDA by coyotes due to their consumption and subsequent elimination of contaminated small mammals (Arthur and Janke 1986). Approximately 49% of the deer mice (*Peromyscus maniculatus*) and 20% of the kangaroo rats (*Dipodymus ordii*) which inhabit the SDA encounter areas of buried radioactive waste or contaminated soil (Arthur et al. 1987) and burrowing by these small mammals

transports transuranics to the surface in the excavated soil (Arthur and Markham 1983). Arthur et al. (1987) estimated that 1066 kBq $y^{-1}$ of mixed radioactivity in feces was deposited on the surface of the SDA by deer mice and 310 kBq $y^{-1}$ was transported from the SDA by dispersing deer mice.

Although a relative wealth of information is available concerning radionuclide transport by biota at the SDA, no studies have been published reporting similar investigations of trace elements and organics. The objectives of this study, therefore, were to determine whether concentrations of trace elements and organics pesticides are greater in SDA surface soils than background areas and to determine whether burrowing by small mammals has brought trace elements and organic pesticides to the soil surface at the SDA. As a result of finding Aldrin in some of the samples (see below) these objectives were expanded in 1994 to include determining whether Aldrin entered the SDA in cover soil contaminated by upstream agriculture.

## OBJECTIVES

To meet the overall objectives of the study (above) the following objectives were established for April - December, 1994:

- Analyze the data already collected for this study.

  Ninety soil samples have already been collected by John Boone, now at the University of Colorado, for this study. Four transects were established on the SDA by Arthur and Markham (1983) for similar work they did with radioactive contaminants. From these same transects, 40 samples of soil excavated by small mammals and 40 samples of surface soil (undisturbed by small mammals) were collected. In addition, 10 samples of surface soil were collected from a control area. All of these samples were analyzed for trace elements, organochlorine pesticides and PCBs. These data were to be summarized and interpreted this year.

- Collect soil samples from the Big Lost River spreading areas near the SDA.

  In 1976, a new soil cover was placed on some of the areas of the SDA under study. The soil for this cover came from the spreading areas of the Big Lost River, an area into which Big Lost River water is diverted during high water years. Thus, Aldrin found in the soils excavated by small mammals may have been used as a pesticide in the agricultural fields upstream from the SDA and washed downstream into the spreading areas, contaminating the soil used to complete the cover. To determine the origin of the Aldrin, additional soil samples from the spreading areas are required.

## PROJECT ACCOMPLISHMENTS

- We summarized and interpreted the results from previously collected soil samples.

Preliminary results showed that, although several trace elements were found in higher concentrations at the SDA than in background areas, all fell within the ranges found naturally throughout the region (Rope et al. 1988). Over all transects, Hg was found at higher concentrations in non-excavated soils than in excavated soils, possibly as a result of industrial operations at SDA.

The organic pesticide Aldrin was found in soils excavated by small mammals at the SDA in concentrations of up to 18 $\mu g\ kg^{-1}$. It was not found in non-excavated soils. In order to explain the presence of Aldrin, banned throughout the United States in 1970, in these soils, the Foundation decided it was necessary to analyze additional soil samples.

- We collected additional samples from the spreading areas. These samples will be analyzed in FY-1995.

## PRODUCTS

No products have resulted from this study to date.

## LITERATURE CITED


Arthur, W. J. and D. H. Janke. 1986. Radionuclide concentrations in tissues of wildlife occurring at a solid radioactive waste disposal area. Northwest Science 60:154-159.

Arthur, W. J. and O. D. Markham. 1982. Ecological vectors of radionuclide transport at a solid radioactive waste disposal facility in southeastern Idaho. p. 574-580 *in* M. A. Faraday, ed., Proceedings of the International Conference on Radioactive Waste Management. Winnipeg, Manitoba.

Arthur, W. J., O. D. Markham, C. R. Groves and B. L. Keller. 1987. Radionuclide export by deer mice at a solid radioactive waste disposal area in southeastern Idaho. Health Physics 52:45-53.

Arthur, W. J. and O. D. Markham. 1983. Small mammal soil burrowing as a radionuclide transport vector at a radioactive waste disposal area in southeastern Idaho. Journal of Environmental Quality 12:117-122.

Rope, S. K., W. J. Arthur, T. H. Craig and E. H. Craig. 1988. Nutrient and trace elements in soil and desert vegetation of southern Idaho. Environmental Monitoring and Assessment 10:1-24.

## APPENDIX A

## TECHNICAL PRESENTATIONS: APRIL 11 - DECEMBER 31, 1994

Anderson, J. E. Evapotranspiration in cold deserts: applications to hazardous waste management. Invited Seminar. University of Nevada, Las Vegas.

Blom, P. E., and J. B. Johnson. An 'ant farm' for laboratory colonies of *Pogonomyrmex salinus* (Hymenoptera: Formicidae). Annual Meeting of the Idaho Academy of Science. Idaho State University, Pocatello.

Bowlin, T. R. Low altitude multi-spectral video mapping of vegetation in arid rangelands. Invited Classroom Presentation: Advanced Science Class. Malad High School, Malad, ID.

Bowlin, T. R. Remote sensing for resource monitoring in arid rangelands. Invited Classroom Presentation: Advanced Science Class. Malad High School, Malad, ID.

