9. ECOLOGICAL RESEARCH AT THE IDAHO NATIONAL ENVIRONMENTAL RESEARCH PARK

9.1 Ecological Research at the Idaho National Environmental Research Park

The Idaho National Laboratory (INL) Site was designated as a National Environmental Research Park (NERP) in 1975. The NERP program was established in response to recommendations from citizens, scientists and members of Congress to set aside land for ecosystem preservation and study. This has been one of the few formal efforts to protect land for ecosystem preservation and study and to protect land on a national scale for research and education. In many cases, these protected lands became the last remaining refuges of what were once extensive natural ecosystems.

There are five basic objectives guiding activities on the Research Parks. They are to:

1. Develop methods for assessing and documenting the environmental consequences of human actions related to energy development.
2. Develop methods for predicting the environmental consequences of ongoing and proposed energy development.
3. Explore methods for eliminating or minimizing predicted adverse effects from various energy development activities on the environment.
4. Train people in ecological and environmental sciences.
5. Use the Research Parks for educating the public on environmental and ecological issues.

The NERPs provide rich environments for training researchers and introducing the public to the ecological sciences. They have been used to educate grade school and high school students and the general public about ecosystem interactions at U.S. Department of Energy (DOE) sites; train graduate and undergraduate students in research related to site-specific, regional, national, and global issues; and promote collaboration and coordination among local, regional, and national public organizations, schools, universities, and federal and state agencies.
Establishment of NERPs was not the beginning of ecological research at federal laboratories. Ecological research at the INL Site began in 1950 with the establishment of the long-term vegetation transect study. This is perhaps DOE’s oldest ecological data set and one of the most intensive data sets for sagebrush steppe. Other long-term studies conducted on the Idaho NERP include the reptile monitoring study initiated in 1989, which is the longest continuous study of its kind in the world; as well as, the protective cap biobarrier experiment initiated in 1993, which evaluates the long-term performance of evapotranspiration caps and biological intrusion barriers.

Ecological research on the NERPs is leading to better land-use planning, identifying sensitive areas on DOE sites so that restoration and other activities are compatible with ecosystem protection and management, and increased contributions to ecological science in general.

The Idaho NERP provides a coordinating structure for ecological research and information exchange at the INL Site. The Idaho NERP facilitates ecological research on the INL Site by attracting new researchers, providing background data to support new research project development, and providing logistical support for assisting researcher access to the INL Site. The Idaho NERP provides infrastructure support to ecological researchers through the Experimental Field Station and museum reference collections. The Idaho NERP tries to foster cooperation and research integration by encouraging researchers using the INL Site to collaborate, develop interdisciplinary teams to address more complex problems, and encourage data sharing, and by leveraging funding across projects to provide more efficient use of resources. The Idaho NERP has begun to develop a centralized ecological database to provide an archive for ecological data and facilitate retrieval of data to support new research projects and land management decisions. The Idaho NERP can also be a point of synthesis for research results that integrates results from many projects and disciplines and provides analysis of ecosystem-level responses. The Idaho NERP also provides interpretation of research results to land and facility managers to support the National Environmental Policy Act (NEPA) process natural resources management, radionuclide pathway analysis, and ecological risk assessment.

The following sections describe ecological research activities that took place at the Idaho NERP during 2007.

9.2 Monitoring Amphibian and Reptile Populations on the Idaho National Laboratory: Indicators of Environmental Health and Change

 Investigators and Affiliations
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Charles R. Peterson, Professor, Herpetology Laboratory, Department of Biological Sciences, ISU, Pocatello, Idaho
**Funding Sources**
Idaho State University Graduate Student Research and Scholarship Committee
U.S. Department of Energy Idaho Operations Office

**Background**
Many amphibian and reptile species have characteristics that make them sensitive environmental indicators. The main research goal of this project is to provide indicators of environmental health and change by monitoring the distribution and population trends of amphibians and reptiles on the INL Site. This information is important to the DOE for several reasons: (1) as an indicator of environmental health and change; (2) for management of specific populations of sensitive species; (3) meeting NEPA requirements regarding the siting of future developments; (4) avoiding potentially dangerous snake-human interactions; and (5) providing a foundation for future research into the ecological importance of these species.

**Objectives**
The main objective of this project is to monitor amphibian and reptile distribution on the INL Site. Specific objectives for 2007 included the following:

- Continue monitoring snake and lizard populations at the three main den complexes (Figure 9-1);
- Expand monitoring program to include a 170 km driving loop to complement the den data (Figure 9-1). This has been added because Denim Jochimsen’s data showed that the proportion of gopher snakes on the roads is higher than at the main den sites;

![Figure 9-1. Map of the Idaho National Laboratories with the Three Main Den Complexes and the 170 km Drive Loop.](image-url)
• Continue to monitor breeding sites for Great Basin Spadefoot “toads” (*Spea intermontana*)
• Continue entering current herpetological information into a geographic information system (GIS) tool database;
• Provide herpetological expertise, as needed;
• Provide snake safety workshops; and
• Provide educational opportunities for undergraduate and graduate students.

**Accomplishments Through 2007**
Specific accomplishments for 2007 include the following:

• We continued monitoring of snake populations at three den complexes (Cinder Butte, Crater Butte, and Rattlesnake Cave) allowed us to increase the total number of snakes captured by 481 snakes (Figure 9-2), 332 of which were new marks.
• We found 51 snakes during eight road cruising trips.
• We did not confirm spadefoot toad breeding activity at the Big Lost River sinks in 2007.
• In two man hours of searching we were not able to confirm the presence of Long-nosed Leopard Lizards (*Gambelia wislizenii*) on the INL Site in 2007.
• We conducted three snake safety talks in May of 2007 at the INL Site.

**Figure 9-2. The Number of Captures from each Species Caught at Each Den Site Over the 2007 Field Season (CROR = Rattlesnakes, PICA = Gopher snakes. MATA = Striped-whipped snakes, COCO = Racer, CRAB = crater butte, CINB = cinder butter, RCAV = rattlesnake cave).**
Results
The number of marked snakes on the INL Site was increased to 4,400 in 2007, which includes all snakes PIT-tagged since 1994 and marking data collected at Cinder Butte from 1989 to 1994.

- We found that in 2007, 10 percent of females were gravid at Cinder Butte, 30 percent were gravid at Crater Butte, and 10 percent were gravid at Rattlesnake Cave.
- No observations of a leopard lizard (*Gambelia wislizenii*) were made at Circular Butte in 2007. Western skinks (*Eumeces skiltonianus*) were found in funnel traps at Rattlesnake Cave. Sagebrush lizards (*Sceloporus graciosus*) were found across the entire INL Site.
- We found 34 gopher snakes, 16 rattlesnakes, and one unidentifiable snake during our road cruising surveys (Figure 9-3).
- Spadefoot toad (*Spea intermontana*) breeding was not observed in the Big Lost River Sinks.
- We provided herpetological expertise in the form of snake safety talks for the INL Site, as well as, at the Idaho Falls Earth Day celebration and to elementary school children at different schools and libraries.
- Through the continuation of Scott Cambrin’s masters research he has also started to look at some of the factors affecting body condition and pregnancy rates. Using the results from a laboratory study he has modeled neonate overwinter survival for the three main den sites (Figure 9-4).

Plans for Continuation
Scott Cambrin will complete a thesis and approximately two manuscripts will be submitted to peer reviewed scientific journals.

Figure 9-3. Number of Snakes Found During the Road Cruising Survey on the INL. All snakes were found dead.
9.3 Developing a Conservation Management Plan for the Idaho National Laboratory

**Investigators and Affiliations**
Christopher L. Jenkins, Conservation Scientist, North America Program, Wildlife Conservation Society, Idaho Falls, Idaho

**Funding Sources**
U.S. Department of Energy Idaho Operations Office

**Background**
The sagebrush steppe of western North America is one of the most endangered ecosystems in the world. Sagebrush steppe is threatened by soil disturbance (especially associated with overgrazing) that promotes invasion by exotic annual vegetation (such as cheatgrass, *Bromus tectorum*) which in turn alters natural fire regimes. These types of landscape changes are having significant effects on sagebrush steppe wildlife. Despite the widespread nature of the threats to sagebrush steppe, the INL Site has experienced only limited disturbance and is likely the most intact example of sagebrush steppe remaining.

Without an adequate management plan in place the biodiversity of sagebrush habitats on the INL Site are at a greater risk of being degraded. Localized threats to biodiversity on the INL Site include livestock grazing in peripheral areas, invasion by cheatgrass (*Bromus tectorum*) and crested wheatgrass (*Agropyron cristatum*), fire, raven depredation, and road and facility development. In addition, complex interactions can exist between threats.
Developing a conservation management plan for the INL Site is important because it will help preserve one of the best remaining sagebrush steppe ecosystems in the world. A conservation management plan is also important to DOE because it will facilitate land use planning on the INL Site. For example, with a conservation management plan in place and an understanding of the distribution of important biological resources DOE will save time and money when planning projects such as a new construction.

