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National Environmental Research Parks

MASTER

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U.S. Department of Energy ■ Office of Energy Research ■ Washington, DC 20585

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Acronyms

AEC	Atomic Energy Commission
ALE	Arid Lands Ecology
DOE	Department of Energy
FNAL	Fermi National Accelerator Laboratory
GIS	Geographic Information Systems
INEL	Idaho National Engineering Laboratory
LANL	Los Alamos National Laboratory
NEPA	National Environmental Policy Act
NPDES	National Pollutant Discharge Elimination System
NTS	Nevada Test Site
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
PNL	Pacific Northwest Laboratories
SREL	Savannah River Ecology Laboratory
SRS	Savannah River Site
TLD	thermoluminescent dosimeters
USGS	U.S. Geological Survey

Preface

Seven ecosystem sanctuaries—open to researchers for ecological studies and the general public for environmental education—are the heart of the National Environmental Research Park Program managed by the Department of Energy (DOE). The program was established in the 1970s in response to recommendations from environmental visionaries—citizens, scientists, and members of Congress—to set aside land for ecosystem preservation and study. At that time, DOE's Research Park Program was one of the few formal efforts created to protect land for research and education. The Savannah River Site in South Carolina was designated as the first research park in 1972. Later, DOE named six more sites as research parks, the most recent being the Nevada Test Site in 1992. Over the years, these large protected land holdings became, in some cases, the last remaining refuges of what had once been extensive naturally balanced ecosystems.

For more than 40 years, ecological studies have been conducted in the areas now designated as research parks. The studies provide a unique, but sometimes unrecognized, record of valuable information on both sensitive and robust ecosystems—information that directly addresses national concerns about global environmental change and environmental restoration. The seven research parks are located at DOE facilities and associated with national laboratories whose resident researchers and guest scientists are accustomed to working in

multidisciplinary teams. These teams have a strong record of developing and utilizing advanced technologies and methods for environmental research and using computer resources and infrastructure to establish, maintain, and manage sophisticated environmental databases.

The wealth of environmental information collected in the research parks is now leading to better land-use planning in their respective regions. In addition, scientists are using the research findings to identify sensitive areas within the DOE sites so that restoration, cleanup, and other activities proceed in the manner most compatible with ecosystem protection and management. Researchers and planners with broad-based environmental interests have stimulated the development of data analysis and synthesis into an information system called ParkNet. This network has successfully provided insights on ecosystem trends, gradients, and differences in biodiversity across the seven research parks.

DOE's broad mission is to provide the technical information and the scientific and educational foundation that is necessary to achieve efficiency in energy use, diversity in energy sources, a more productive and competitive economy, a secure national defense, and improved environmental quality. Environmental and ecological research at the seven DOE parks directly supports the last mission goal and indirectly supports the wise development of the other four goals.

This document gives an overview of the events that led to the creation of the research parks. Its main purpose is to summarize key points about each park, including ecological research, geological characteristics, facilities, and available databases. For detailed information on each research park, contact the Park Director whose name and address are given at the beginning of the section describing the park. General information about the DOE National Environmental Research Park Program can be obtained from the—

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Introduction

The National Environmental Research Parks are outdoor laboratories that provide opportunities for environmental studies on protected lands that act as buffers around Department of Energy (DOE) facilities. The research parks are used to evaluate the environmental consequences of energy use and development as well as the strategies to mitigate these effects. They are also used to demonstrate possible environmental and land-use options. The research parks were established by DOE and its predecessors, the Atomic Energy Commission and the Energy Research and Development Administration. The seven parks are administered through the regional DOE Operations Offices and coordinated and guided by the Office of Energy Research through the Office of Health and Environmental Research.

The concept of environmental research parks grew out of the National Environmental Policy Act of 1969, the Energy Reorganization Act of 1974, and the public's desire to protect the environment. The idea is also consistent with the 1969 policy statement of the Federal Council for Science and Technology, encouraging Federal laboratories to make their unique research and training facilities available to a broader spectrum of the scientific community.

The DOE National Environmental Research Parks provide opportunities for many types of environmental studies. The parks are especially convenient because they are associated with the

DOE national laboratories which have a stable infrastructure and a cadre of environmental scientists who are a resource for visiting researchers and the public.

The objectives of the research parks are to conduct research and education activities that will—

- Develop methods for assessing and documenting the environmental consequences of human actions related to energy and weapons use.
- Develop methods for predicting the environmental consequences of ongoing and proposed energy development.
- Explore methods for eliminating or minimizing predicted adverse effects of various energy and weapons activities on the environment.
- Train people in ecological and environmental sciences.
- Use the parks for educating the public on environmental and ecological issues.

The seven DOE National Environmental Research Parks are located within six major ecoregions of the United States (Figure 1). These ecoregions cover more than half of the nation. In some cases the research parks are the only ecological sanctuaries in the region. The parks are especially important because, within their

Figure 1. Department of Energy National Environmental Research Parks and Associated Ecoregions

borders, they provide secure settings for scientists to conduct research on a broad range of subjects, such as plant succession, biomass production, environmental behavior of radionuclides, cost and effectiveness of recolonization of disturbed lands, and thermal effects on freshwater ecosystems. The parks also provide rich environments for training researchers and introducing the public to ecological sciences.

History of the Research Parks

Interest in ecological research evolved after World War II as the United States sought security and safety by producing nuclear weapons in isolated regions surrounded by large buffer zones of undeveloped land. DOE's predecessor, the Atomic Energy Commission (AEC), began to recognize the need to track both radioactive fallout from the testing of nuclear

weapons and inadvertent radioactive releases from nuclear weapons production facilities into the environment and into the human food chain.

As early as 1952, ecological research on radionuclide cycling was under way at the Hanford site and on land surrounding other nuclear weapons facilities. Scientists sought to understand the natural ecosystem and the transport, cycling, and fate of radionuclides and other contaminants in soils, water, and air. Out of the radionuclide research grew pioneering technologies for quantifying the movement both of natural materials such as nutrients and fluids and of introduced pollutants through the ecosystem. In 1967, AEC formally designated a portion of the Hanford site, the Arid Lands Ecology Reserve, as a study area for scientists and educators—2 years before the National Environmental Policy Act directed each Federal agency and department to make environmental protection a part of its mission.

In 1972, AEC established its first research park at the Savannah River Site in South Carolina. The plan for a research park emerged during a formal review of the environmental research activities at Savannah River. The review team, consisting of scientists, representatives from other Federal agencies, and members of the newly formed President's Council on Environmental Quality, found the site well suited for ecological research for several reasons: its security, current knowledge of its environment, and the fact that it offered examples of most major ecosystems in the southeastern United States. Savannah River also illustrated environmental disturbances caused by energy and weapons development, and it had streams and swamps that served as study sites for the fate and effects of pollutants in aquatic ecosystems.

Some of the review team's recommendations shaped the charter that was drawn up for the DOE research parks. The charter appears in the Appendix together with directives for the research parks. Although some priorities have changed since the 1970s and some terms have acquired new meanings, the charter and its directives still address many current environmental concerns and therefore continue to be relevant and appropriate today.

Ecological Research at the DOE Parks

The seven DOE research parks provide ideal settings to study the nature of present and future environmental consequences stemming from the Department's mission. Environmental research and education on these DOE sites include—

- Long-term observations of climate, animal and plant populations, and physical changes—in some cases extending over several decades—to determine successional patterns of biota and soils resulting from energy and weapons activities and natural disturbances such as floods, drought, and fires.
- Research on ecosystem dynamics, contaminant transport, bioremediation, model development, and theory validation, often utilizing the long-term data sets that have been developed.
- Establishment of ParkNet, an interactive network among the seven research parks for cross-site synthesis and analysis, to determine environmental trends and processes across major ecoregions ranging from arid and semiarid desert to tallgrass prairie, deciduous forest, and cypress swamp.

- Education of grade-school and high-school students and the general public about the ecosystem and interactions among humans, plants, animals, and soils at DOE sites.
- Training of undergraduate, graduate, and postdoctoral students and faculty in environmental research related to site-specific, regional, national, and global issues.
- Collaboration and coordination among local, regional, and national public organizations, state and Federal government programs, schools, universities, and private institutes that are concerned with environmental preserves and their appropriate use.

Most of the land on the research parks is undeveloped, with minimal cultivation and almost no human residents; therefore, the parks have always functioned as quasi-natural areas and provided some exceptionally long-term data sets. To take advantage of the long history of research, the available data sets, and the experience of investigators at the parks, several computational and synthesis workshops have been held to analyze and synthesize data across the network of parks. Workshop topics included comparison of population diversity and population dynamics, multiple landscape scales and patterns, paleo-ecological rates of change, and bird population comparisons. Data analysis from the workshop on bird populations demonstrated the value of the research parks as sanctuaries for wild birds in shrub-steppe and grassland ecoregions, where the biodiversity and abundance of populations was much greater on ecosystems located inside the research parks compared with the same ecosystem types located outside.

