Giving Back: Collaborations with Others in Ecological Studies on the Nevada National Security Site– 13058

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ABSTRACT

Formerly named the Nevada Test Site, the Nevada National Security Site (NNSS) was the historical site for nuclear weapons testing from the 1950s to the early 1990s. The site was renamed in 2010 to reflect the diversity of nuclear, energy, and homeland security activities now conducted at the site. Biological and ecological programs and research have been conducted on the site for decades to address the impacts of radiation and to take advantage of the relatively undisturbed and isolated lands for gathering basic information on the occurrence and distribution of native plants and animals. Currently, the Office of the Assistant Manager for Environmental Management of the U.S. Department of Energy (DOE), National Nuclear Security Administration Nevada Site Office (NNSA/NSO) oversees the radiological biota monitoring and ecological compliance programs on the NNSS. The top priority of these programs are compliance with federal and state regulations. They focus on performing radiological dose assessments for the public who reside near the NNSS and for populations of plants and animals on the NNSS and in protecting important species and habitat from direct impacts of mission activities.

The NNSS serves as an invaluable outdoor laboratory. The geographic and ecological diversity of the site offers researchers many opportunities to study human influences on ecosystems. NNSA/NSO has pursued collaborations with outside agencies and organizations to be able to conduct programs and studies that enhance radiological biota monitoring and ecosystem preservation when budgets are restrictive, as well as to provide valuable scientific information to the human health and natural resource communities at large. NNSA/NSO is using one current collaborative study to better assess the potential dose to the off-site public from the ingestion of game animals, the most realistic pathway for off-site public exposure at this time from radionuclide contamination on the NNSS. A second collaborative study is furthering desert tortoise conservation measures onsite. It is the goal of NNSA/NSO to continue to develop such collaborations in the sharing of resources, such as personnel, equipment, expertise, and NNSS land access, with outside entities to meet mutually beneficial goals cost effectively.

INTRODUCTION

The NNSS encompasses about 3,522 square kilometers (km), ranges in elevation from 823 meters

(m) to 2,341 m, and is located 88 km northwest of Las Vegas, with no public access since the 1940's. Most of the site remains relatively undisturbed. Because the site is situated in three ecoregions containing portions of the Mojave Desert, Great Basin Desert, and the transitional area between these two deserts, wildlife unique to these deserts occur adding to the ecological diversity.

The area known as the NNSS was under the jurisdiction of Nellis Air Force Base and was part of the Nellis Bombing and Gunnery Range between 1940 and 1950. The site was established in 1950 to be the primary location for testing the nation's nuclear explosive devices. It was named the Nevada Test Site in 1951 and supported nuclear testing from 1951 to 1992. The types of tests conducted during this period included atmospheric, underground, and cratering tests, as well as a few other types of nuclear-related experiments. Tests conducted through the 1950s were predominantly atmospheric tests. These tests involved a nuclear explosive device detonated while on the ground surface, on a steel tower, suspended from tethered balloons, dropped from an aircraft, or placed on a rocket. Several tests were categorized as "safety experiments" and "storage-transportation tests," involving the destruction of a nuclear device with non-nuclear explosives. Some of these tests resulted in the dispersion of plutonium in the test vicinity. The first underground test, a cratering test, was conducted in 1951. The first totally contained underground test was in 1957. Nearly all tests after 1962 were conducted in sealed vertical shafts drilled into Yucca Flat and Pahute Mesa or in horizontal tunnels mined into Rainier Mesa. From 1951 to 1992, a total of 828 underground nuclear tests were conducted at the NNSS. Approximately one-third of these tests were detonated near or in the saturated zone; this has resulted in the contamination of groundwater in some areas. Five earth-cratering (shallow-burial) tests were conducted from 1962 through 1968 as part of the Plowshare Program that explored peaceful uses of nuclear explosives. The first and highest yield Plowshare crater test, Sedan, was detonated at the northern end of Yucca Flat on the NNSS. The second-highest yield crater test was Schooner, located in the northwest corner of the NNSS. Mixed fission products, tritium, and plutonium were entrained in the soil ejected from the craters and deposited on the ground surrounding the craters.