**Objectives**
The overall goal of the project is to conserve sagebrush steppe ecosystems while facilitating land use planning on the INL Site. Specific objectives include:

- Determine the distribution and abundance of pygmy rabbits on the INL Site.
- Determine the distribution and abundance of sage grouse on the INL Site.
- Conduct a biodiversity inventory of the INL Site.
- Develop a vegetation map for the INL Site.
- Set conservation priorities on the INL Site.
- Develop an interactive GIS tool for the INL Site.
- Prepare a conservation management plan for the INL Site.

Some of the objectives above will be focused on the entire INL Site (Pygmy Rabbit Studies, Sage Grouse Studies, and Vegetation Mapping) while the Biodiversity Inventory will be focused in two smaller areas in the south central part of the INL Site designated the Development Corridor and Development Zone (Figure 9-5). Thus, conservation priorities, the interactive planning tool, and the Conservation Management Plan (CMP) will only completely cover all important biological resources within these two areas.

**Accomplishments Through 2007**

**Pygmy Rabbit Surveys.** In 2007 we continued conducting ground surveys for pygmy rabbits. These surveys detected the presence of 422 burrow systems bringing the total number of burrow systems identified during the CMP project over 600.

**Sage Grouse Surveys.** In 2007 we conducted ground surveys for sage grouse leks. We found a total of two new leks during these surveys to bring the total number of new leks found during the CMP to six.

**Biodiversity Inventory.** As part of the biodiversity inventory we selected a suite of indicator taxa including vegetation, reptiles, passerine birds, raptors, bats, small mammals, mammalian mesocarnivores, and ungulates. Accomplishments in 2007 by taxa are as follows:

- **Vegetation.** We sampled approximately 50 modified Whitaker plots.
We sampled reptiles using 14 trapping arrays, >100 visual surveys, and a series of road surveys. We found over 1000 individual reptiles of six species. Sagebrush lizards and horned lizards were the most commonly sampled species.

**Breeding Birds.** We sampled approximately 65 plots for breeding birds using point counts.

**Raptors.** We sampled approximately 100 plots for raptors.

**Small Mammals.** We sampled a total of approximately 50 plots for small mammals using Sherman live traps and Havahart traps.

**Plans for Continuation**

In 2008 we plan to continue surveys for pygmy rabbits, continue developing an abundance index for pygmy rabbits, and will be begin a movement and critical habitat study on sage grouse. Finally, we will continue a study on raven depredation of sage grouse nests that is primarily funded through a U.S. Bureau of Land Management (BLM) grant.
9.4 Historical Fire Regimes of Wyoming and Basin Big Sagebrush Steppe on the Snake River Plain

Investigators and Affiliations
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Funding Sources
U.S. Department of Energy Idaho Operations Office

University of Idaho, College of Natural Resources, Department of Rangeland Ecology and Management, Moscow, Idaho

Background
The fire histories of sagebrush-dominated vegetation types are difficult to document with traditional methods such as utilizing multiple fire scars or macroplot population demographic composition. Individual sagebrush plants do not fire scar and a fire usually removes all sagebrush plants within the burned area. In some areas sagebrush steppe fire history has been extrapolated from adjacent vegetation types that contain conifer species that are scarred by fire (e.g., western juniper (Juniperus occidentalis), ponderosa pine (Pinus ponderosa), Douglas-fir (Pseudotsuga menziesii)). These species, however, are largely not available for most of the Snake River Plain.

There is an urgent need for understanding the relationship between seasonal climate patterns and large fire potential in sagebrush steppe, as little information is available on the relationship of climate and fire size for sagebrush ecosystems. As the impact of climate variability and extreme climatic events on fire occurrence and size can vary depending on scales at which they are analyzed, fire history is being reconstructed across multiple spatial scales, with the INL Site at the finest scale. Studies of fire history and ecology are vital to understanding and forecasting the impacts of climate change on sagebrush steppe ecosystems. An improved understanding and the ability to forecast future impacts can serve as the scientific foundation upon which fire and land management decisions can be based.

Objectives
There are few studies of fire history in the sagebrush steppe and none that examine the changes in occurrence of large fires (5000+ acres) and consecutive climatic conditions. The specific objectives of this research are to: 1) reconstruct the fire history (1960-2003) for sagebrush steppe ecosystems across three spatial scales of sagebrush-dominated steppe: a. Idaho National Laboratory Site, b. Snake River Plain, and c. portions of the Northern Basin and Range to include the Snake River Plain; 2) examine the links between climate and large fire events in sagebrush-steppe vegetation by investigating a range of potentially important climatic variables (e.g. drought, ENSO and PDO); and 3) develop predictive models to assess how climate variation will affect fire frequency and size characteristics within sagebrush steppe ecosystems.
Accomplishments Through 2007

- Downloaded climate data (Daymet) for future analyses
- Secured vegetation coverage of area (GAP)
- Collected and compiled various historical fire data into a GIS layer
- Obtained and averaged climate data into monthly, seasonal divisions, and annual divisions
- Modified precipitation and temperature to use Western Regional Climate Center (WRCC) data to extend full range of dates of fire history (1960-2003)
- Compiled Palmer Drought Severity Index (PDSI) data for study areas into spreadsheet

Results
Because data collection was not initiated until 2007 and no data analyses have yet been compiled, no results are reported here.

Plans for Continuation
In 2008, we plan to complete the data analysis and report preparation. To investigate the probability of future regional fire years in sagebrush steppe in response to changes in climate, six hypothetical scenarios are currently being used, where each scenario is simulated as a departure from baseline mean temperature and precipitation. These six scenarios were derived using three downscaled general circulation models and the Intergovernmental Panel on Climate Change A2 and B1 scenarios, which simulate the upper and lower limits of projected greenhouse gasses, respectively. The probabilities of future regional fire years in sagebrush steppe under different climate scenarios are being examined.

Publications, Theses, Reports, etc.
No publications have resulted from this research at this time. We anticipate completion of M.S. thesis during this current year

9.5 Minimizing Risk of Cheatgrass Invasion and Dominance at the Idaho National Laboratory Site

Investigators and Affiliations
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Robert S. Nowak, Professor, Department of Natural Resources and Environmental Science, University of Nevada, Reno, Nevada

Kimberly G. Allcock, Postdoctoral Associate, Department of Natural Resources and Environmental Science, University of Nevada, Reno, Nevada
**Funding Sources**
U.S. Department of Energy Idaho Operations Office
Nevada Arid Rangeland Initiative and the Nevada Agricultural Experiment Station

**Background**
Predicting plant community susceptibility to invasion by introduced species and determining mechanisms of resistance are fundamental concerns of ecology and ecosystem management. In the Great Basin, the invasive annual cheatgrass (*Bromus tectorum*) was introduced in the late 1800s and by the 1990s has grown to dominate more than 3 million acres, with another 14 million acres heavily infested and 60 million acres considered at risk for potential domination (Pellant and Hall 1994). However, the eastern portion of the Snake River Plain, including the INL Site, has largely escaped the cheatgrass dominance found in the western portions of the Snake River Plain and in northern and central Nevada.

There are several characteristics of the eastern Snake River Plain that might contribute to the relatively minor extent of cheatgrass invasion. The maintained cover of native species may make the vegetation of the INL Site resistant to invasion (Anderson and Inouye 2001). INL Site has a markedly different landscape disturbance history than more heavily cheatgrass invaded sites. Climate variables, such as colder winter temperatures and more late spring precipitation on the eastern Snake River Plains also differ from most cheatgrass dominated areas. The relatively minor extent of cheatgrass invasion at the INL Site in comparison with surrounding areas provides an exciting and unique opportunity to identify environmental conditions, community characteristics or management practices conferring ecosystem resistance to invasion.

**Objectives**
The goal of this project is to use a combination of field surveys and mechanistic hypothesis driven greenhouse experiments to tease out the influences of environment, plant community, and land management on cheatgrass invasion success.

**Comparative Surveys.** We are conducting comparative surveys along a latitudinal climatic gradient from central Nevada, where cheatgrass dominated much of the landscape, to INL Site. We are establishing sampling plots at several hundred locations along this ‘mega-transect’ taking care to adequately sample sites with different types of disturbance legacies, management histories, vegetation composition, temperature and precipitation regimes. We will continue to sample intensively at the INL Site; at sites near INL Site which are climatically similar but with different land use and disturbance histories; and at sites in both northern and central Nevada with a range of disturbance, community composition and climatic variables. We are collecting information ranging in scale from microscopic (soil nutrients and microbes) to community (vegetation and animal) to landscape (climate and land use patterns) to parameterize a structural equation model (SEM) (Grace 2006) and specifically test hypotheses about how site characteristics affect invasion success of cheatgrass.
SEM is a powerful statistical way to infer causality: specifically, we are using it to determine why cheatgrass is more abundant in certain locations and less in others. An additional benefit of SEM is that we can include variables based on ‘expert opinion’ rather than relying on strictly empirical data. This means we can include a wealth of invaluable information that would not be otherwise useable in a more traditional quantitative model.