The parks exhibit differences in biomass and productivity of several orders of magnitude. Therefore, the network approach to analysis is valuable for identifying gradients across geographic regions, as well as differences between ecosystems set aside as refuges and those more open to human use.

FERMILAB

National Environmental
Research Park

- Wetland Protection
- Prairie Development
- Habitat Reclamation
- Soil Development
- Threatened and Endangered Species Conservation

0 Miles 1.25
0 Kilometers 2

■ Fermilab National Environmental
Research Park

□ Water (creeks, drainage)

Fermilab National Environmental Research Park

Park Director

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Location

The National Environmental Research Park at the Fermi National Accelerator Laboratory (FNAL) is located 48 km west of Chicago, IL, in eastern Kane and western Du Page counties. The center of the 2,750-ha park lies at 88°14' West longitude and 41°50' North latitude, and its boundaries are coincident with those of the FNAL site.

Biotic Description and Associated Research

The Fermilab research park is representative of a tallgrass prairie remnant and an oak-hickory parkland. The park's major communities of vegetation and characteristic species include upland and bottomland deciduous forest, oak savanna, the tallgrass prairie remnant and reconstructions (since 1975), pasture, nonnative grasslands, old fields, row-crop agricultural fields, fence rows, urban lawns, marshes and scrubby wetlands, and creeks and ponds.

The primary purpose of FNAL is fundamental research in high energy physics. Because the facility was designed and land use was planned in accordance with the National Environmental Policy Act, FNAL operations have resulted in only minor environmental impacts. Creeks on the research park are occasionally affected by elevated water temperatures because the park's surface water bodies are used for cooling.

As part of a tallgrass prairie reconstruction project, annual plantings at the research park have taken place since 1975. However, the Fermilab park does not have a long history of environmental and ecological research. The land was acquired from private owners in the late 1960s, and the park was added to the DOE network of research parks in 1989. Therefore, environmental and ecological research has only recently begun. Nevertheless, the park's diverse land uses (such as savanna, pasture, old fields, forest, wetlands, creeks, and ponds) and prairie reconstructions make it particularly well suited for fundamentally important studies such as restoration ecology, chronosequencing, agroecosystems, and landscape ecology. Also of interest is the park's introduced bison herd.

Park researchers come primarily from regional colleges and universities, the Chicago Academy of Science, the Morton Arboretum, and nearby Argonne National Laboratory. Current research projects include work on the evolution of plant defenses against herbivory,

plant-soil interactions in prairie ecosystems, small mammal population dynamics, introduction of American hazel into prairie/savanna ecosystems, impacts of white-tailed deer on plant communities, and soil invertebrate communities in early successional prairies. In addition, park personnel have initiated an ambitious project on a 100-ha plot to create a controlled chronosequence of prairie plantings over the next 20 years.

Threatened and Endangered Species Conservation

The Fermilab Prairie Restoration Project, with the associated park woodlands and wetlands, is home to more than 200 species of birds, at least 80 of which nest there regularly. Use of the site by endangered or threatened bird species is common and well documented. In particular, the park is well known as a nesting site of the upland sandpiper, which the state classifies as threatened. The prairie itself, although still in early succession, hosts several threatened species of plants. The management policy of the laboratory is to protect not only the endangered or threatened species already present, but to conserve and protect habitat suitable for rare species.

Physical Description

Elevation and Climate

Most of the Fermilab research park is relatively flat, with elevations ranging from 218 to 244 m above mean sea level. Climate in the research park area is typically continental with cold winters, warm summers, and frequent short-duration fluctuations in temperature, humidity, cloudiness, and wind direction. Monthly average precipitation is generally

lowest in January and February and highest from April through August. Temperature data have not been recorded at the park; however, the annual mean air temperature at nearby Argonne National Laboratory is 8.9°C. July is the warmest month and January is the coldest, with mean monthly air temperatures at 22.4°C and -6.4°C, respectively. A meteorological station was installed and brought into operation in January 1994. This will allow the collection of long-term weather baseline data, including temperature, relative humidity, dew point, precipitation, wind speed and direction, and incident solar radiation. Data will be collected based on hourly, daily, and monthly means and archived in ASCII format on optical discs.

Geology

Bedrock in northern Illinois consists of a Precambrian granite basement (depth 1,225 m) and sedimentary rocks of Cambrian through Pennsylvanian age (depth 18 to 1,225 m). The sedimentary rock units are primarily marine sandstones, shales, dolomites, and limestones that dip gently in a south-southeasterly direction. Because of significant episodes of uplift and erosion between the Silurian and Pennsylvanian Periods and between the Permian and Quaternary Periods, nearly all of the upper Paleozoic rocks (Devonian through Pennsylvanian) and the Cretaceous and Tertiary deposits have been eroded from northeastern Illinois. Thus, the surface bedrock consists of approximately 420-million-year-old Silurian dolomite at depths of 10 to 30 m. Quaternary deposits, which overlie this bedrock, are primarily glacial till, outwash, and lacustrine deposits of Wisconsin age (10,000 to 60,000 years old). Surficial deposits (where present) are generally of loessial silts, lacustrine silts and sands, and alluvial silts and sands. These deposits are about 3 m thick with 30 to 90 cm of loess.

Soils

Most of the soils found within the research park are silt loams and silty clay loams that formed under prairies (Mollisols) or deciduous broadleaf forests (Alfisols). Parent materials for soils were typically thin layers of loess and silty materials over glacial deposits of till, outwash, or lacustrine sediments. Of the 20 soil series found on site, 12 are dark-colored prairie soils, 2 are light-colored forest soils, and 2 are organic soils (Histosols) that developed in depressions and adjacent to water bodies where the water table fluctuates and water-saturated conditions frequently occur. Although classified as Alfisols, the remaining four soil series are moderately dark-colored. They are considered transitional soils because they exhibit the influences of both forest and prairie vegetation. Prairie and transitional soils occur throughout the relatively flat central portion of the research park, whereas forest soils occur primarily with transitional soils on the more rolling topography of the park's northwestern and eastern edges.

In general, the prairie soils have surface horizons that range from slightly acidic to slightly alkaline, with organic matter content ranging from 3 to 7 percent in the plow layer. Surface horizon pH in the forest and transitional soils ranges from moderately acidic to neutral. Organic matter in the plow layer ranges from 2 to 4 percent in the transitional soils to 1 to 3 percent in the forest soils. Most soils found on site have medium subsoil supplies of potassium but relatively low subsoil supplies of phosphorus.

Long-Term Data Sets and Database Information

- Maps, including topographic, aerial photographs, current land use, monitoring sites, and natural areas and land use within 25 km of the research park.
- Climatology data, including precipitation since 1972; meteorological and air quality data for 1979 and 1980; and representative meteorological, air quality, and atmospheric deposition data from Argonne National Laboratory, which is 26 km to the southeast of the research park. Expanded long-term meteorological data collection beginning January 1994 includes temperature, precipitation, relative humidity, wind speed and direction, and incident solar radiation.
- Geology and soil survey data.
- Historic data, including copies of 1839 and 1840 General Land Office surveys of the site, an archaeological survey, and test excavation data.
- Species lists, including plants, fish, amphibians, reptiles, birds, mammals, some insects, and threatened and endangered species.
- Prairie Restoration Project data, including seed mix, burns, and qualitative plant species abundance records. Quantitative data on plant communities beginning in 1992.
- Quantitative characterization of trees and ground layer plants in upland deciduous forest and oak savanna.

- Plant-soil interaction studies of above-ground standing crops and nutrient content; root and rhizome standing crops and nutrient content; root density, internal and external mycorrhizal fungi standing crops; mycorrhizal spore populations; microbial biomass; soil phosphatase; soil chemical and physical characterization; and water-stable soil aggregate size distribution for selected prairie reconstructions, pastures, and cultivated fields.
- Environmental monitoring, including continual long-term monitoring data both for radiation in stack emissions, surface water, sediment, and vegetation and for water quality of drinking water wells and surface water.

Significant Publications

Please contact the Park Director for publications and reports about the Fermilab research park.

Facilities and Accommodations for Cooperative Research

FNAL provides a full range of support resources for visiting researchers. These include mail and telephone message centers, clerical assistance, a travel/transportation office, some onsite housing and housing assistance, food service, first aid and medical assistance, office and working space, library, computing support, publication support, and photography services.