Bromenshenk, J. J. Assessing ecological risks in terrestrial systems with honey bees. Invited Paper. International Symposium on Biomonitors as Indicators of Environmental Change. Windsor, Canada.

Duffin, E. C. Progress of snowmelt erosion study: 1993-1994 field season. Environmental Science and Research Foundation research review presentation. Idaho Falls, ID.

Flake, L. D. Research on the INEL concerning sage grouse, mourning doves, bird use of ponds and raptors. Classroom Presentation: Wildlife Management. South Dakota State University, Brookings.

Flake, L. D. Bird studies on the INEL. Classroom Presentation: Ornithology. South Dakota State University, Brookings.

Hampton, N. L., R. C. Morris, R. L. VanHorn, and R. Brewer. An approach to grouping species for ecological risk assessment. Annual Meeting of the Society of Environmental Toxicology and Chemistry. Denver, CO.

Hansen, R. W. Ecological relationships between nesting Swainson's and red-tailed hawks in southeastern Idaho. Annual Meeting of the Raptor Research Foundation. Flagstaff, AZ.

Hansen, R. W. Raptor studies on the Idaho National Engineering Laboratory. Graduate Seminar. South Dakota State University, Brookings.

Hansen, R. W. and L. D. Flake. Nesting of three *Buteo* species on the Upper Snake River Plain. Annual meeting of the South Dakota Chapter of The Wildlife Society. Huron, SD.

Ibrahim, S A. Selected radiotracer results from the INEL. Technical interchange: NASA/DOE contractors meeting -- environmental pathways of Pu resulting from accidents during the launch of space vehicles. Fort Collins, CO.

Limbach, W. E., J. E. Anderson, and S. A. Hardegree. Seed-priming enhanced emergence of thickspike seedings at cool temperatures. Annual Meeting of the Society of Range Management. Colorado Springs, CO.

Limbach, W. E., T. D. Ratzlaff, J. E. Anderson, T. D. Reynolds, and J. W. Laundré. Design and implementation of the protective cap experiment at the Idaho National Engineering Laboratory. Thirty-third Hanford Symposium on Health and Environment - In Situ Remediation: Scientific basis for current and future technologies. Pasco, WA.

Limbach, W. E. Seed priming enhanced emergence of thickspike wheatgrass seedlings at cool temperatures. Annual Meeting of the Idaho Academy of Sciences. Idaho State University, Pocatello.

Pearson, L. C. Using lichens to monitor air pollution. Invited classroom presentation: Agronomy. Ricks College, Rexburg, ID.

Pearson, L. C. Results of monitoring air pollution with lichens and other plants. Invited classroom presentations (2): General Studies. Ricks College, Rexburg, ID.

Peterson, S., R. Brewer, R. Morris, and R. VanHorn. A case study for evaluation of ecological risks at the Idaho National Engineering Laboratory. Annual Meeting of the Society of Environmental Toxicology and Chemistry. Denver, CO.

Rasmuson, K. E. Physiological and growth responses of *Bromus tectorum.* Annual Meeting of the Idaho Academy of Sciences. Idaho State University, Pocatello.

Ratzlaff, T. D. Soil water dynamics in sagebrush steppe habitats. Annual Meeting of the Idaho Academy of Sciences. Idaho State University, Pocatello.

Ratzlaff, T. D. Soil water dynamics in sagebrush steppe habitats. Annual Meeting of the Idaho Academy of Sciences. Idaho State University, Pocatello.

VanHorn, R., T. Bensen, T. Green, N. Hampton, C. Staley, R. Morris, R. Brewer, and S. Peterson. Ecological risk assessment at the Idaho National Engineering Laboratory: Overview. Annual Meeting of the Society of Environmental Toxicology and Chemistry. Denver, CO.

## APPENDIX B

## PUBLICATIONS BY FOUNDATION RESEARCHERS APRIL 11 - DECEMBER 31. 1994

### TECHNICAL PUBLICATIONS


Anderson, J. E., R. S. Nowak, K. E. Rasmuson, and N. L. Toft. In Press. Gas exchange and resource-use efficiency of *Leymus cinereus* (Poaceae): Diurnal and seasonal responses to naturally declining soil moisture. American Journal of Botany.

Blom, P. E., J. B. Johnson, B. Shafii, and J. Hammel. 1994. Soil water movement related to distance from three *Pogonomyrmex salinus* (Hymenoptera: Formicidae) nests in southeastern Idaho. Journal of Arid Environments 26:241-255.

Bosworth, W.R. 1994. Characteristics of winter activity in *Plecotus townsendii* in Southeastern Idaho. Unpublished thesis, Idaho State University, Pocatello. 74 pp.

Bromenshenk, J. J., R. C. Cronn, and J. J. Nugent. Submitted. Monitoring fluoride with honey bees in the Upper Snake River Plain of Idaho. Journal of Environmental Quality.

Bromenshenk, J. J., J. L. Gudatis, and R. C. Cronn. In Review. Post-closure assessments of industrial complexes with honey bees. Journal of Environmental Quality.

Bromenshenk, J. J., G. C. Smith, and V. J. Watson. In Review. Assessing ecological risks in terrestrial systems with honey bees. Chapter for peer-reviewed book to be published by Plenum Press.

Cieminski, K. L. and L. D. Flake. In Press. Invertebrate fauna of wastewater ponds in southeastern Idaho. Great Basin Naturalist.

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