**Controlled Greenhouse Studies.** We are using controlled-environment experiments that involve individual species and constructed communities to establish a mechanistic understanding of competition between cheatgrass and native species. We are investigating competitive relationships, effects of diversity, density and disturbance and response to variation in water regime (timing and pulse size). Preliminary single-species trials indicate that cheatgrass and perennial species differ in their abilities to respond to water pulses depending on size and frequency of water events, and that moisture at the right time in the life cycles of cheatgrass could promote high competitive ability and possible invasion (K. Allcock, unpublished data). A mesocosm experiment is currently underway to test the interactions of precipitation timing and community composition in determining invasion success.

**Accomplishments Through 2007**

**Comparative Surveys.** The GIS data collected in 2006 was used to help identify potential sampling points. For our sites at INL Site, we selected areas with a diversity of vegetation type and fire history. In June 2007, we visited INL Site and sampled our first 100 sites. We measured several plant community characteristics, signs of disturbance and physical environment variables. Soil samples were collected and analyzed for soil nutrients, texture, seed bank and soil food web dynamics. In October 2007, we returned to INL Site and inserted resin capsules into the soil. These capsules will collect soil nutrients over the winter. We will collect the resin capsules when we return to INL Site in spring 2008. It is our hope that these resin capsules will decrease the amount of lab work required to characterize soil nutrients as well as provide a time integrated measure of soil nutrient availability.

In November 2007, over 150 field sites in Nevada were identified, visited and resin capsules inserted. Our Nevada sites are in two areas, one is located outside Midas in northwestern Nevada and the other about 40 miles north of Austin in the central part of the state. These sites offer a huge variation in land use patterns, fire history, vegetation types and climate variables.

The data collected is being processed and used for model building and method refinement.

**Controlled Greenhouse Studies.** In late 2006 and early 2007, we established a series of two-species plant communities in 50-gallon barrels on the University of Nevada Reno. These communities were comprised of combinations of early-season native species (*Poa secunda*, *Achnatherium hymenoides* or *Elymus elemoides*), late-season native species (*Pseudoroegneria spicata*, *Acnatherium thurberii* or *Hesperostipa comata*), or one of each group. All plants were collected from the wild and transplanted to our constructed communities. One fourth of the barrels were not planted with any perennial species. All barrels were seeded with cheatgrass at a rate of 2000 seeds per m². Each of these communities (early, late, mixed, or no perennials) was then subjected to either elevated total precipitation (150 percent normal precipitation for Reno, Nevada) or ambient total precipitation
(equal to the amount of precipitation received through the growing season in Reno, Nevada). Finally, this ‘precipitation’ was either all distributed evenly through the course of the experiment (watered uniformly once per week) or 50 percent of the total precipitation amount was distributed evenly and the other 50 percent was applied in three randomly-timed ‘storm events’ in which barrels received 1/6 of the total allotted water volume for that treatment over the course of three days. We had six replicates of each community type, water amount, and water distribution combination, giving a total of 96 barrels.

Substantial mortality of transplanted perennials in the constructed communities in early 2007 meant that many plants had to be replaced at the beginning of the 2007 growing season (March-April 2007), so we delayed implementation of our experimental treatments until June 2007 in order to allow the replaced plants to establish. Watering treatments continued through November 2007, and final harvest occurred in December 2007. At the time of harvest we recorded density of cheatgrass, and clipped above-ground biomass, sorted by species. Samples are currently being oven-dried and weighed.

Results

Comparative Survey. We only have data from 100 of the anticipated 500+ sites in the comparative survey and are still processing the samples and data. Thus, preliminary results are not yet available.

Controlled Greenhouse Studies. We are processing the above-ground biomass samples collected in December 2007. While the data are not yet ready to analyze, it appears that the ambient-amount, irregular-distribution watering regime caused some stress to both cheatgrass and perennial transplants, with fewer cheatgrass plants germinating and emerging, and several perennial transplants dying. The higher-precipitation treatments fared better. Emergence of cheatgrass in the high-precipitation, irregular-distribution treatment was initially low, but increased dramatically after the first ‘storm event’. There did not appear to be any obvious visual effect of the planted species on cheatgrass density or biomass. There was no effect of planted species on soil water content (as measured by time domain reflectometry, [TDR]) in the top 10 cm of soil, and minimal effect of the watering treatments on surface soil water content 24 hours after the water pulses were applied.

Plans for Continuation

This project will continue through 2010. We will continue collecting field data for the comparative survey at INL Site and our other field sites in 2008 and 2009. A select number of sites at INL Site will be followed year to year; however, most sites for the comparative survey will only be visited once. SEMs require a large number of data points in order for the algorithms used to identify reliable parameter values (Tanaka 1987), and we plan on sampling approximately 500 sites through the course of this study.

Publications, Reports, Theses, etc.

We anticipate several peer reviewed publication and conference proceedings on varied topics (such as, but not limited to: the effects of soil microbial community on cheatgrass success, the effects of soil surface morphology on cheatgrass germination and the effects of varied precipitation regime on cheatgrass competitive ability), in addition to the Ph.D. dissertation to be completed by Lora Perkins in 2009.
9.6 Development and Evaluation of a Monitoring Program for Pygmy Rabbits

**Investigator and Affiliations**
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Janet Rachlow, Professor, Department of Conservation of Natural Resources, University of Idaho, Moscow, Idaho

Christopher Jenkins, Conservation Scientist, North American Program, Wildlife Conservation Society, Bozeman, Montana

**Funding Sources**
United States Department of Energy, Idaho Operations Office

Idaho Bureau of Land Management Challenge Cost Share Program (with Idaho Department of Fish and Game)

**Background**
The recent petition for Endangered Species Act (ESA) listing for pygmy rabbits was, in part, based on a perceived decline in the species, however, data to evaluate this supposition are not available. Efforts during the past 2-3 years have documented numerous new occurrences of the species in Idaho, which have helped to fill out the statewide distribution of pygmy rabbits. However, it is not known if populations of pygmy rabbits fluctuate or cycle, as documented in other lagomorphs, and some observations suggest that populations may shift across a landscape over time. Therefore, an understanding of population trends over time requires information on changes in both abundance and distribution. This work addresses the first of these population criteria.

Monitoring burrow systems over the past six years in the Lemhi Valley has documented marked fluctuations in density of active burrows, which likely reflect fluctuations in population density of rabbits. Although burrow entrance counts are commonly used to estimate population abundance for semi-fossorial mammals, this relationship has not been evaluated for pygmy rabbits. Therefore this work will investigate the link between density of burrow systems and density of rabbits, and this information will be used to evaluate an index of rabbit abundance that could be employed by wildlife biologists to monitor changes in abundance of pygmy rabbit populations over time.

**Objectives**
The purpose of this research is to develop a standardized method to monitor abundance of pygmy rabbits and to gain an understanding of how pygmy rabbits affect their habitat. Specific objectives are to:

- Calibrate an index of abundance based on burrow systems by correlating the index with estimates of population density;
- Evaluate factors that affect the probability of detection during mark-resight exercises;
• Design standardized protocols for monitoring abundance; and,
• Evaluate the effect of pygmy rabbits on sagebrush shrubs around burrow systems

**Accomplishments Through 2007**

**Project Design.** Three sites were delineated for 2007 field work: two sites in the Lemhi Valley and one site at the INL Site. A census of all burrow systems and mark-resight exercises were completed at all three study sites. Census of burrow systems provide an evaluation of the density and activity status of rabbit burrows, and mark-resight exercises provide an estimate of abundance of rabbits. A second method for estimating abundance of rabbits based on observations of tracks at burrow systems immediately following snow fall will continue through the winter. Mark-resight and snow-track techniques will be used to evaluate and calibrate an index of abundance based on burrow systems.

**Burrow Censuses.** A complete census of burrow systems was conducted at two sites in the Lemhi Valley (Cedar Gulch and Rocky Canyon) and on one site on the INL Site (Atomic City). For each burrow system, global positioning system (GPS) locations and the number of burrow entrances were recorded, pellets were collected at a random selection of active burrow systems for species confirmation, and each system classified based on sign/activity as described by Roberts (2001).