HANFORD

National Environmental
Research Park

- ▶ Comparative Ecological Observations
- ▶ Field Validation of Ecological Theory
- ▶ Environmental Restoration
- ▶ Ecosystem Dynamics
- ▶ Threatened and Endangered Species Conservation

0 Miles 20
0 Kilometers 32

Hanford National Environmental Research Park

Hanford National Environmental Research Park

Park Director

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Location

The National Environmental Research Park at the Pacific Northwest Laboratories (PNL) Hanford Site is located in Benton and Franklin counties in southeastern Washington. The centrally located meteorological station lies at 119°36' West longitude and 46°34' North latitude. The boundaries of the 148,000-ha park, which coincide with those of the Hanford Site, enclose four types of land-use areas: an industrial zone, the Arid Lands Ecology (ALE) Reserve, the U.S. Department of the Interior's Saddle Mountain Wildlife Refuge, and the Washington State wildlife management area.

Biotic Description and Associated Research

The ALE Reserve in the Hanford research park represents the only remaining sizable remnant (312 km²) of a Washington shrub-steppe landscape still in a nearly pristine state of vegetation (Rogers and Rickard, 1988). The

research park's major plant communities and characteristic species include sagebrush-bluebunch wheatgrass, sagebrush-sandberg grass, sagebrush-bitterbrush-needle and thread grass, cheatgrass (old fields), and riparian (Columbia River and spring streams) cottonwoods and willows. Local areas may be dominated by the following shrubs: antelope bitterbrush, three-tip sage, gray rabbitbrush, winterfat, roundheaded buckwheat, greasewood, spiny hopsage, stiff sage, and thyme buckwheat. The understory to these shrubs is largely composed of the following grasses: bluebunch wheatgrass, needle and thread grass, sandberg bluegrass, bottlebrush squirrel tail, cheatgrass, prairie June grass, and Indian ricegrass.

Hanford's industrial land-use zone contains nine retired plutonium production reactors, a commercial nuclear reactor, a uranium fuel fabrication facility, chemical separation facilities, and high- and low-level radioactive waste management areas. During the 50 years of Hanford operations, low levels of radionuclides have been released in limited amounts into the ground, ponds, and the Columbia River. These releases have afforded researchers opportunities to follow specific radionuclides into and through many types of ecosystems, thereby gaining insights into the structure and function of these systems.

The ALE Reserve, a 260-km² portion of the Hanford park, was established in 1967 for long-term, intensive ecosystem studies. This reserve has been the focus of more than 25 years of

integrated studies on air, water, and land resources from a regional ecosystem perspective (Rickard et al., 1988). The reserve encompasses a variety of topographic situations, altitudes, soils, and plant communities, each with sufficient area to permit large-scale field experiments on natural and human-induced environmental impacts, including fire, drought, flooding, and restricted contaminant releases. For example, sagebrush-bunchgrass communities have been examined (Rickard and Vaughan, 1988) relative to harsh environmental conditions created by natural stresses (such as wildfire and nutrient and water limitation) as well as anthropogenic disturbances (such as grazing, agriculture, and bioinvasions).

The ALE Reserve also provides opportunities for research on mobile populations of birds, mule deer, elk, coyotes, and other species. Animal communities, including aquatic systems (Cushing and Vaughan, 1988), have been extensively investigated in terms of natural factors and human-induced impacts (Rickard, 1985; Rogers et al., 1988), including biomonitoring to evaluate potential environmental contamination (Cadwell and Fitzner, 1984; Gray and Rickard, 1989). Scientists at the ALE Reserve have also made important contributions to wildlife biology (Eberhardt et al., 1984 and 1989), conservation biology (Rickard and Rogers, 1983; Gray and Rickard, 1989), and landscape ecology (Carlile et al., 1989; Simmons et al., 1992; Cullinan, 1992).

Threatened and Endangered Species Conservation

A number of sensitive plant and animal species found in the Hanford park are listed as endangered or threatened by Washington State or the Federal Government, or are candidates for such listing. Some are listed as monitor species

by the State. The lists include a large number of species: 36 birds, 23 plants, 4 mammals, 2 molluscs, 1 reptile, and several insects. The status of plants and animals under consideration for formal listing by Washington State and the Federal Government can change rapidly. Lists showing the current status of sensitive species are available from the Park Director upon request.

Physical Description

Elevation and Climate

Elevation at the Hanford park ranges from a low of 130 m along the Columbia River to a high of 1,160 m along the crest of the Rattlesnake Hills. The climate is semiarid with hot, dry summers and relatively wet, cold winters. The average monthly precipitation recorded at the meteorological station (223 m elevation) varies from a low of 3.81 mm in July to a high of 23.4 mm in January, with an average annual accumulation of 160 mm. Temperatures range from an average monthly low of -1.5°C in January to a high of 24.6°C in July, with an annual average of 11.7°C .

Geology

The park is underlain by a series of basaltic layers that are part of the Columbia River Tertiary (Miocene) lava field and are more than 11 million years old. The lava is generally level in the valleys and plains, but folded, steeply inclined layers form the canyon walls, benches, terraces, and rocky outcrops. The basalt is often overlain by up to 150 m of unconsolidated materials of loessial, eolian lake-laid, and stream-laid origin that serve as the parent material for soil formation. Age of the unconsolidated material ranges from late Tertiary to Quaternary.

Soils

Surface soils range from silt loams to sand, all of which are generally low in organic matter with nearly neutral pH and exchangeable cations dominated by calcium and magnesium. Mineral particles are mostly sand and silt size with only small percentages of clay-sized particles. The crest of Rattlesnake Mountain, down to approximately 750 m, consists principally of basalt overlain by a 25- to 50-cm layer of loess with numerous rocky outcrops. ALE soils, derived from loess, are usually greater than 150 cm deep. Brown soils, occurring at elevations above 360 m, are underlain by basalt with dark, grayish-brown A horizons and a calcareous horizon below 90 cm. These soils, underlain by reworked lacustrine deposits, extend downslope to 180 m. The soils at lower elevations, derived from lacustrine and stream-laid deposits redistributed by the wind, are principally Regosols, Sierozem-Regosol intergrades, or alluvial soils. The Regosols develop principally in unconsolidated, wind-blown sands, which are usually less than 100 cm deep and underlain by gravelly alluvium. These soils are poorly developed, reflecting the physical and chemical properties of the parent material, although some leaching has occurred. The Sierozem-Regosol intergrade or alluvial soils lie in intermittent stream bottoms and alluvial fans from these streams.

Although finer textured than the Regosols, alluvial soils have weakly developed profiles. They form in recent alluvium that derived from loess and lacustrine sediments.

Long-Term Data Sets and Database Information

- Monthly summaries of data from the meteorological station that have been compiled since 1913.
- Climatological data and soil-water accretion and depletion patterns measured with large weighing lysimeters on ALE.
- Groundwater depths and flow patterns from hundreds of wells on the research park.
- Satellite imagery and aerial photographs of the research park obtained for various special purposes.
- Species lists of vascular plants, fish, mammals, birds, reptiles, and insects.
- Geographic Information Systems (GIS) data sets of sensitive species distributions.
- Primary production estimates for serial plant communities on abandoned, formerly cultivated fields and natural plant communities.
- Long-term monitoring records of nesting Canadian geese, spawning salmon, bald eagles, nesting Buteo hawks, insects, and elk.
- Environmental monitoring of air, surface water, soil, groundwater, wildlife, and fish since 1945.

Significant Publications

Although lists of publications have not been maintained, information on a particular topic may be available. Requests should be addressed to the Park Director.

Facilities and Accommodations for Cooperative Research

PNL offers opportunities for joint research and education in its long-term research programs for environmental sciences. Most efforts are supported through the Associated Western Universities, Inc., on the Washington State University campus in Richland, WA. Collaborative efforts may also be arranged directly with PNL. Facilities and equipment (including plant gas exchange chambers, greenhouses, GIS retrievable site information, large weighing lysimeters, and remotely sensed imagery) are available for research in the atmospheric, earth, microbiological, chemical, and life sciences and in the computational sciences. In addition, field-station facilities located on the ALE Reserve provide office, computer, and laboratory support for students and staff members conducting field research. A security clearance is required for access to the Hanford site. Housing is available in the nearby cities of Richland, Kennewick, and Pasco, WA.

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IDAHO

National Environmental Research Park

- Physical and Biological Processes Relating to Waste Management
- Pollutant Monitoring
- Plant Physiology
- Long-Term Vertebrate and Vegetation Sampling
- Threatened and Endangered Species Conservation

0 Miles 15
0 Kilometers 24

■ Idaho National Environmental
Research Park

Idaho National Environmental Research Park

Park Director

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Location

The National Environmental Research Park at the Idaho National Engineering Laboratory (INEL) is located on the upper Snake River plain in southeastern Idaho and includes portions of Butte, Bingham, Bonneville, Clark, and Jefferson Counties. The 230,000-ha park has boundaries coincident with those of INEL. The research park's centrally located meteorological station lies at 112°49' West longitude and 43°44' North latitude.