Legacy Ecosystem Contamination on the NNSS

The largest amounts of legacy radiological contamination (approximately 40 to 60 million curies (Ci), based on the most recent decay corrected estimate from 1992) [1] is within the groundwater below historical underground nuclear test locations. However, it is legacy contaminated surface soils and surface waters on the NNSS which pose the current radiological exposure pathways to plants, animals, and the off-site public. Based on over 20 years of assessing and monitoring potential human dose pathways for residents surrounding the NNSS, a viable pathway with the highest potential exposure is through ingestion of game animals which could be contaminated from drinking water and foraging on plants in legacy radiological areas on the NNSS, move off the site, and then killed and consumed by humans. [2]

Radioactively contaminated surface soils resulting from nuclear weapons testing and ancillary

operations exist at approximately 100 sites on and around the NNSS. [1] The primary radioactive isotopes that remain in NNSS soils from historic nuclear testing include americium, plutonium, cesium, and strontium. Tritium is also prevalent, emanating from the soil as tritiated water. [1] Areas of surface soil contamination on the site have been identified, fenced, and/or posted. The aggregated area of these contaminated areas is about 24.3 square km, [3] or less than 1 percent of the overall area of the NNSS. A decay-corrected estimate of the total NNSS surface source term as of January 2012 is about 1,614 Ci with a range of uncertainty between 820 and 3,300 Ci. [4] Corrective actions for soil contamination sites range from removal of soil to "closure in place," in which the site is fenced, warnings are posted, and access is restricted. Restricted access controls do not prevent exposure to onsite plants and animals.

Radioactively contaminated surface waters on the site resulting from nuclear weapons testing include the E-Tunnel Ponds on Rainier Mesa in the northern part of the site. These earthen ponds were constructed to retain contaminated groundwater which seeps out of the sealed tunnel. Discharged E-Tunnel waters are monitored under a state water pollution control permit, and measured tritium in the pond water (461,000 pCi/L in 2011) [2] has never exceeded the 1,000,000 pCi/L permit limit. Other temporary surface waters which are radiologically contaminated include plastic lined sumps into which groundwater is pumped from "hot wells" (wells in which groundwater tritium concentrations exceed 400,000 pCi/L) during groundwater characterization activities. The contained groundwater eventually evaporates from these sumps. Numerous wildlife species including game animals such as mule deer, quail, rabbits, and mourning doves have access to the E-Tunnel Ponds and the temporary sumps as drinking water.

DISCUSSION

Current Biological Programs on the NNSS

NNSA/NSO conducts the Routine Radiological Monitoring Program (RREMP) which includes radiological monitoring of plants and animals exposed to legacy contamination. The purpose of radiological biota monitoring is to assess: 1) the potential dose to the public from the ingestion of game animals that have become contaminated on the NNSS and then been hunted, 2) the dose to NNSS plant and animal populations themselves which are exposed to legacy contamination, and 3) the radionuclide body burdens of animals and plants which burrow into or grow on State-approved waste covers of radioactive waste disposal cells. Such monitoring documents whether public and biota doses from legacy contamination exceed DOE limits and if the covers of waste disposal cells maintain their integrity. The program includes routine sampling of plants and animals in known contaminated and uncontaminated control areas of the NNSS and in the Area 3 Radioactive Waste Management Site (RWMS) and the Area 5 RWMS.