As expected, systematic censuses in the Lemhi Valley and on the INL Site indicate a difference in the number of burrow systems in each activity class and the density of burrow systems on each of the 3 study areas. Cedar Gulch had the lowest total number of burrow systems (131) and the lowest density of burrow systems, while Rocky Canyon had the largest number of burrow systems (505) and the highest density burrow systems. Atomic City fell in the middle with 449 total burrow systems (Figure 9-6).

**Trapping and Radio-collaring.** Trapping was conducted from 4-14 days on the 3 study sites. At sites in the Lemhi Valley a visual search and chase technique was the sole method used to capture animals; however, due to low success of this technique on the INL Site other methods were employed. Additional techniques used were: drift fences, spotlighting, and placing traps in active locations during daylight hours. Captured animals were fitted with 4.2 g radio transmitters (Holohil Inc., Toronto), PIT tags were implanted, and standard mammalian measurements were collected (weight, hind foot, ear length).

Trapping in the Lemhi Valley was conducted for approximately 12 days between the two study areas. On Cedar Gulch, 13 animals were fitted with radio-collars (5 males, 8 females) and on Rocky Canyon 14 animals were collared (6 males, 8 females). The day after capture we located rabbits to visually check collar fit.

Trapping effort at Atomic City yielded only one animal captured. The visual technique used in the Lemhi Valley proved to be inefficient, and therefore other techniques were attempted. We set Tomahawk and Havahart traps at sites of active sign. Traps were set at sunrise and baited with apples, carrots or green beans, and checked at sunset. After several days without success, we constructed four drift fences (Burak 2006, Faulhaber et al. 2005) and placed them in areas where we had spotted rabbits previously. Traps were placed along the fences. Drift fences proved to be
unsuccessful, but with some improvement might be a useful method in the future. The one rabbit that was successfully trapped (male) was caught by the visual technique, and remained in the same complex of burrows it was captured.

**Mark-resight Work.** Upon completion of trapping events, mark-resight surveys commenced. Animals were resighted by using maps and GPS to navigate to all burrow systems categorized as “active” or “recently active” during the previous burrow censuses. Using this technique allowed us to maximize resight probabilities of all animals. In the Lemhi Valley resight occasions were rotated every other day.
between Rocky Canyon and Cedar Gulch, for five resight days on Rocky Canyon and six resight days on Cedar Gulch. On the INL Site, resight events were conducted every day for five resight occasions.

Mark-resight surveys in the Lemhi Valley yielded a total of 25 collared and 44 uncollared rabbit sightings on Cedar Gulch over 6 days, and 25 collared, 22 uncollared rabbits on Rocky Canyon over five days. On several occasions one or two rabbits were documented offsite at both Rocky Canyon and Cedar Gulch, and thus were not available for resight (Table 9-1).

Mark-resight surveys at Atomic City yielded 10 sightings of rabbits over five occasions. The collared rabbit was observed three out of five occasions and a total of seven uncollared rabbits were recorded (Table 9-1). This information represents a preliminary summary. The mark-resight data will be analyzed using Program MARK to estimate numbers of rabbits using each site. Observations at Atomic City suggest that more burrow systems are used per rabbit at Atomic City where sagebrush appears much more continuous than in the Lemhi Valley. An understanding of factors that influence the relationship between rabbits and burrows is essential for developing an index based on burrow systems. To this end, we will be conducting vegetation measurements at each site.

**Plans for Continuation**

In 2008, we plan to conduct snow-track surveys as weather permits on the three established study areas. We also plan to establish further study sites on the INL Site, in the Lemhi Valley, and possibly Camas Prairie. Burrow censuses, mark-resight, and snow-track surveys will continue to be used in order to develop an index of rabbit abundance based on burrow systems. Additionally, vegetation analysis will be conducted over the summer months at the Lemhi sites to gain an understanding of pygmy rabbit use and impact on vegetation around their burrow systems.

### Table 9-1. Summary of Results from Mark-resight Surveys on 3 Study Sites. Cedar Gulch (CG) had the largest number of resights, followed by Rocky Canyon (RC), then Atomic City (AT).

<table>
<thead>
<tr>
<th>Study Area</th>
<th># collared</th>
<th># uncollared</th>
<th># offsite</th>
<th># Collared On-site</th>
<th>Total resights</th>
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<td>CG</td>
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<td>13-14</td>
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9.7 Landscape Genetics of Great Basin Rattlesnakes, *Crotalus Oreganus Lutosus*, on the Upper Snake River Plain

**Investigators and Affiliations**
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**Funding Sources**
U.S. Department of Energy Idaho Operations Office

Idaho State University Molecular Core Research Facility Seed Grant

**Background**
This project will model how landscape characteristics affect gene flow and population structure in Great Basin rattlesnakes, *Crotalus oreganus lutosus*. Over the last three decades, a significant body of baseline data has been amassed addressing various aspects of Great Basin rattlesnake ecology on the INL Site, through efforts of an 18 year reptile monitoring project funded by the Department of Energy, and various theses completed by students of Idaho State University’s Herpetology Laboratory. Although data exists on population size dynamics, reproduction, neonate survivorship, and disturbance effects, there has yet to be genetic component to this ongoing research. Genetic distance data can effectively ascertain landscape features influencing movement patterns and gene flow among sampling locations of animals (Bushar et al. 1998). The field of landscape genetics, made possible by GIS and microsatellite DNA imaging technologies, attempts to correlate habitat heterogeneity with patterns of gene flow and population structure (Manel et al., 2003, Storfer et al., 2006). This type of analysis is valuable for understanding the interplay between rattlesnake ecology and their physical environment, as well as lending insights to ways of avoiding the deleterious effects of habitat fragmentation, reproductive isolation, and genetic drift on genetic variability and population viability of snake species (Bushar et al. 1998).

**Objectives**
- To understand how landscape characteristics influence genetic connectivity among populations of Great Basin rattlesnakes from over-wintering sites (dens) in the shrub-steppe ecosystem of the Upper Snake River Plain in eastern Idaho.
- To understand the effects of natural and anthropogenically altered landscapes on gene flow among rattlesnake populations.
Accomplishments Through 2007
- 243 rattlesnakes from 13 geographically distinct denning locations have been captured and had a tissue sample collected for subsequent DNA analysis.
- DNA has been extracted from individuals captured at 10 geographically distinct denning locations.
- Of 17 potential microsatellite loci developed for genotyping use in other species of rattlesnake, six loci have been successfully amplified and used to genotype 180 Great Basin rattlesnakes.
- Digital geospatial data files for cover type, soils, geology, elevation, grazing, infrastructure, landownership, and burn status on the INL Site and surrounding BLM managed lands have been compiled and incorporated into a GIS.

Results
Initial results have shown that population genetic sub-structuring is highly likely among the rattlesnake dens on the INL Site, but are not reported due to insufficient sample size used in this preliminary analysis.

Plans for Continuation
- In-depth statistical analysis of genotype data will be performed.
- ArcMap will be used to make correlations between molecular and geospatial data to determine how landscape attributes affect gene flow and population connectively among the Great Basin rattlesnake dens on the INL Site.

Publications, Theses, Reports, etc.
Thesis research will be completed December 2008, and submitted for publication early 2009.

9.8 Modeling and Mapping Reptile Distributions on the Idaho National Laboratory Site

Investigators and Affiliations
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Funding Sources

Idaho State University, teaching assistantship.

Background
This study was designed for the purpose of understanding factors affecting reptile distribution and to make predictive distribution maps for individual species across the development zone (central 259 km²) of the INL Site. This information will be used to help develop the conservation management
plan for the INL Site, which will help the Department of Energy make decisions about future facility locations.

**Objectives**
The main objective of this project is to assist in development of a conservation management plan that will be used for future facility siting decisions: Specific objectives for the 2007 season included:

- Develop and apply a habitat-based sampling design for reptiles
- Determine the occurrence, distribution, and habitat relationships of reptiles on the development zone
- Develop a habitat model for each reptile species in the development zone
- Make and test predicted distribution maps.

**Accomplishments Through 2007**
Reptile data collection was completed and modeling procedures for six reptile species on the INL Site were developed. Three distribution modeling techniques were also completed: 1) Boolean Modeling, 2) Trapping and observational probability modeling, and 3) Mahalanobis Distance Modeling.

**Results**
- Incidental observation was the sampling technique that provided most reptile observations. However, skinks were not detected using this method.
- Visual Encounter Surveys produced the second highest number of reptile observations. All six species were detected.
- Trapping detected all species but in few numbers. However, the use of traps was required to sample for night snakes, which potentially occur in the study area.

**Distribution Modeling.** *Boolean Model.* Uses all positive data to determine in which environmental types each species occurs, then map all suitable environmental type polygons

*Trapping / Observational Probability Model.* Uses all positive and negative trapping and visual encounter survey data to calculate a probability of trapping or observing a particular species in a particular environmental type.