Biotic Description and Associated Research

The Idaho research park exemplifies a regional fragment of a sagebrush-steppe community with essentially natural vegetation and without major human disturbances such as livestock grazing, agriculture, or development. The major communities and characteristic species of vegetation include sagebrush grassland (18 distinct types), juniper/grassland,

Great Basin wild rye, crested wheatgrass plantings, and aquatic bodies—such as ephemeral rivers, Lost River sinks, river diversion spreading areas, and artificial ponds.

DOE activities at INEL include nuclear power development and testing, nuclear fuels reprocessing, and radioactive waste management as well as livestock grazing and associated range improvement practices. The park's environmental research focuses on following pathways of radionuclides and various nonradioactive tracers to biota and humans, understanding chemical and physical aspects of liquid radioactive and nonradioactive waste ponds, determining sensitive biological indicators of concentrations and effects of pollutants, and monitoring short- and long-term effects of habitat alteration on vegetation and wildlife. A significant effort has been made to establish ecological baseline data for future impact comparisons.

Scientists at the Idaho park have a strong research program in wildlife ecology (Reynolds et al., 1986). Applied research in radioecology focusing on a variety of wildlife species has documented the success of biomonitoring of radionuclides for big game (Markham et al., 1982), waterfowl (Halford and Markham, 1984), large predators (Arthur and Markham, 1982), and small mammals (Arthur et al., 1986). Noteworthy long-term vegetational studies initiated in 1950 document variability in community structure and the lack of a deterministic, directional pattern in observed successional

phenomena (Anderson and Holte, 1981; Anderson, 1986). Still other vegetation studies have examined water use efficiency (Toft et al., 1989) and soil water relations (Shumar and Anderson, 1986; Anderson et al., 1987).

One federally endangered species, the bald eagle, and four Category 2 species—the ferruginous hawk, loggerhead shrike, pygmy rabbit, and Townsend's big-eared bat—are regular visitors to the research park.

Physical Description

Elevation and Climate

The Idaho research park is located on a plain with elevations ranging from 1,454 to 1,624 m and several extinct volcanoes protruding up to 2,003 m. It has a semiarid, cold-temperate climate characterized by cold winters and hot, dry summers. The average annual precipitation is 22.4 cm, ranging from 11.4 to 36.6 cm. May and June are the wettest months, each with an average of slightly more than 3 cm of moisture. July, the hottest month, has an average temperature of 20.1°C, and January, the coldest month, averages -8.9°C. The maximum and minimum temperatures recorded are 39°C and -44°C, respectively.

Geology

INEL is located on the eastern Snake River plain, a structural basin covered by basaltic and rhyolitic lava flows up to 3,000 m thick. Surficial basalt flows vary in age from 15,000 to 1 million years. The plain is bounded on the north and northwest by basin and range fault block mountains composed of Paleozoic sedimentary rocks and Tertiary volcanics. Unconsolidated sediments on the site include lacustrine clays and silts, eolian sands, fluvial sands and silts, and alluvial fan gravels.

Soils

The research park has three dominant depositional environments for soils: basalt flows, alluvium, and lacustrine deposits. All three environments include windblown silts and sands over some sections. Basalt flows dominate the landscape, and alluvial deposits dissect the park from northeast to southwest. A small section of lake beds and associated beach and bar deposits are found at the north end of the park. Basalt flows produce rolling topography, and associated soils formed over basalt are Typic Calciorthids, with a diagnostic calcic horizon in the subsurface. These soils vary from very shallow on the sideslopes to very deep in depressions. Alluvial deposits consist of Typic Torriorthents, sandy soils with little development, and Typic Camborthids—sandy soils with diagnostic horizons. Lacustrine deposits consist primarily of Typic Camborthids and Typic Calciorthids. Psamments, sandy deposits with little soil development, are found in the associated beach and bar deposits.

Long-Term Data Sets and Database Information

- Maps, including surface geology; vegetation; roads, trails, and landmarks; grazing areas; aerial photographs; surface radiation levels; topography; and sampling locations for soil, air, and thermoluminescent dosimeters (TLD).
- Climatology data, including ground surface, soil, and air temperature data; vertical air temperature profiles; wind direction and velocity; precipitation and relative humidity; atmospheric pressure; solar and terrestrial radiation; and atmospheric trajectories.

- Soils and geology.
- Vegetation transects since 1950.
- Data on birds, including midwinter eagle counts, raptor surveys, and censuses of breeding birds.
- Data on mammals, including quarterly counts on black-tailed jack rabbit, annual American pronghorn productivity and wintering counts, and semiannual small mammal surveys.
- Effects of burned areas on vertebrates, invertebrates, and vegetation.
- Vertebrate species abundance lists.
- Subsurface water quality and geophysical morphology.
- Extensive radioecology and general ecology baseline data.
- Air quality.
- Radioactivity in air, soil, water, and foodstuffs and environmental radiation levels.
- Reference collections for vascular plants, lichens, insects, and small mammals.

Significant Publications

Listing of publications, theses, and DOE reports are presented in *National Reactor Testing Station Environmentally Related Publications* (Markham, 1973; AEC/IDO-12078) and *Publications of the Idaho National Engineering Laboratory Radioecology and Ecology Program: 1974-1991* (Markham and Reynolds, 1991; DOE/ID-12125). Both of these documents are available from the Park Director.

Facilities and Accommodations for Cooperative Research

Office and laboratory space is generally available for cooperative research, but security passes are required. Lodging is available for short-term researchers, and a cafeteria provides meals.

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LOS ALAMOS

National Environmental
Research Park

- ▶ Environmental Response to Disturbance
- ▶ Ecological Technology for Environmental Restoration
- ▶ Field Demonstration of Environmental Processes and Control Technology
- ▶ Advanced Environmental Measurement Technology
- ▶ Threatened and Endangered Species Conservation

Los Alamos National Environmental
Research Park

Los Alamos National Environmental Research Park

Park Director

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Location

The National Environmental Research Park at the Los Alamos National Laboratory (LANL) is located north-northeast of Albuquerque and northwest of Santa Fe, NM, in Sandoval and Santa Fe Counties. The 11,500-ha park is situated on the Pajarito Plateau between the Jemez Mountains to the west and the Rio Grande Valley to the east. Its center lies at 106°19' West longitude and 35°53' North latitude, and its boundaries are coincident with those of the LANL site.

Biotic Description and Associated Research

The vegetation in the Los Alamos research park is more diverse than that of the other western research parks. It ranges from upper Sonoran to pinyon-juniper woodland and includes some aspects of southern Rocky Mountain flora at higher elevations. The major communities and characteristic species of vegetation include Ponderosa pine, pinyon-juniper, juniper-

grassland, and mixed conifer—Douglas fir and white fir on the northern aspects of upper canyons.

Established in 1943, the Los Alamos Scientific Laboratory emphasized improving fission bombs and developing thermonuclear weapons during its first decade of research and development. The site includes more than 10 low-level radioactive and chemical development waste disposal areas; 3 major canyon systems that have been used for chemical and radioactive liquid waste disposal; and 3 major explosive testing areas containing depleted uranium, beryllium, and explosive residues. Therefore, ecological research needs revolve around ecological risk methods, environmental regulatory issues, ongoing studies of surface and subsurface hydrologic processes, and efforts to develop innovative technologies for environmental remediation. Because of the steep environmental gradient across the site and its unique setting at the interface between semiarid community types, this research park is an excellent location for long-term studies of the scaling properties of ecosystem processes along gradients.

Current research at the Los Alamos park emphasizes understanding the fundamental processes governing the interaction of ecosystems and the hydrologic cycle. Basic ecological research has also dealt with advances in statistical methodologies for field studies (White and Garrott, 1986; Morrison and Kennedy, 1989) and population dynamics and behavior of elk,

deer, and raptors (White and Bartmann, 1983; Kennedy, 1986; Kennedy, 1990). Related studies have made strong contributions to ecological theory, modeling, and management (White et al., 1985; Kelly and Kennedy, 1990). Ecosystem studies at the park have focused on gas exchange (Barnes and Cunningham, 1990) and the overall productivity of the pinyon-juniper woodland (Lajtha and Barnes, 1990). Ecological field-testing of a noninvasive Raman lidar-based system for high-resolution landscape measurements of water-vapor concentrations over vegetated terrain was pioneered on the research park and has been successfully transferred to large global change programs (Barnes et al., 1990). In addition, a number of applied environmental studies at the research park have addressed questions of contaminant transport (Hakonson, 1975; Watters et al., 1983) and biological invasion of waste sites (Hakonson et al., 1982).