Over 24 game animals have been sampled since 2001 for radioanalysis from over five separate contaminated surface soil or surface water sites and their respective control sites. [2] The majority are small game animals (e.g., Gambel's quail, mourning dove, cottontail rabbits), which are

captured and sacrificed for analysis. Trapping efforts for these animals are often budget and manpower limited. Large game animals such as deer and pronghorn are sampled opportunistically (e.g., from roadkills). The largest component of dose to the public in 2011, as in previous years, is estimated to come from the ingestion of game animals in comparison to the other pathways of air, direct radiation, and drinking water. [2]

TABLE 1. Estimated radiological dose to the public from 2011 NNSS operations

	Dose to Public	
Pathway	**(mSv/yr)**	**(mrem/yr)**
Ingestion of wildlife	0.0047	0.47
Air	0.0007	0.07
Direct	0	0
Water	0	0
All Pathways	0.0054	0.54

Site biologists conducted a multi-step process in 2003 to identify NNSS plant and animal populations at risk of exceeding the biota dose limits established that year: 1 rad/day for aquatic animals and terrestrial plants, and 0.1 rad/day for terrestrial animals. [5] A graded approach was followed to best utilize existing funds and resources. Existing data on surface water and soil contamination were used to identify over 30 dose evaluation areas (DEAs) (i.e., areas of surface water and soil contamination) in which doses to biota were estimated with DOE-approved computer models. Biota doses within the DEAs were found to be below the DOE dose limits, [6] but site-specific sampling of plants and animals, conducted under the RREMP at low intensity over consecutive years, is necessary to support this preliminary finding.

NNSA/NSO also conducts the Ecological Monitoring and Compliance (EMAC) Program on the NNSS which ensures compliance with applicable laws and regulations related to species and ecosystem protection, defines and delineates NNSS ecosystems, and provides ecological information that can be used to predict and evaluate the potential impacts of proposed projects and programs on those ecosystems. EMAC tasks include Endangered Species Act (ESA) [7] compliance, Migratory Bird Treaty Act compliance, wetlands and natural water source monitoring, revegetation for soil stabilization and habitat restoration, habitat mapping, monitoring biological impacts of chemical release tests at the Nonproliferation Test and Evaluation Complex, and identifying and monitoring the distribution of important plant and animal species throughout the NNSS. Important species include those whose long-term viability has been identified as a concern by natural resource experts or those classified as protected, and/or regulated by state or federal agencies.

The use of available funds within both programs, under a climate of restricted budgets, is prioritized to first ensure that compliance with federal and state regulations is maintained. For the RREMP biota monitoring program, this means that public dose pathways are assessed annually,

that plant and animal dose assessments are performed based on a graded approach over time, and that periodic radioanalysis of biota from waste covers are conducted. For the EMAC program, this entails that all permit requirements issued by the U.S. Fish and Wildlife Service (USFWS) to NNSA/NSO to conduct work in the habitat of the desert tortoise, protected as a threatened species under the ESA, are followed and that migratory birds, their nests, and eggs continue to be protected from harm. Additional studies which may enhance biota dose monitoring, ecosystem monitoring and preservation and may support DOE environmental policy and site sustainability goals of land remediation and reuse are often unable to be implemented. Collaboration with outside agencies and organizations within the past few years have provided opportunities to obtain needed funding and/or ecological information of benefit to both the RREMP and EMAC programs.

Current Collaborations Enhancing NNSS Biological Programs

NNSA/NSO collaborated with the USGS in 2010 and initiated a radiotelemetry study of mountain lions to be captured and collared on the NNSS. Mountain lions are regulated by the State of Nevada as a game animal. They occur on the site and are known to prey on mule deer, bighorn sheep, and wild horses, as well as smaller carnivores such as coyotes. The NNSS and surrounding areas encompassing the Nevada Test and Training Range, Tonopah Test Range, and Desert National Wildlife Range constitute one of the largest areas (over 15,540 square km) in North America where human-caused mountain lion mortality is extremely low, and the size of the area is large enough to allow for the emergence of population dynamics likely to typify an unexploited population of lions. This area is also located in some of the driest ecosystems in North America with relatively low prey densities. Of primary interest to NNSA/NSO is the safety of the work force. Workers have spotted mountain lions near facilities, in 2010 a mountain lion was accidentally killed by a vehicle, and in 1991 a site biologist was attacked by a mountain lion.