*Mahalanobis Distance Model.* Uses all positive data to create a habitat similarity index based on the characteristics of pixels in the GIS layers for sites where a species of interest is known to occur.

**Model Ranking.** We used our sample sizes, statistical analyses, and knowledge of species ecology to rank each model for each species. We also used this information to determine our relative confidence for the highest ranked model for each species.

**Species Richness**
- The species richness map was made by overlapping all of the boolean distribution model results.
The number of species within the Development Zone varied from 2 to 6.

The area with the highest reptile species richness is located on the southern end of the L shaped corridor where development is most likely to occur.

The highest species richness areas are characterized by big sagebrush and no recent burns.

**Plans for Continuation**
Additional modeling approaches will be tried (e.g., DOMAIN and Maximum Entropy).

**Publications, Theses, Reports, etc.**
Thesis and publications are in progress.

### 9.9 Plant Community Classification and Mapping at the Idaho National Laboratory Site

**Investigators and Affiliations**
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**Funding Sources**
United States Department of Energy, Idaho Operations Office

**Background**
Accurate classification and mapping of vegetation communities have become increasingly important tools for conservation management. By understanding the distribution and condition of plant communities on a landscape, a number of conservation goals can more easily be met including:

- Determining which community types are intrinsically rare or have been severely degraded
- Identifying the best remaining occurrences of natural communities across their geographic ranges
- Development of habitat suitability models for predicting species occurrences, and
- Classifying areas for their importance in conservation management planning.

Previous vegetation maps of the INL Site are inadequate to serve these conservation management planning goals because they are outdated. The most recent effort was almost twenty years ago and does not capture important changes that have occurred since that time including fires, sagebrush die-off and invasion by non-native plants. Also, methodologies for vegetation classification and mapping have been refined and standardized since those earlier maps and will allow for continuity between classification on the INL Site and on neighboring lands managed by other agencies. Among others,
those standards include the U.S. National Vegetation Classification System (USNVC) and the Federal Geographic Data Committee spatial data transfer and metadata standards.

Understanding the distribution and condition of plant communities on the INL Site will support the Conservation Management Plan through habitat mapping, development of Habitat Suitability Indices and will help to focus surveys for sensitive species. Additional benefits to land management at the INL Site include guiding revegetation and weed management efforts, increasing the efficiency of assessing environmental impacts and siting plots for research, and inventory and monitoring activities. It will also serve as an important background database for research on the National Environmental Research Park.

**Objectives**

The overall goal of vegetation community classification and mapping is to assess the distribution of plant communities on the INL Site. Specific objectives are to:

- Determine the community types present on the INL Site
- Determine the distribution of those community types on the landscape, and
- Conduct an accuracy assessment of the resulting map.

The approach planned includes two parallel processes (plant community classification and delineating mapping units) that are brought together in the final step to produce the map.

The plant community classification process includes collection of new field data from many locations representing distinct community types. The final classifications will be based on these field data analyzed using ordination and cluster analysis. These results will then be cross-walked to the USNVC vegetation associations.

The delineation and mapping process begins by collecting new color-infrared aerial imagery in a digital format. That imagery is then processed using image analysis software and other techniques to define areas of similarity in the imagery.

The next step will be to bring these two processes together by linking the community classifications to the mapping units derived from the aerial imagery. It is important to note that in some cases there may be more than one association linked to a single mapping unit and vice-versa. This allows for a consideration of vegetation associations that occur as a mosaic at a finer scale than can be delineated using this process.

Finally, we will conduct an accuracy assessment by selecting sites from the new map and collecting field data at those sites. The final products will include a report describing the plant community classes existing on the INL Site and a GIS database of plant communities on the INL Site at multiple geographic scales suitable for use with the Conservation Management Plan.
**Accomplishments through 2007**
The only activity scheduled in 2007 was the collection of new aerial imagery. Due to the extremely dry conditions across the INL Site this spring, the originally scheduled image acquisition was cancelled and postponed until spring of 2008. Following a few days of heavy consistent rainfall in June, we visited representative vegetation communities across the INL Site and determined that the influx of moisture resulted in a response in the vegetation that would likely assist with image classifications. On June 15, color-infrared digital imagery was collected at 1 m ground sample distance across the entire INL Site.

We began Quality Assurance/Quality Control (QA/QC) assessments of the imagery to determine that it met our data quality requirements. Following the initial spatial accuracy assessment, the imagery appears to have about 1 m or less horizontal accuracy.

**Results**
Because the project is in the initial data collection phase, results are not yet ready to be reported.

**Plans for Continuation**
In 2008, we plan to begin the two major efforts of classification and delineation. Using pre-existing data a preliminary vegetation community classification, necessary for the field data collection, is expected to be completed in May 2008. Field data collection is expected to occur in June, July, and August of 2008. Data analysis to define community classification is expected to begin in the fall of 2008.

The delineation effort is expected to start in the spring of 2008 and should be completed by spring 2009. Further refinements and additional delineations may occur following the accuracy assessment to produce the final map.

Linking the plant community classification to the delineated map is expected to occur in winter of 2009 with field accuracy assessments to occur in spring and summer of 2009. The final report and project completion is expected in 2010.

**Publications, Reports, Theses, etc.**
Because the project has just begun, no publications or reports have been produced.

### 9.10 Long-Term Vegetation Transects

**Investigators and Affiliations**
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Background

The Long-Term Vegetation (LTV) Transects and associated permanent vegetation plots (Figure 9-7) were established at the Arco Reactor Test Site, now the INL Site, in 1950 for the purpose of assessing the impacts of nuclear energy research and production on surrounding ecosystems (Singlevich et al. 1951). Vegetation abundance data were first collected in 1950 for inclusion in an ecological characterization of the Site. Samples of plant and animal tissues were also collected from these plots and analyzed for radionuclide concentrations on an annual basis for several years. The effort to collect tissue samples was eventually discontinued because the effects of fallout from nuclear reactors were determined to be negligible (Harniss 1968), at least in terms of radionuclide concentrations in the environment. However, collection of vegetation abundance data has continued on a regular basis for nearly sixty years.

The data generated from the LTV Transects comprises one of the oldest, largest, and most comprehensive vegetation data sets for sagebrush steppe ecosystems in North America. Since their establishment, the LTV Transects have been used extensively for various tasks to support the INL Site mission and have been the basis for major milestones in understanding practical and theoretical ecology of sagebrush steppe vegetation dynamics. Applications of the LTV data include:

- Plant community classification and mapping,
- Assessing the effects of drought and livestock grazing,
- Understanding fire history and recovery,
- Characterizing species invasion patterns,
- Testing theories of vegetation succession and change,
- As a basis for habitat suitability modeling for sensitive species,
- Supporting NEPA processes,
- Making appropriate land management recommendations, and
- Developing specific revegetation recommendations.

In addition to the functions listed above, the LTV data set is still used to assess the impacts of energy development on the environment, as was intended in 1950. However, impacts beyond radioactive fallout, such as exotic species invasion, habitat fragmentation, and global climate change are of current interest.
**Objectives**
The eleventh LTV data set was collected during the summer of 2006. Two tasks were undertaken in association with the 2006 data collection. The first task involves a major effort in updating and describing the data archives. The second includes summarization and analysis of the 2006 and all previously collected abundance data.

**Figure 9-7.** Map of the INL with Locations for Permanent LTV Plots Located Along Two Macro-transects.
The last attempt at organizing and archiving the LTV data was completed in the early 1980s. Although care has been taken to format and store data collected since 1983 in a manner consistent with the protocol established at that time, the data archives have become outdated. The software available for archiving and processing data has improved substantially over the past 25 years, necessitating an update of the LTV data files. A considerable amount of the work associated with entry and summary of the 2006 data includes designing and populating a relational database for all of the LTV data from 1950-2006. Additionally, a specific sampling protocol will be developed and a thorough history included for the LTV as part of the reporting effort.

Analyses on the 2006 and previous data can be summarized under two focus areas. The first includes characterizing general plant abundance and community composition trends, similar to analyses described in previous LTV reports. The second group of analyses will concentrate on characterizing patterns of exotic species invasion and determining the effects of invasion on vegetation cover and composition of native plant communities subsequent to invasion.

**Accomplishments Through 2007**
Accomplishments through 2007 include collection of the 2006 data and completion of QA/QC procedures on that data set. The 2006 data were also summarized and formatted for inclusion in a comprehensive database. A specific protocol for use in collecting LTV data was designed and outlined in association with the 2006 data collection effort. A Microsoft Access database was designed to house historical LTV data and to facilitate future data collection, including straightforward processes for updating data tables. The database will also expedite current and future analyses on the complete LTV data set. Incorporation of historical and 2006 LTV data into the database was mostly completed in 2007. Data verification and validation efforts were also completed primarily in 2007. Verification and validation processes were used to ensure the integrity and completeness, as well as to resolve issues associated with taxonomic classifications and scaling, of the historical data set as it was integrated into the new database.