Physical Description

Elevation and Climate

The elevation at Los Alamos varies east to west from 1,650 to 2,500 m above sea level over a horizontal distance of about 16 km. The area generally has a semiarid continental mountain climate. Average annual precipitation is slightly more than 45 cm, with 75 percent falling from May through October. Precipitation may be as little as 20 cm annually at lower elevations near the Rio Grande, but as much as 50 cm or more at higher elevations where winter precipitation, most of which falls as snow, can total as much as 260 cm. Maximum daytime temperatures reach as high as 32°C, but this occurs on average only 2 days per year. During January, the coldest month, daytime shade temperatures are usually about 0°C, and an average winter includes only 18 days with temperatures below freezing.

Geology

In the park, the Rio Grande Rift is about 60 km wide and includes the Española Valley, Pajarito Plateau, and Jemez Mountains. The geologic formations in this area developed by sedimentation and volcanism that began in the late Oligocene or early Miocene age (18 to 25 million years ago) and culminated in the Pleistocene (1.1 to 1.4 million years ago). The oldest rocks in the park are pinkish-tan siltstones and sandstones of the Tesuque Formation, which is more than 1,000 m thick. Deposited on a broad flood plain of the Rio Grande Rift, the formation contains some interbedded basalts. The Tschicoma Formation overlies the Tesuque Formation in the western part of the research park and forms the volcanic highlands of the Jemez Mountains. The Tschicoma Formation, estimated to exceed 800 m, consists of andesites, dacites, rhyodacites, and quartz latites. The Puye Formation is a conglomerate made up of volcanic debris eroded from the volcanic pile to the west. This formation is exposed in grayish-buff cliffs along the Puye Escarpment and White Rock Canyon and in some of the deeper canyon cuts into the eastern edge of the plateau. Thin beds of ash and pumice are common. The thickness of the conglomerate exceeds 200 m near the center of the plateau. The basaltic rocks of the Chino Mesa along White Rock Canyon overlie the Tesuque Formation and interfinger to the west into the Puye Formation. The dark gray basalts originated as a series of flows and interbedded sediments that exceed a thickness of 350 m. The Bandelier Tuff forms the upper surface of the Pajarito Plateau. It consists of air-fall pumice and both welded and nonwelded rhyolite tuff. The thickness of the Bandelier Tuff may exceed 300 m in some places on the plateau.

Major north-south trending faults, part of the Rio Grande Rift fault system, displace the Bandelier Tuff of the Pajarito Plateau. The Pajarito Fault, the major fault zone that trends north to south along the western margin of the plateau, has displaced the tuff approximately 120 m. The structural graben formed by faulting is filled with sediments and volcanic rocks and exceeds 3,600 m in thickness. Ephemeral streams dissect the surface of the plateau, causing narrow mesas separated by canyons that range from 60 to 120 m deep.

Soils

Of the 10 internationally recognized soil orders, 5 exist in the research park: Alfisols, Aridisols, Entisols, Inceptisols, and Millisols. Almost 80 percent of the soils fall into the Alfisol, Entisol, and Inceptisol soil orders. Alfisols occur along the base of the Jemez Mountains. They have significantly more clay in the B horizon (argillic in Alfisols) than in the A horizon and are generally forest soils. Aridisols are found in the southeastern portion of the research park. Their surface horizons are normally light in color and have a soft consistency when dry. The horizons may be the result of translocation and accumulation of salts, carbonates, and silicate clays or of cementation by carbonates or silica. In contrast to the Alfisols, the Entisols show little or no evidence of developing pedogenic horizons. They are found intermingled with the Aridisols and Alfisols on the research park landscapes, on steep, actively eroding slopes, or on floodplains that receive new deposits of alluvium at frequent intervals. Some older Entisols consist mostly of quartz or other minerals that do not alter or form horizons.

Long-Term Data Sets and Database Information

All data sets and database information are available on GIS as follows:

- Maps, including topographical and aerial photographs at several scales.
- Habitat characterization/population dynamics, including lists for plant, fish, reptile, bird, and invertebrate species.
- Life history studies of Rocky Mountain mule deer, elk, and small mammals.
- Endangered species studies of the gramma grass cactus, peregrine falcon, and Jemez Mountain salamander.
- Fire ecology, including nutrient cycling and long-term fire succession.
- Long-term water and nutrient dynamics on pinyon-juniper habitats.
- Computer-based interactive overlay mapping system.
- Climatology data, including 45 years of precipitation data and 23 years of wind data and solar radiation.
- Soil surveys.
- A long-term environmental surveillance database on radionuclides and stable elements in environmental media.
- Long-term vegetation map with species occurrences.
- Root distributions of native plants.

Significant Publications

A bibliography of publications sponsored by the Los Alamos National Environmental Research Park is available from Publication Information, Environmental Science Group, MS J-495, Los Alamos National Laboratory, Los Alamos, NM 87545.

Facilities and Accommodations for Cooperative Research

LANL maintains active collaborations with a wide variety of governmental agencies and universities. Research park offices, facilities, and field sites are located mostly in publicly accessible areas of LANL, and security clearances are not required for most work. Onsite collaborators have access to excellent computing facilities with high-level graphics capabilities. Greenhouse facilities are on site, as is instrumentation for most field and laboratory techniques. Manipulative field experiments are also possible at the park. Active offsite collaborations are currently maintained in ecology, ecological risk, hydrology, meteorology, and surface-atmosphere interactions.

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NEVADA

National Environmental Research Park

- Dynamics of Transitional Desert Biota
- Radioecology of Nuclear Disturbed Areas
- Comparative Baseline Studies of Desert Ecosystems
- Geohydrology of Nuclear Test Site
- Threatened and Endangered Species Conservation

Nevada National Environmental Research Park

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Location

The National Environmental Research Park at the Nevada Test Site (NTS) consists of 350,000 ha of arid basin and range terrain located in south-central Nevada. Adjacent to the north and west boundaries of the park is the Nellis Air Force Range; next to the east boundary is the Desert National Wildlife Range; and bordering the south boundary is public domain under the management of the Bureau of Land Management. The center of the research park lies at 116°09' West longitude and 36°59' North latitude, and its boundaries are coincident with those of NTS.

Biotic Description

The three major biotic communities on the Nevada research park are the Mojave and Great Basin Deserts and the Transition Desert between them. Limited public access for more than 40 years has resulted in the biotic communities

being in relatively natural balance. Plant communities typical of the Mojave Desert are found in the southern part of the park. Dominant plant species are creosote bush and white bursage. Grasses and herbaceous perennials are common, and annual herbs are abundant after periods of high rainfall.

Two categories of plant communities typify the transition between the Mojave and Great Basin Deserts: those on the upper bajadas above the Mojave communities and those on the lower elevations and floors of closed basins. Blackbrush is the dominant species on the upper bajadas, but the basin floors are usually covered by stands of wolfberry and hoshpage.

Vegetation typical of the Great Basin Desert communities appears on the mountains and drainages of most of the northern two-thirds of the park. Big sagebrush is the most abundant species on deep soils, but it is replaced by black sagebrush in areas with shallow soils. Singleleaf pinyon and Utah juniper are common above 1,830 m. Valley floors in this region are dominated by shadscale or fourwing saltbush.

The park fauna is well documented, and species lists are available. The park hosts many species: at least 33 reptiles, 190 birds, and 47 mammals have been identified. Small mammal populations at low elevations are mainly kangaroo rats, pocket mice, and antelope ground squirrels. Deer mice and woodrats are common in mountainous areas, while coyotes and bobcats roam over much of the park. Mule deer are

present in the mountainous areas and a small herd of wild horses inhabits the north-central part of the research park.

Approximately 86 percent of the bird species are either transient or seasonal residents. The raven is ubiquitous, the western kingbird is common, and numerous sage sparrows winter in the park. Game species include mourning dove, Gambel's quail, and the introduced chukar. Red-tailed and sparrow hawks are familiar sights.

Reptiles are abundant, particularly certain lizards such as the whiptail, leopard, sagebrush, and *uta*. The desert tortoise is the only federally listed threatened species in the park. Other sensitive species include one Category 1 plant, two Category 2 mammals, five Category 2 birds, and ten Category 2 plants.

Physical Description

Elevation and Climate

The Nevada research park's elevation ranges from a low of approximately 910 m in the basins to a high of 2,331 m on Rainier Mesa. The park experiences extremes in temperature, precipitation, and wind velocity; these variations occur not only from year to year but also between specific locations in the park. The average annual precipitation ranges from about 102 mm, accumulated in generally less than 30 days per year at 762 m elevation, to about 305 mm, accumulated in 50 or more days per year at 2,286 m.