NNSA/NSO collaborated with the USGS, Southwest Biological Research Center (SBRC) to begin a multi-year radiotelemetry study of NNSS mountain lions. NNSA/NSO's initial goal was to gather information helpful in the management of human activities to reduce worker exposures to mountain lions at times and places where they are most likely to be predatory. The USGS provides personnel to trap and affix radio collars to the animals and performs all data analysis and report preparation in exchange for access to the site and the use of site biologists to collect needed information from documented mountain lion kill sites (e.g., species, age, sex of prey animals killed). To date, seven mountain lions have been captured and radio collared. Three have died while being monitored, one from a suspected fall, one from potential trapping injuries, and one from unknown causes. The study is already providing USGS with valuable natural history information (e.g., home range, prey selection, and kill frequencies) and data useful for comparisons with mountain lion data gathered from two other USGS study sites in Arizona. One female NNSS lion killed 18 mule deer and 13 desert bighorn sheep on and around the NNSS; these

kills document for the first time that a reproducing population of bighorn sheep occur on the NNSS. One male has a documented home range of 3,844 square km and may be one of the largest documented for mountain lions. [2]

The remains of prey animals killed by mountain lions, while providing useful ecological data to the USGS, are sampled by site biologists for tissue radioanalysis as a means of obtaining more information on the levels of contamination in game animals which may be hunted and consumed by humans. The collaboration provides NNSA/NSO with sample collection opportunities for large game species for the radiological biota monitoring program which would not be possible otherwise. As mentioned previously, ingestion of hunted NNSS game animals is currently the most realistic pathway of exposure to NNSS radionuclide contamination to the off-site public and additional samples to better quantify radionuclide body burdens in big game are of value.

A successful collaboration agreement was finalized in February 2012 between NNSA/NSO, the USFWS, and the San Diego Zoo Institute for Conservation Research (ICR). This collaboration allows site biologists to conduct a desert tortoise radiotelemetry study of their movements. The desert tortoise is the only federally protected species on the site which has the potential to be impacted by NNSS activities. It is listed as threatened under the ESA and occurs in the southern third of the site. Activities on the NNSS in desert tortoise habitat must comply with a Biological Opinion, which was first issued to NNSA/NSO by the USFWS in 1992. NNSA/NSO has disturbed 181 hectares of tortoise habitat since 1992, which has been mitigated under USFWS requirements, by the payment of nearly $300,000 of NNSA/NSO project funds to a Desert Tortoise Public Lands Conservation Fund. This fund supports the operation of the Desert Tortoise Conservation Center (DTCC) located near Las Vegas, Nevada and operated by the San Diego Zoo Institute for Conservation Research (ICR). The DTCC cares for over 2,000 captive tortoises that have been legally displaced from the wild, predominately by permitted construction activities within Clark County. The mitigation fees paid by NNSA/NSO provide no protection benefits to onsite tortoise populations.

Desert tortoise protection activities carried out by site biologists and project personnel mandated under the ESA are effective. No tortoises have been harmed or killed by new project activities since 1992. However, 14 tortoises have been accidentally killed on paved roads. Such deaths are minimized by worker education, posted road signs, and by workers who move tortoises off paved roads out of harm's way. Site biologists developed a proposal to study roadside tortoise movements to determine effective ways to further minimize such deaths and approached the USFWS in November 2011 requesting funds to conduct the study. Requests for funds from the USFWS is allowed, and funds can be issued by the USFWS for approved tortoise conservation projects. A successful collaboration agreement was finalized in February 2012 with the Desert Tortoise Recovery Office (DTRO) of the USFWS and the San Diego Zoo ICR. The USGS, Biological Resources Division (BRD) was also a contributing collaborator in providing biological

expertise. The agreement offered NNSS lands as a needed translocation research site for tortoises being held at the DTCC in exchange for funds to purchase radiotelemetry equipment needed for the NNSS roadside tortoise movement study. The NNSS radiotelemetry study began in May 2012 and site biologists are currently collecting movement data from 11 adult tortoises. The San Diego Zoo ICR released 60 juvenile desert tortoises onto the NNSS in September 2012 and uses community volunteers, university students, and San Diego Zoo researchers to conduct the work.