**Results**
The database includes seven raw data and metadata tables. The general structure of the database is depicted in Figure 9-8. The metadata tables include information about plant species on the INL Site and information about each of the permanent plots on the LTV Transects. The species information data table can, and should be used for all future vegetation data collection on the INL Site. It contains standardized information for each vascular plant species documented to occur within or adjacent to the Site boundary. Information contained in the species information table will facilitate summarizing data into functional groups, and allows the definitions of functional groups to be easily changed.

The species information table reconciles species codes traditionally used for data collection on the INL Site with a national standard (USDA, NRCS 2008). This data table can be readily updated in response to changes in taxonomy and contains unique numeric codes for each species so that a species is always identified correctly for summarization in current and historical data sets even though taxonomy and species codes have changed through time.

The plot information data table contains metadata about each permanent plot along the LTV macro-transects and several additional plots sampled in 1957 and 1965, referred to as the century series.
The plot information table contains data about the location and history of each plot including; coordinates, elevation, grazing allotment, plant community classification, soils information, fires, etc. An additional metadata table, the sample frequency table, contains information about the types of data collected and sample periods for collection of each type of data on each plot. The data contained in the sample frequency table is not entirely unique. For example, determining whether all three types of abundance data were collected on a specific plot in a certain year can be accomplished by querying all three abundance data tables. However, running one query against the sample frequency table streamlines the process. The sample frequency table also houses information about sampling details (i.e. only 40 point frames were sampled on plot 36 in 1995 instead of the usual 50 frames). These details are critical for obtaining accurate summary statistics.

The database contains four data tables; three tables are comprised of vegetation abundance data and one includes information about plot photos. The abundance data tables contain density/frequency data, cover data estimated using line interception, and cover data estimated using point interception. The abundance data incorporated into the data tables were left in as raw a form as possible.
possible; however, most of the historical data archives were summarized to some extent, which dictated the level of data summarization used in the actual database. The photograph specifications data table was designed to consolidate data associated with photos taken during LTV data collection efforts including, photo dates, exposure, aperture, camera angle, etc. The photo data was designed such that the record of each photo can include a hyperlink to a digital copy of that photo. Accordingly, all of the historical photos were digitized as part of the update to the LTV archive.

**Plans for Continuation**

Analyses and reporting will be completed for the 2006 LTV data during 2008. Two peer-reviewed publications containing results from the current LTV data set will also be prepared and submitted as time and funding allow.

**9.11 The Protective Cap/Biobarrier Experiment**

**Investigators and Affiliations**

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**Funding Sources**

U.S. Department of Energy Idaho Operations Office

**Background**

Shallow land burial is the most common method for disposing of industrial, municipal, and low-level radioactive waste, but in recent decades it has become apparent that conventional landfill practices are often inadequate to prevent movement of hazardous materials into ground water or biota (Suter et al. 1993, Daniel and Gross 1995, Bowerman and Redente 1998). Most waste repository problems result from hydrologic processes. When wastes are not adequately isolated, water received as precipitation can move through the landfill cover and into the wastes (Nyhan et al. 1990, Nativ 1991). Presences of water may cause plant roots to grow into the waste zone and transport toxic materials to aboveground foliage (Arthur 1982, Hakonson et al. 1992, Bowerman and Redente 1998). Likewise, percolation of water through the waste zone may transport contaminants into ground water (Fisher 1986, Bengtsson et al. 1994).

In semiarid regions, where potential evapotranspiration greatly exceeds precipitation, it is theoretically possible to preclude water from reaching interred wastes by (1) providing a sufficient cap of soil to store precipitation that falls while plants are dormant and (2) establishing sufficient plant cover to deplete soil moisture during the growing season, thereby emptying the reservoir of stored water.
The Protective Cap/Biobarrier Experiment (PCBE) was established in 1993 at the Experimental Field Station, INL Site, to test the efficacy of four protective landfill cap designs. The ultimate goal of the PCBE is to design a low maintenance, cost effective cap that uses local and readily available materials and natural ecosystem processes to isolate interred wastes from water received as precipitation. Four evapotranspiration (ET) cap designs, planted in two vegetation types, under three precipitation regimes have been monitored for soil moisture dynamics, changes in vegetative cover, and plant rooting depth in this replicated field experiment.

**Objectives**

From the time it was constructed, the PCBE has had four primary objectives which include; (1) comparing the hydrologic performance of four ET cap designs, (2) examining the effects of biobarriers on water movement throughout the soil profile of ET caps (3) assessing the performance of alternative ET cap designs under current and future climatic scenarios, and (4) evaluating the performance of ET caps planted with a diverse mix of native species to those planted with a monoculture of crested wheatgrass.

Specific tasks for the PCBE in 2007 included maintenance of the study plots, continuation of the irrigation treatments, and collection of soil moisture and plant cover data. An update to the 2003 PCBE summary report (Anderson and Forman 2003) was finalized in February 2007 (Janzen et al. 2007) which focused upon long-term cap performance. The 2007 report built upon the original objectives by adding four additional objectives; (1) comparing plant cover and soil moisture dynamics from the 1994-2000 study period with the relatively drier 2002-2006 study period, (2) assessing the spatial and temporal stability of total vegetation cover, (3) understanding how vulnerable the native and crested wheatgrass communities are to invasion from neighboring communities, and (4) quantifying the relationship between vegetation cover and ET.

During the 2007 field season collection of finer time-scale vegetation cover measurements and direct transpiration measurements began in order to clarify soil-plant water relationships occurring on the PCBE. Specific objectives for these measurements include: (1) identify the relationship between vegetation cover and ET on plots planted with a native seed mix, (2) determine relative contribution by species to plot ET, and (3) determine if community dynamics have been shaped by either cap design or irrigation treatment.

**Accomplishments Through 2007**

Soil moisture and vegetation cover data from 1994-2006 were analyzed according to the 2007 report objectives listed above and the final report was published in February 2007. A copy of the report, entitled “PCBE Revisited: Long-Term Performance of Alternative Evapotranspiration Caps for Protecting Shallowly Buried Wastes under Variable Precipitation” (Janzen et al. 2007), is available at www.stoller-eser.com.

Two supplemental irrigation treatments were completed on the PCBE in 2007. A summer irrigation treatment was applied in fifty millimeter increments on a biweekly basis beginning in late June and ending in early August; totaling 200 millimeters of irrigation. The fall/spring irrigation application of 200 millimeters was completed during late September and early October. Soil moisture data were
Vegetation cover data were collected throughout the month of July and early August. Fine scale measurements in the form of photographs were taken on a monthly basis for all planted native plots beginning in May and ending in October. Transpiration measurements for selected native species were collected on deep-biobarrier caps receiving both fall/spring irrigation and summer irrigation, and Resource Conservation and Recovery Act (RCRA) cap types receiving summer irrigation at the end of July, August, and early October.

**Results**

Because data collection was initiated in 2007 for the new outlined objectives, limited data analysis has been completed, however, analysis on long-term community dynamics has been completed and results are presented below.

- Vegetative cover in RCRA cap types was generally lower than in all other cap types. Long-term trends in diversity indices do not differ significantly among cap types when data analysis includes all irrigation treatments.
- Vegetative cover and Inverse Simpson’s index was lowest in the ambient treatment than in either of the irrigated treatments. Long-term trends in other diversity indices did not differ significantly among irrigation treatments.
- Species rank abundance was relatively similar among cap types with the exception of the shallow biobarrier cap types which had significantly different species ranks for *Ericameria nauseosus* and *Hedysarum boreale*.
- Species rank abundance varied among irrigation treatments. Plots receiving the ambient treatment generally had a higher species rank for forbs and the lowest species rank for *Agropyron cristatum* than either of the irrigation treatments.

**Plans for Continuation**

During the upcoming growing season we will continue to monitor vegetation cover and soil moisture as we continue to assess long-term alternative ET cap performance. Additionally, we will continue to collect fine scale vegetation cover measurements and direct transpiration measurements throughout the growing season in 2008. The measurements taken during the 2007 and 2008 field seasons will be used to better characterize and quantify the soil-plant water relationships on the PCBE, which will be useful for modeling long-term cap performance, as well as improving cap performance through directed revegetation design.