Temperatures fluctuate widely under conditions of predominantly clear skies and low relative humidities. At Yucca Flat, the average annual daily minimum is 3°C, and the average annual daily maximum is 22°C. Recorded minimum and maximum extremes are -26°C and 43°C, respectively.

Geology

The geology of the Nevada research park is structurally complex. At least 17 Paleozoic formations and 1 formation of Tertiary age have been recognized. The former consist primarily of limestone, dolomite, quartzite, shale, and conglomerates, with a composite section approximately 12,200 m thick. About 30 percent of the outcrops on the site are sedimentary in origin. The remainder are predominantly volcanics of Tertiary age. During the Mesozoic Era, uplift, folding, and thrust faulting occurred in the region followed by volcanic deposition during the Tertiary age. The central and western portions of the park had numerous volcanic centers, five of which gave rise to calderas. The principal volcanic rocks are ash-flow tuffs of rhyolitic and quartz-latic composition. These Tertiary formations have a composite section more than 9,100 m thick and represent the most widespread formation on the site. Quaternary deposits are mainly mixtures of detrital material derived from bedrock areas and a fill of caliche, siltstone, and conglomerates. They spill down-slope from the mountains and hills into the basins as extensive bajadas leading often to a playa. Quaternary sediments in valleys are between 244 and 457 m in depth. The playas themselves consist almost entirely of impermeable fine silt and clay. These alluvium-filled basins occupy about 30 percent of the land area.

Soils

There has not been a definitive soil survey of the Nevada research park. Most information has been gathered to answer specific programmatic needs in widely separated areas. On the basis of preliminary information, most of the soils have developed on alluvial deposits that contain

unconsolidated parent materials of both sedimentary and volcanic origins. The soils have developed under desert conditions and are characterized by coarse texture, having low organic-matter content and low carbon/nitrogen ratios, with a caliche layer within a few feet of the surface. Most of the soils can be classified as belonging to the Thermic Families, with those at higher elevations fitting into the Mesic Family.

Long-Term Data Sets and Database Information

A considerable amount of data and database information exists from past and present long-term studies at the research park. Examples include the following:

- Comparative baseline studies of desert ecosystems.
- Radioecology of nuclear disturbed areas.
- Environmental monitoring data.
- Groundwater monitoring data.
- Dynamics of transitional desert biota.
- Cultural resource survey information.
- Site environmental reports.

Significant Publications

Please contact the Park Director for publications and reports about the Nevada research park.

Facilities and Accommodations for Cooperative Research

NTS provides many support resources for visiting research scientists and students. Although primarily intended to meet the needs of the weapons testing and environmental restoration programs, many of the support services may be useful to environmental researchers as well. These services include mail and telephone services, clerical assistance, onsite housing, food service, first aid and medical assistance, office/working space, various types of earthmoving equipment, procurement, accounting, shipping and receiving, fax services, photocopying, photographic services, public information, testing and analysis laboratories, and recreational facilities. The DOE Nevada Operations Office will accept research proposals from any individuals or group(s), both public and private.

OAK RIDGE

National Environmental
Research Park

- ▶ Comparative Ecological Observations
- ▶ Field Validation of Ecological Theory
- ▶ Long-Term Analysis of Key Ecological Parameters
- ▶ Advanced Instrumentation Testing
- ▶ Threatened and Endangered Species Conservation

Oak Ridge National
Environmental Park

Oak Ridge National Environmental Research Park

Park Director

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Location

The National Environmental Research Park of the Oak Ridge National Laboratory (ORNL) is located at Oak Ridge, TN, approximately 48 km northwest of Knoxville in Anderson and Roane Counties. This park is unusual because it consists of segments totaling 5,008 ha spread over the 14,266-ha Oak Ridge Reservation (ORR). It is the only research park whose boundaries are not coincident with those of the DOE site itself. ORR is located at 84° West longitude and 36° North latitude.

Biotic Description and Associated Research

The Oak Ridge research park is situated in the eastern deciduous forest. Major communities and characteristic species include natural yellow pine forests, eastern red cedar barrens, bottomland hardwood forests, oak-hickory forests, northern hardwood forests, loblolly pine plantations, old fields, grasslands, and streams and rivers.

Three major DOE research and production facilities are located on the reservation: ORNL, Oak Ridge Gaseous Diffusion Plant, and the Oak Ridge Y-12 Plant. Constructed in 1943, the facilities are involved in energy-related research, production of nuclear material, and production and development of weapons components. Operations associated with these facilities result in both radioactive and nonradioactive solid, gaseous (airborne), and liquid waste materials, providing a variety of environmental research opportunities.

The best known study at this site is one on biogeochemical cycling in the Walker Branch Watershed (Johnson and Van Hook, 1989), a long-term interdisciplinary investigation initiated in 1967. It has made important scientific contributions to the understanding of atmospheric deposition to forests (Lindberg et al., 1982, 1989), biogeochemical cycles (Johnson et al., 1985; Johnson and Henderson, 1989), forest dynamics (Edwards et al., 1989), and nutrient limitation and cycling (spiraling) in streams (Newbold et al., 1982; Mulholland et al., 1985; Elwood and Turner, 1989). Although these studies initially focused on questions concerning basic ecosystem processes, results of the Walker Branch Watershed research have been applied to problems such as regional-scale assessments of atmospheric pollution, groundwater management, and site characterization of potential shallow land-burial sites (Van Hook, 1989).

Other areas of significant research at the park include landscape ecology (Turner, 1989), ecological risk assessment (Suter, 1990; Hunsaker et al., 1990), and general ecosystem theory (O'Neill et al., 1989).

Threatened and Endangered Species Conservation

The park consists of 41 natural areas (terrestrial and aquatic) that provide habitat protection for rare plant and animal species. Seven of these areas have been registered as State Natural Areas with the Tennessee Department of Environment and Conservation. Seventeen plant species are on the Tennessee Rare Plant list; some of them are also under consideration for Federal listing. Rare wildlife species, listed by the Tennessee Wildlife Resources Agency as endangered, threatened, or in need of management, include 1 fish, 2 amphibians, 2 reptiles, 17 birds, and 2 mammals.

Research park reference areas provide protection for 40 sites that include vegetation representative of the southern Appalachian region or that possess unique biotic features. Many of these areas are important sources of baseline information for long-term observations and monitoring.

Physical Description

Elevation and Climate

The elevation of the Oak Ridge reservation ranges from 226 to 413 m above mean sea level. The area has a mild climate with warm, humid summers and cool winters. Spring and fall are usually long, with normally pleasant, dry, sunny weather and mild temperatures. Total annual precipitation is 136 cm. Snowfall averages about 0.25 m per year, and precipitation peaks in

January and February. Annual mean air temperature is 14.4°C. Diurnal swings in temperature are relatively constant from month to month (about 11.1°C).

Geology

The principal rock groups (Rome, Conasauga of Cambrian age, Knox, and Chickamauga of Ordovician age) are more than 450 million years old and have experienced the most folding, thrusting, and faulting. All the ridges and valleys tend southwest to northeast, whereas underlying rock units dip to the southeast. The Rome Formation is a heterogeneous, variegated mixture of sandstone, siltstone, shale, dolomite, and limestone. It mainly occurs just above the major thrust faults and is commonly folded and overlapped. Rock types of the Rome Formation weather as a shallow mantle of sandstone and siltstone chips. The carbonate rocks weather more deeply and form local bodies of yellow, generally silty clay with a red-brown soil layer. The Conasauga Shale consists of light-green, olive-green, and dull-purple shale; the light green is the purest clay-shale, and the purple is the most silty. The Conasauga Shale generally weathers to a thin acid soil full of shale chips, but where limestone is present, the soil is deeper and richer. The Knox Group is composed primarily of massive, siliceous dolomite. The general lithology is from massive, dark-gray, crystalline, very cherty dolomite at the base to generally less massively bedded, lighter gray, densely to finely crystalline, and less cherty dolomite at the top. The Chickamauga Group contains many varied lithologies arranged in complex interbedding. The surfaces of valleys underlain by the formation are irregular, with the more silty and cherty layers underlying low ridges and hills. The structure of the entire reservation is complex because of the extensive

faulting and deformation present in the region. Three regional thrust faults (Kingston, Whiteoak Mountain, and Copper Creek) strike to the northeast and dip to the southeast.

Soils

The research park is overlain primarily by residual soils and, to a lesser extent, by alluvial soils. The alluvium occurs only in floodplains and along stream beds; it is a mixture of organic and mineral particles. Residual soils are formed in place by the decomposition of the underlying bedrock that is part of the Ridge and Valley Province of the eastern overthrust belt. The ridges consist of dolomite and limestone, which have weathered over time to form fine-grained, reddish clay soils with depths of up to 27.5 m and with well-developed internal drainage. The valley soils, generally much shallower, are a mix of clays, silts, and weathered shales.