The NNSA/NSO has collaborated with the Southern Nevada Health District (SNHD) since 2004 to determine if mosquitoes on the NNSS carried the West Nile Virus (WNV). WNV is a potentially serious illness that spreads to humans and other animals through mosquito bites. It was first detected in southern Nevada in 2004. NNSS biologists worked with SNHD personnel to learn the proper sampling protocol and establish sampling locations throughout the NNSS using traps provided by SNHD. Mosquitoes are sampled annually by site biologists and identified and tested for WNV by SNHD personnel. Although mosquito species known to carry the virus occur on the NNSS, to date, no individuals have tested positive for WNV. This exchange of labor for analysis results assists NNSA/NSO in monitoring the potential health risks to NNSS biota as well as to workers. This collaboration benefits SNHD by avoiding the added costs of sampling this region of southern Nevada.

TABLE 2. Summary of benefits from ongoing collaborations

Agency/Entity	CollaborationBenefits
Desert Tortoise Movements Study	
NNSA/NSO	Receipt of funds from USFWS DTRO to purchase radiotelemetry equipment Receipt of training from USFWS for desert tortoise health assessments, tortoise handling, and radio transmitter application Access to data and expertise from San Diego Zoo ICR and USGS personnel upon request Application of study results which will enhance the protection of the NNSS tortoise population
USFWS DTRO	Furthers DTRO's primary mission of tortoise population recovery Acquisition of data needed to design effective relocation programs
San Diego Zoo ICR	Access to lands protected from human impacts on which to conduct relocation studies
USGS BRD	Access to data and expertise from NNSA/NSO and San Diego Zoo ICR personnel upon request
Public and University Community	Volunteer opportunities and undergraduate and graduate degree program opportunities
Mountain Lion Radiotelemetry Study	
NNSA/NSO	Provision of experienced researchers to trap and radio collar mountain lions Receipt of information and NNSS maps on seasonal probability of mountain

	lion activity and predation to help manage human activities on the NNSS to minimize human/lion interactions Acquisition of large game animal tissue samples for radioanalysis to better assess the radiological dose to hunters from ingestion of NNSS game animals
USGS SBRC	Receipt of funds from the NNSA/NSO to provide trappers and radio collars Acquisition of ecological and natural history information for comparison with other USGS radiotelemetry studies of mountain lions in other distinctly different habitats
West Nile Virus Surveillance	
NNSA/NSO	Acquisition of information on mosquito species' distribution on the NNSS and on the incidence of WNV in NNSS mosquito population
SNHD	Collection and delivery of NNSS mosquito samples for WNV analysis

In addition to the collaborations mentioned above, over the past ten years NNSA/NSO has opened the site to other outside entities including 8 universities/colleges/science academies, one museum, the Desert Research Institute, the U.S. Forest Service, the USGS, and an environmental consulting firm. Site biologists have provided site support for their ecological investigations regarding ants, termites, crane flies, camel crickets, camel spiders, skinks, breeding birds, burrowing owls, bats, kangaroo mice, small mammal population changes, forest inventory and health analyses, and long term climate change.

The NNSS as a Unique Outdoor Laboratory for Collaborations

The NNSS is a unique laboratory for continued ecological and radiological investigations which reach beyond the scope of regulatory compliance. The NNSS was designated as a DOE National Environmental Research Park (NERP) in 1992. It is one of seven NERPs within the DOE complex which also include Savannah River, Idaho, Los Alamos, Oak Ridge, and Fermilab. According to the NERP Charter, the parks are 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. Each NERP resides in a different ecoregion; the NNSS lies within the Desert Shrub Ecoregion.