**Publication, Reports, Theses, etc.**

We anticipate that we will submit two manuscripts to peer reviewed journals in addition to the completion of a M.S. thesis in late 2008 or early 2009.
9.12 Developing a Habitat Selection Model to Predict the Distribution and Abundance of the Sagebrush Defoliator Moth (*Aroga websteri* Clarke)

**Investigators and Affiliations**
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**Funding Sources**
Idaho State University Graduate Student Research and Scholarship Committee

**Background**
Periodic outbreaks of the sagebrush defoliator moth (*Aroga websteri* Clarke [Lepidoptera: Gelechiidae]) can cause widespread damage to rangelands in the western United States. Sagebrush (*Artemisia spp.*) is the exclusive larval host of *A. websteri* and, in high numbers, larvae can kill host plants and reduce the production of foliage and flowering by surviving plants for years. The overall goal of this project is to use habitat data from sagebrush communities in southeastern Idaho to determine which variables (e.g., presence, relative cover, or height of sagebrush species; presence of other plant species; presence of other moth and insect species; land use attributes; or weather conditions) most strongly predict the presence or absence and abundance of *A. websteri*. Development of a predictive model would be a first step toward identifying the locations of potential *A. websteri* outbreaks. A better understanding of the location, timing, and pattern of defoliator outbreaks would allow land managers to better maintain and manage critical sagebrush habitats.

**Objectives**
Specific project objectives for 2007 were to:

- Determine the presence and relative density of *A. websteri* in 45 locations along 3 permanent INL Site Breeding Bird Survey (BBS) transects;
- Use counts of *A. websteri* on sagebrush branches to develop an estimate of *A. websteri* density and to calibrate trap efficiency;
- Characterize vegetation and other habitat attributes at each sampling location;
- Compile and analyze field data.

**Accomplishments Through 2007**
Project accomplishments for 2007 include the following:

- Insect traps were used to sample *A. websteri* in 40 locations along INL Site roads spanning portions of 2 permanent BBS transects;
- An inventory of *A. websteri* on branches collected from sagebrush in each of the 40 trapping locations was completed;
• Plant composition (relative abundance rank), distance from each trap to the nearest sagebrush, height, canopy width (in two compass directions) and distance to nearest neighbor were obtained at each location and non-target insect species captured in the traps were preserved;

• Temperature, precipitation, and wind-speed for all sampling dates were obtained from climatological monitoring stations at the Central Facilities Area (CFA) and the Materials and Fuels Complex (MFC).

Results

• A. websteri was captured in 11 (about 28 percent) of the sampled locations (Figure 9-9). A maximum of three individuals was captured in any location.

• Evidence of A. websteri was also found in sagebrush branches from only eight of the 40 sites (20 percent), which could account for the low numbers captured in traps;

• Although collection of 45 samples along three transects was planned, time constraints and habitat destruction associated with a wildfire that started on July 18, 2007, resulted in the elimination of sampling along the Twin Buttes BBS transect. An unintended consequence was that all sites with more than one sagebrush host species were eliminated.

• A. websteri and other specimens were preserved and are in the process of being sorted and mounted for identification.

Plans for Continuation

• To support an analysis of host-plant composition, sampling in 2008 will be conducted in a sagebrush community with two or more host-species (location to be determined).

• INL Site sites sampled in 2007 will be re-sampled (or sub-sampled) in 2008 to verify low A. websteri densities and to further quantify potential correlations with densities of A. websteri and other insects in grazed and un-grazed habitats.

• Combined data from 2007 and 2008 will be used to develop alternative models to determine which habitat variables (e.g., relative cover or height of sagebrush species, presence of other plant species, presence of other moth and insect species, land use attributes, or weather conditions) most strongly predict the presence or absence and abundance of A. websteri.

Publications, Reports, Etc.

A manuscript documenting project results will be submitted for publication in a peer-reviewed journal in December 2008. Results also will be included as a chapter of my Ph.D. dissertation and will contribute to other integrated presentations and publications on the biology and outbreak dynamics of A. websteri and other insect pests of western rangelands.
Figure 9-9. The Number of *A. websteri* Captured in 2007 at INL Sample Locations.
9.13 Dynamics of Post-wildfire Wind Erosion of Soil in Semiarid Rangelands, Idaho

**Investigators and Affiliations**
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**Funding Sources**
INRA – Inland Northwest Research Alliance
NCALM – National Center for Airborne Laser Mapping
U.S. Department of Defense

**Background**
Aeolian sediment transport is a fundamental geomorphic process that has wide-ranging environmental implications for human and environmental health, ecological functioning at multiple spatial and temporal scales, local and global biogeochemical cycling, and contaminant transport. Aeolian sediment transport is a function of the wind’s ability (impeded by vegetation and terrain) to entrain soil particles, and the soil’s susceptibility to this entrainment. Field-based research on aeolian transport in non-agricultural systems has largely focused on arid landscapes, however semiarid landscapes, and shrublands in particular, exhibit considerable annual fluxes of wind-transported sediment. The addition of fire in semiarid landscapes can generate locations that are susceptible to substantial, locally recurring wind erosion.

**Objectives**
The overall goal of our research is to determine and describe wildland fire effects on wind erosion potential of shrub steppe in southeastern Idaho. The specific objective for our research at the INL Site is to identify hydroclimatological and vegetation controls on post-fire wind erosion potential.

**Accomplishments Through 2007**
We have monitored saltation, aeolian threshold wind velocity, aeolian sediment flux, and soil loss and deposition at the East Butte Fire, Moonshiner Fire, and an adjacent control site since September 2007.

We have submitted an abstract with our results on hydroclimatological controls on post-fire wind erosion to the International Grasslands Congress (IGC) in Huhot, China (July 2008). We are preparing a manuscript based on the hydroclimatological results submitted to IGC. NCALM collected a lidar data set for our INL Site study area in November 2007. We will use this data to investigate vegetation controls on post-fire wind erosion potential.
Results
Little saltation activity was detected and threshold could not be assessed at the unburned site. Threshold increased during the course of the study at the burned site (Figure 9-10a), suggesting that erodibility was highest immediately following fire and decreased throughout fall. Water, temperature, and relative humidity (Figure 9-10b, c, and d) were moderately-strongly correlated with threshold (Pearson’s correlation = 0.70, -0.68, 0.76, respectively, all p < 0.00). A multiple regression model with relative humidity and water as predictors explained substantial variability in threshold (threshold = 6.92 * 0.02 relative humidity * 0.10 water, r² = 0.75, p-values < 0.00).

Preliminary findings from this study suggest that wildland fire has the potential to increase wind erosion susceptibility in the semiarid rangeland environment we studied. Erodibility, as measured by daily mean threshold wind speed, appeared to be highest in the weeks immediately following fire. Both subsurface hydrology and boundary layer atmospheric conditions appear to be major controls on the dynamics of post-fire wind erosion.

Plans for Continuation
We intend to continue our monitoring work through at least fall/winter 2008.

Figure 9-10. Daily Mean Threshold, Soil Water Content, Relative Humidity, and Air Temperature for Erosion Events Occurring After Summer Wildfire.
9.36 INL Site Environmental Report

Publications, Theses, Reports, etc.
We have submitted an abstract with our results on hydroclimatological controls on post-fire wind erosion to the IGC in Huhot, China (July 2008). We are preparing a manuscript based on the hydroclimatological results submitted to IGC.


Investigators and Affiliations
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Accomplishments
This research was conducted as part of a doctoral program and has been completed

Dissertation Abstract
Creeping environmental changes are impacting some of the largest remaining intact parcels of sagebrush steppe ecosystems in the western United States, creating major problems for land managers. The INL Site, located in southeastern Idaho, is part of the sagebrush steppe ecosystem, one of the largest ecosystems on the continent. Scientists at the INL Site and the University of Idaho have integrated existing field and remotely sensed data with geographic information systems technology to analyze how recent fires on the INL Site have influenced the current distribution of terrestrial vegetation. Three vegetation mapping and classification systems were used to evaluate the changes in vegetation caused by fires between 1994 and 2003. Approximately 24 percent of the sagebrush steppe community on the INL Site was altered by fire, mostly over a 5-year period. There were notable differences between methods, especially for juniper woodland and grasslands. The Anderson system (Anderson et al. 1996) was superior for representing the landscape because it includes playa/bare ground/disturbed area and sagebrush steppe on lava as vegetation categories. This study found that assessing existing data sets is useful for quantifying fire impacts and should be helpful in future fire and land use planning. The evaluation identified that data from remote
sensing technologies is not currently of sufficient quality to assess the percentage of cover. To fill this need, an approach was designed using both helicopter and fixed wing unmanned aerial vehicles (UAVs) and image processing software to evaluate six cover types on field plots located on the INL Site. The helicopter UAV provided the best system compared against field sampling, but is more dangerous and has spatial coverage limitations. It was reasonably accurate for dead shrubs and was very good in assessing percentage of bare ground, litter and grasses; accuracy for litter and shrubs is questionable. The fixed wing system proved to be feasible and can collect imagery for very large areas in a short period of time. It was accurate for bare ground and grasses. Both UAV systems have limitations, but these will be reduced as the technology advances. In both cases, the UAV systems collected data at a much faster rate than possible on the ground. The study concluded that improvements in automating the image processing efforts would greatly improve use of the technology. In the near future, UAV technology may revolutionize rangeland monitoring in the same way GPS have affected navigation while conducting field activities.