Long-Term Data Sets and Database Information

- Maps of climatology, soils, surface geology, topography, vegetation, land use, protected areas, monitoring sites, and waste management areas.
- Inventories and characterization of Walker Branch Watershed; habitat selection of breeding fall and winter birds; inventory of forest research plots; precipitation and stream flow; vegetation; animal listing and habitat types for reptiles, amphibians, arthropods, birds, mammals, and fish; Clinch River sampling of fish, clams, sediment, and water for radio-nuclides (1958 to 1963); and hydrologic characterization of waste disposal sites.
- Population studies, including litter and soil bacteria and fungi plate counts in fertilized plots on Walker Branch Watershed, bird community studies, population/habitat relationships, edge effect, bobcat tracking studies, deer population studies and road-kill data (1969 to the present), deer hunt data (1984 to the present), feeding rates and balances of cesium and potassium in bluegill, microbial populations and respiration rates in a tulip poplar forest floor under different microclimatic conditions, and plant population studies (1977 to the present).
- Element cycling and analyses, including major anions and cations plus pH, conductivity, trace metals, amount of rainfall, and acidity strength in rain and throughfall at Walker Branch Watershed (1981 to the present); major ion chemistry of suspended and deposited particles at Walker Branch Watershed (1981 to the present); nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sodium (Na) content in wetfall, dryfall, and streamflow at 1-week intervals for Walker Branch Watershed; nutrient concentrations in soil as measured from soil solution collected by using tension lysimeters in fertilized plots at Walker Branch Watershed; seasonal biomass and N, P, K, Ca, Mg, Na, lead, cadmium, and zinc content in animals; carbon dioxide evolution rates from partitioned litter horizons; concentration of chromium from cooling-tower drift in vegetation, animals, and soil; Liriodendron seedling nutrient data; and photo-synthetic allocation in white pine.

- Climatology data from Walker Branch Watershed (1973 to the present), detailed forest meteorology data on Walker Branch Watershed, and Oak Ridge area climatology data (1951 to the present).
- Historic data, including archaeological surveys in the reservation.
- Continual long-term environmental monitoring data for air, groundwater, streams, sediment, fish, benthoinvertebrates, soil, and vegetation.

Significant Publications

Publications about the research park can be obtained from the Environmental Sciences Division Publications Office. Reprints are available at the Reprint Office, Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN 37831-6335.

Facilities and Accommodations for Cooperative Research

Facilities include well-equipped field research sites with advanced instrumentation, laboratories, greenhouses, computer networking and support, and libraries. Information on housing in the city of Oak Ridge is available through ORNL's Office of Housing.

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SAVANNAH RIVER

National Environmental
Research Park

- Biological and Chemical
Cycling Processes and
Interactions
- Wildlife Population and
Community Dynamics
- Landscape Ecology and
Community Development
of Wetland Habitats
- Ecological
Characterization of
Natural and Impacted
Communities
- Threatened and
Endangered Species
Conservation

0 Miles 5.5
0 Kilometers 9

Savannah River National
Environmental Research Park

Swamp

Savannah River National Environmental Research Park

Park Director

Nat B. Frazer

Drawer E

Savannah River Ecology Laboratory

Aiken, SC 29802

(803) 725-2472, Fax (803) 725-3309

Location

The National Environmental Research Park at the Savannah River Site (SRS) is located in west-central South Carolina on the northern banks of the Savannah River about 242 km inland from the ocean and about 32 km below the fall line. The park, which contains portions of Aiken, Barnwell, and Allendale Counties, is centered at 81°40' West longitude and 33°15' North latitude and encompasses 79,000 ha of land. The research park boundaries are coincident with those of SRS.

Biotic Description and Associated Research

The Savannah River research park's principal biome is southeastern evergreen forest, including both upland and bottomland forest types, and significant swamp forests associated with the Savannah River floodplain. The major communities of vegetation and characteristic species include pine plantations; old fields; natural forests composed of upland oak and

hickory, mixed pine and hardwood, sandhills oak and pine; bottomland hardwood and bald cypress-water tupelo swamp; and wetlands of the Savannah River (first to fifth order tributary streams), farm ponds, reservoirs, and Carolina bays.

The major DOE facilities on SRS include nuclear production reactors, chemical separation areas, uranium fuel processing facilities, waste processing facilities, and numerous support facilities such as coal-burning power plants and cooling reservoirs. Their operations—production of nuclear materials for national defense and management of high-level radioactive wastes—offer numerous opportunities for conducting ecological research on interactions between industrial activities and the natural environment. Within the park, DOE has set aside large land areas for ecological research that serve as natural reference areas because they are not directly affected by DOE operations. In addition, some areas not affected by DOE operations are managed by the U.S. Forest Service for timber production and research purposes. Because several of the facilities release cooling water effluents at high temperatures, a considerable amount of research has focused on thermal effects on individual animals (Gibbons et al., 1978), populations (Gibbons, 1970), and communities (Sharitz et al., 1974) in both aquatic and wetland habitats. General reviews (Gibbons and Sharitz, 1981; Sharitz and Gibbons, 1981) have indicated the subsidy-stress nature (Odum et al., 1979) of these elevated water temperatures.

Scientists at the Savannah River research park have also conducted a strong research program in population genetics, especially on white-tailed deer (Chesser et al., 1982; Cothran et al., 1983; Smith et al., 1986; Chesser and Smith, 1987). Other areas of research involve the use of remote sensing to study wetland systems (Jensen et al., 1986), including wildlife habitat monitoring (Hodgson et al., 1988). Scientists at the research park have also investigated the fate of environmental contaminants, particularly the bioaccumulation of toxic elements (Newman and McIntosh, 1983; Newman and Doubet, 1989).

Threatened and Endangered Species Conservation

The Savannah River park serves as a refuge for the endangered red-cockaded woodpecker, bald eagle, wood stork, and smooth purple coneflower. The American alligator, a threatened species, is also common in the lakes on the park. Scientists at the Savannah River Ecology Laboratory (SREL) conduct research on these species, whereas the Savannah River Forest Service is responsible for their management.

Physical Description

Elevation and Climate

Situated on the Southeastern Coastal Plain, the Savannah River park is about 160 m above mean sea level in the northwest end and at sea level in the southeast. The research park has a temperate climate with mild winters and long summers. The region is subject to continental influences but is protected from the more severe winters in the Tennessee Valley by the Appalachian Mountains to the north and

northwest. The average annual precipitation is about 122 cm, evenly distributed throughout the year. The average annual temperature is about 17°C.

Geology

The research park is underlain by unconsolidated and semiconsolidated Upper Cretaceous, Tertiary, and Quaternary sediments deposited on an eroded basement of Precambrian and/or Paleozoic igneous and metamorphic rocks and consolidated Triassic sediments. The basement rocks are about 175 to 425 m deep at the research park and dip to the southeast underneath the coastal plain sediments. A Triassic rift basin filled with sandstones, siltstones, and mudstones underlies approximately one-third of the research park (southeastern portion). The coastal plain sediments form a wedge ranging in thickness from a few meters at the fall line (approximately 40 km northeast) to more than 425 m on the southeast. The geologic formations that immediately overlie the basement rock were deposited about 70 million years ago in the late Cretaceous Period. The Cretaceous formations have a combined thickness of approximately 150 to 1,809 m and consist of interbedded sand and clay. Overlying the Cretaceous age sediments are several formations of Tertiary age. These formations have a combined thickness ranging from about 30 to 175 m and consist primarily of clay/sand and sand/clay with small distinct zones of either sand or clay. A zone that often contains calcareous cement, small lenses of limestone, and some shale appears at depths ranging from 30 to 60 m. At some locations, sediments of Tertiary age are overlain by more recent terrace deposits of alluvium. The surface morphology of the research park is characterized by broad interfluvial areas and narrow steep-sided valleys.

Soils

Throughout the upland areas of the research park, the major soils are Fuquay, Blanton, and Dothan. These well-drained soils cover about 36,420 ha; the thicknesses of the sandy surface horizons vary from 25 cm to more than 100 cm. Nearly half of the 36,420-ha park has small patches of minor soils. Blanton and Lakeland (well-drained to excessively drained, mostly sandy) soils are found in about 14,570 ha along the uplands. About 8,090 ha, mainly in the uplands along sloping to steep areas that are adjacent to drainageways, consist of Vacluse or Ailey soils with well-drained loam that often has a light brown sandy surface and a brittle subsoil. Troup and Lucy soils (well-drained with sandy surface horizons in shades of brown or reddish brown) occur in the uplands along strongly sloping to steep breaks. These areas lead into the Pickney soil of the floodplains, which have a dark, nearly black, mucky surface, usually composed of 10 to 15 percent organic matter. About 8,090 ha fall into this group.