9.15 Meteorological Research at the Idaho National Laboratory Site Improved Atmospheric Dispersion Modeling for the Idaho National Laboratory Site

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Funding Sources
U.S. Department of Energy Idaho Operations Office

National Oceanic and Atmospheric Administration, Air Resources Laboratory

Background
The Field Research Division of the National Oceanic and Atmospheric Administration Air Resources Laboratory (NOAA ARL-FRD) provides meteorological support to the INL Site. This includes maintaining the INL Site meteorological tower network (the INL Site Mesonet) and running atmospheric dispersion models for emergency response applications. For many years NOAA ARL-FRD has used a locally developed dispersion model called MDIFF to simulate potential hazardous releases from INL Site facilities. However, MDIFF has not been significantly upgraded in many years and is showing its age. Both INL Site and NOAA staff have requested new modeling capabilities that are not present in MDIFF. While MDIFF could in principal be upgraded, it is more cost effective to adopt a newer model that already has many of the requested capabilities.

The NOAA Air Resources Laboratory already has an advanced dispersion model called HYSPLIT that contains many of the features that have been requested for future INL Site applications. HYSPLIT is used operationally within NOAA for various applications including smoke forecasting from wildfires and forecasting the movement of ash plumes from volcanic eruptions. It is also used by the National Weather Service to produce plume forecasts for toxic releases.
NOAA ARL-FRD recommended several years ago that HYSPLIT be adopted for INL Site use, but funding restraints did not allow any efforts along these lines until 2007. Adoption of HYSPLIT benefits both INL Site and NOAA as a whole. INL Site benefits because HYSPLIT is a more modern model with new modeling and display capabilities. Unlike MDIFF, HYSPLIT also has broad support within NOAA, so the limited resources available locally can be leveraged through interactions with the broader HYSPLIT community within NOAA. The benefit to NOAA is that any improvements to HYSPLIT made for INL Site applications can feed back to the wider HYSPLIT community.

**Objectives**

The objectives of this work are to

- Transition INL Site dispersion modeling from MDIFF to HYSPLIT
- Develop more realistic wind fields that account for the local topography and changes in the wind with height
- Improve the dispersion model output so it is more useful to decision makers in the INL Site Emergency Operations Center
- Provide capability to forecast future plume movements using gridded atmospheric models
- Develop release scenarios for INL Site facilities that are compatible with the HYSPLIT model inputs

**Accomplishments Through 2007**

Many of the capabilities required for using HYSPLIT at INL Site actually coincide with the needs of other HYSPLIT users within NOAA. NOAA ARL-FRD has therefore collaborated with these other groups in adding many features. These include improving the model output so that it more useful for decision makers and adding a chemical database within HYSPLIT that is used in generating contours. Output from the model can be provided in a GIS format that allows it to be layered with other geographical data. A basic radiological dose calculation algorithm has also been added, although it is still undergoing testing.

NOAA ARL-FRD is running a version of the WRF gridded atmospheric weather prediction system with a horizontal grid spacing of 4 km over the INL Site region. The forecast winds from WRF can be used in HYSPLIT to create forecasts of future plume movements.

**Results**

HYSPLIT now has many of the capabilities that are needed for INL Site dispersion modeling. The main obstacle remaining is the development of a realistic three-dimensional wind field based on the INL Site Mesonet data, and this is discussed below.

**Plans for Continuation**

Unlike MDIFF, HYSPLIT requires a three-dimensional wind field that accounts for vertical changes in the winds and for terrain effects. This can already be done using the output from gridded models such as WRF, but it must be remembered that these gridded models are only producing forecast winds and not actual winds. These forecasts can fail just like the models used by the National
Weather Service in producing general weather forecasts. For this reason, it is not advisable to rely solely on forecast model winds when generating plume plots in an emergency-response environment.

NOAA ARL-FRD therefore plans to develop a capability to generate a three-dimensional HYSPLIT wind field based directly on the INL Site Mesonet data. Such a wind field is a “nowcast” rather than a forecast, since it involves current conditions rather than future conditions. MDIFF currently creates two-dimensional nowcasts simply by horizontally interpolating between Mesonet towers. The situation is more complicated with HYSPLIT because of the need to deal with vertical variations in the wind. In addition, it is highly desirable to have the HYSPLIT winds flow realistically over or around terrain obstacles and to obey mass continuity. Simple interpolation does not produce such results. NOAA ARL-FRD is therefore looking at either adopting or developing a so-called diagnostic wind-field model that matches the Mesonet observations as closely as possible while still obeying physical constraints such as terrain blockage and mass continuity. Once such a wind-field model is in place, the transition from MDIFF to HYSPLIT can be initiated.

9.16 Improving INL Wind Forecasting with Cluster Analysis of Wind Patterns

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*Background*
NOAA ARL-FRD has provided INL Site climatology monitoring and specialized weather forecasting such as wind forecasts for nearly 60 years. Understanding wind patterns and forecasting winds are of interest at the INL Site for various applications. Short-term wind forecasts are used during emergency operations to track the potential transport of hazardous substances and in predicting the spread of wildfires. Wind forecasts are also important for the safety of personnel and the efficiency of many routine INL Site activities. For example, some operations at the INL Site can only be conducted when the wind speed remains under specific thresholds. Climatological wind patterns are also one factor that must be considered as part of INL Site’s efforts to ensure it meets regulatory requirements for public safety.

The meteorologists working at NOAA ARL-FRD have long known that a few typical wind patterns recur frequently across the INL Site and the surrounding area. For example, meteorologists have learned to expect northeast, down-valley winds on summer mornings and up-valley, southwesterly flows on summer afternoons. Cluster analysis is one mathematical approach used to identify common patterns in data. A cluster analysis of the NOAA INL Site Mesonet wind observations was completed to better understand the frequent wind patterns and to exploit them in weather forecasting.
This analysis identified eight clusters or typical wind patterns which seem to be well correlated to commonly observed meteorological conditions.

**Objectives**

The main objective of this project is to formally identify recurring wind patterns and create a method to categorize wind fields according to these patterns. Three goals of the project once these clusters are defined are to:

1. Understand how the wind fields evolve over time and obtain a better understanding of the physical processes driving the wind fields.
2. Improve wind forecasting, both short and long term at the INL Site.
3. Investigate whether the wind patterns are correlated with other factors such as precipitation coverage and wildfire frequency.

**Accomplishments Through 2007**

A cluster analysis was conducted using Mesonet data from November 1993 to February 1999 which identified eight wind field clusters. These were further refined by taking all data available from November 1993 to March 2006 and assigning them to clusters and refining the cluster centers. The clusters are numbered from 1 to 8, with 1 being the most common and 8 the least common. A number of statistics for each cluster were calculated including frequency of occurrence by season and time of day, average duration, times when each cluster was most likely to be observed, and the probability of transitions from one cluster to another. The evolution of the clusters has also been studied. A number of software tools have been developed that allow forecasters to examine current and historical wind fields in the context of which cluster they belong to and the expected changes in cluster membership over time.

**Results**

A detailed description of each cluster is beyond the scope of this report. As an example, Figure 9-11 shows the INL Site wind fields representing clusters 1 and 3. The left map shows the most frequent pattern at INL Site, namely a nocturnal drainage flow from the northeast. It is most common during summer nights and early mornings. The right map shows cluster 3, the third most frequent pattern representing moderate up-valley flow. It is often observed during summer afternoons. Overall, the first 5 clusters are more common and are related to normal diurnal trends due to terrain and atmospheric stability conditions. Clusters 6-8 occur less frequently and are associated with large-scale forcing from passing weather systems. People working at INL Site may be somewhat surprised that strong southwest winds are not the most common pattern. However, it must be remembered that most INL Site workers are at the site only during daylight hours, whereas the cluster analysis is based on data from all hours. Also, people usually remember extreme weather events more than the intervening quiescent periods. A more in-depth description of the cluster analysis is found in Clawson et al. (2007).
**Plans for Continuation**

We plan to continue improving our understanding of the physical processes, such as terrain effects, related to each wind cluster. We also plan to improve the cluster forecasting tools. This will allow us to incorporate the clusters into daily forecasting and also to work with the Pocatello National Weather Service in improving short term wind forecasting across SE Idaho and the INL Site.

Eventually we would like to look at whether the clusters are correlated with other spatial factors including precipitation and vegetation distributions and wildfire probability.

**Figure 9-11.** Example INL Site Wind Patterns From Cluster Analysis. The left map shows the most common cluster 1 (northeast flow mostly at night) and the right map is the third most common cluster 3 (moderate southwest flow during the day).
REFERENCES


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House Wren on Nest