Hornsville and Rembert soils are found mostly on the first stream terrace and in some upland depressions. These two soil types contain about 5,670 ha of moderately well-drained and poorly drained soils, with clay subsoils and a large percentage of minor soils. The Chastain, Tawcaw, Shellbluff group cover about 4,860 ha, including about 240 ha of minor soils. These poorly drained, somewhat poorly drained, and well-drained soils, with a texture that is fine or loamy throughout, are found in large floodplain areas generally associated with the Savannah River. About 1,620 ha contain well-drained loamy Orangeburg soil, with about one-third of this area characterized by minor soils. The Orangeburg soil group is found in upland areas of the research park.

Long-Term Data Sets and Database Information

- Maps and aerial photography, including U.S. Geological Survey (USGS) topographic maps, aerial photographs as far back as 1938, SPOT satellite data, 11-band multispectral imagery with each pixel representing 5 to 10 m, soil maps and characterization, vegetation maps, and GIS capabilities.
- Water flow data, some extending back to the 1960s, from USGS gauging stations on all major research park streams and the Savannah River.
- Climatology data and extensive meteorological data collected by the Savannah River Laboratory Weather Center from a seven-tower system.
- Groundwater analyses from more than 1,200 wells that are monitored for an array of chemical and radiological constituents.
- Surface water analyses, including chemical analyses done on samples collected periodically at approximately 70 National Pollutant Discharge Elimination System (NPDES) stations since 1984, baseline water quality monitoring in streams since 1973, and additional chemical and radiological databases generated for research park streams and reservoirs through numerous studies.
- Radiological databases, including long-term data, which have been collected as part of monitoring and research programs on radioisotope concentrations in the air, soils, water, and biota of the research park.

- Ecological databases, including long-term studies of population trends in vertebrate species, genetic profiles of several vertebrate species, taxonomic keys and distribution lists for various plant and animal groups, an inventory of rare and endangered plant species, a herbarium and museum of research park plants and animals, and element concentrations for various plant and animal species.
- Site-specific environmental models for predicting the transport of contaminants through air, water, soil, and biota.

Significant Publications

Publications from environmental studies conducted at the park are available from the Reprint Office, Savannah River Ecology Laboratory, Drawer E, Aiken, SC 29802.

Facilities and Accommodations for Cooperative Research

SREL includes laboratory space at many locations within the research park, a library, an in-house computer system, field vehicles, greenhouses, and animal housing facilities. SREL encourages cooperative research with established professionals on sabbatical leave and with visiting professors, and it supports undergraduate and graduate research. Persons interested in such programs should contact the Park Director or the faculty member leading the specific program. Applications may be directed to Janell Gregory, Education Program, Savannah River Ecology Laboratory, Drawer E, Aiken, SC 29802.

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Appendix

Charter for the National Environmental Research Parks

A National Environmental Research Park is an outdoor laboratory where research may be carried out to achieve national environmental goals, as articulated by the National Environmental Policy Act (NEPA), the Energy Reorganization Act, the Department of Energy Organization Act, and the Nonnuclear Energy Research and Development Act. NEPA translated the public concern for a quality environment into environmental goals, and the National Environmental Research Parks network will provide land to help the Nation comply with the spirit of NEPA. The Energy Reorganization Act of 1974 mandates the Agency to engage in environmental research related to the development of energy sources so as to advance the goals of restoring, protecting, and enhancing environmental quality. The National Environmental Research Parks are actually field laboratories set aside for ecological research, for study of the environmental impacts of energy developments, and for informing the public of the environmental and land-use options open to them.

Because public access to DOE land is limited, environmental research projects can be carried out with a minimum of interference. Any land outside Restricted Areas may be made available by the field manager for study under

site-use procedures. Some natural areas should be protected from all manipulations for definite or indefinite periods of time in order to serve as controls. While execution of the program missions of DOE sites must be ensured, ongoing environmental research projects and protected natural areas must be given careful consideration in any site-use decisions. Where appropriate, research parks may be established with other governmental agencies in interagency agreements.

A wide range of research and demonstration programs will be necessary to systematically address the environmental impacts of human activities. Research parks are not simply sites to conduct research, but have environmental research programs planned to address these general objectives: (1) to develop methods to quantitatively and continuously assess and monitor the environmental impact of human activities, (2) to develop methods to estimate or predict the environmental response to proposed and ongoing activities, and (3) to demonstrate the impact of various activities on the environment and evaluate methods to minimize adverse impacts. Research park programs will be unique at every site, varying in the ecological and energy-related problems addressed and in the participation of researchers who are not funded by the Department.

Directives for the National Environmental Research Parks

The network of research parks was formally established with an insightful statement of objectives organized in three broad categories:

- (1) Assessment and Monitoring—develop methods to quantitatively and continuously assess and monitor the environmental impact of human activities.
- (2) Prediction—develop methods to estimate or predict environmental responses to these activities.
- (3) Demonstration—demonstrate the effects these activities have on the environment and evaluate methods to minimize any adverse effects.

Assessment and Monitoring

- Compile a regional environmental encyclopedia, including species lists, characterization of ecosystems, successional stages, and maps of the vegetation, soils, hydrology, etc. Species characterizations should include population levels, life histories, and the sensitivity to environmental stresses in terms of behavior, physiology, genetics, reproduction, and productivity. Special attention should be given to endangered and threatened species.
- Set aside and characterize research reference areas. To assess the environmental effects of site activities and ecosystem change brought about by stresses, certain minimal representative and/or unique natural areas must be left undisturbed.
- Establish field and laboratory repositories. Reference areas should be set aside to serve as gene reservoirs for organisms common to the region and to allow a wide range of genetic diversity to be retained. Genetic diversity is a natural defense against the vulnerability to epidemics that tend to develop in plants and animals intensively selected for yield or utility. Sites representing the “regional” deposition of air- or water-borne pollutants, not subject to ground-level redistribution, should be preserved and protected from contamination.
- Serve as environmental data centers and ultimately as regional environmental clinics for a particular ecoregion of the United States. As data storage and retrieval systems are developed and each park inserts strong cadres of researchers, DOE has the capacity to establish data centers for regional information, retrieval, assessment, and dissemination.
- Supply basic data so that national environmental decisions, standards, and monitoring programs can be developed using a firm ecological base. A regional monitoring network should be established and operated so that ecosystem responses can be continually monitored and evaluated with full meteorological information.
- Develop and improve ecosystem analysis techniques. Current techniques for conducting ecological surveys, inventorying populations, and measuring ecosystem responses to stresses should be tested and improved upon. Techniques should be developed to assess the general health of ecosystems relative to energy flow, materials cycling, species diversity, community structure, and stability.

- Manipulate ecosystems in carefully designed experiments by applying various environmental stresses, then assessing the ecosystem responses.
- Participate in international environmental programs to contribute to the assessment of human effects on the global environment and to cooperate in improving environmental quality.
- Study the pathways and sinks of pollutants in the environment and their spheres of influence. Predicting the ecosystem and organism response to a pollutant entering the environment necessitates determining the ultimate disposition of the pollutant and any organism or ecosystem components that it affects.
- Serve as a site for successional studies. Environmental insults such as fire, logging, radiation, and thermal effluents continue to affect the environment over time. The rates of secondary succession and/or recovery from such events should be evaluated and used as a basis for determining the optimal rate of resource exploitation.

Prediction

- Develop mathematical models simulating ecosystems to predict organism response to environmental stimuli, organize knowledge about the system, and select research priorities. The flow of energy, population dynamics, and the cycling of water and nutrients should be included in these models. The accuracy and geographical transferability of these models should be validated.
- Identify organisms, organ systems, and ecosystem components that can serve as indicators of environmental quality.
- Develop techniques to predict the ultimate location and deposition of specific pollutants, particularly those techniques allowing estimates of organism effects when full life history and physiological characterizations are not known.
- Study the interactions of pollutants and environmental conditions. Synergistic effects may be unlike suspected effects of single pollutants, consequently predictions of ecosystem and organism responses to pollutants depend on the interactive effects.

Demonstration

- Serve as a public demonstration area where citizens and specialists can observe long-term effects of specific factors and the true costs of alternate options for waste management or other land uses. Where feasible, research parks should offer an extension service to community groups, providing lectures, tours, and a visitors' center.
- Capitalize upon the ecologists at the research parks and develop a core curriculum training program outside or in conjunction with a neighboring university.
- Demonstrate alternate uses of land. Techniques should be developed for translating ecological costs of energy-related activities into economic costs.

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