The NNSS is unique for several reasons other than its designation as a NERP. First, is its unique history as the nation's nuclear weapons testing site. Numerous studies have been conducted over the past four decades to document the types and extent of disturbances to plants and animals that may have resulted from nuclear testing activities on the NNSS. Many of the studies focused on the fate and effects of radionuclides, especially transuranics. Long-term impacts due to nuclear tests and nonradiological causes were also investigated. [8] The ecological fate of radionuclides at this historic site and their ecosystem impacts decades later can continue to be investigated.

Secondly, the NNSS is located along the transition zone between the Mojave Desert and Great

Basin Desert. As a result, this site has a diverse and complex mosaic of plant and animal communities representative of both deserts, as well as some communities common only in the transition zone between these deserts. [9] A total of 752 taxa of vascular plants have been collected in ten major vegetation alliances. Twenty vegetation associations from among the alliances have been identified and mapped. Seventeen vascular plants and 1 non-vascular plant on the NNSS are considered to be sensitive by the Nevada Natural Heritage Program. Sensitive species are those whose long-term viability has been identified as a concern by natural resource experts. Among the animals known to occur on the NNSS, there are approximately 1,200 invertebrates, 34 reptiles, 239 birds, and 59 mammals. No native fish or amphibian species are known to occur on the site. [9] The desert tortoise is the only resident species that is listed as threatened under the Endangered Species Act. All but five birds on the NNSS are protected under the Migratory Bird Treaty Act and/or by the State of Nevada. Most non-rodent mammals of the NNSS are protected by the State of Nevada and managed as game or furbearing mammals, and 13 bats on the NNSS are considered sensitive species. [9] The NNSS may offer biological and ecological research opportunities for students desiring to work within these desert zones and with the diverse biota which inhabit the site.

Thirdly, it is a site which has remained isolated from public access since the 1940's and the majority of the site remains relatively undisturbed from direct human impacts. As a result, numerous undisturbed study plots that were established decades ago still exist within radiological impact areas and uncontaminated control areas. These plots continue to offer invaluable reference and study areas for long-term ecosystem processes such as natural revegetation, the spread of invasive species, and contaminant transport. Also, because of its restricted public access and mission, no hunting, agriculture, livestock grazing, or plant harvesting has occurred for decades on site.

CONCLUSIONS

The NNSS is an historical nuclear testing site as well as the premier federal site supporting nuclear stockpile stewardship, nuclear emergency response, nonproliferation, counterterrorism, and management and disposal of low-level and mixed low-level wastes from DOE and U.S. Department of Defense facilities. The NNSS also provides support facilities and capabilities for other agencies/organizations involved in defense-related activities. To support these current missions, NNSA/NSO maintains two biological programs, the RREMP and the EMAC program. They use limited funds to ensure compliance with all applicable federal and state regulations. Their focus is to ensure that direct impacts from current missions and from historic legacy contamination do not significantly impact the public or onsite biota, including protected fauna.

Over the past several decades, numerous biological and ecological investigations not directly related to the site's primary missions, have been conducted on the NNSS. They have been funded by DOE and/or in part by outside entities. Those site features which continue to make the NNSS

attractive to biological and ecological research are its diverse flora and fauna, transitional setting between two ecoregions, restricted public access, and the availability of historical study plots undistrubed by widespread human impacts such as grazing and hunting. Recognized for its value as one of several unique outdoor laboratories within the complex of DOE managed facilities across the U.S., it is designated a National Environmental Research Park.

Current collaborations with the USGS, USFWS, and the SNHD have been mutually beneficial. They have provided additional radiological tissue samples for the RREMP, funding for conservation measures directly benefiting NNSS desert tortoises, and WNV surveillance for the NNSS. In return, these agencies have received free labor from experienced field biologists and access to the NNSS, providing needed protected lands for the relocation of juvenile threatened desert tortoises, and increasing the aerial extent and field data of mountain lion and WNV investigations.

NNSA/NSO views ecological programs on the NNSS, conducted in collaboration with others, as an opportunity to share a valuable land resource with the environmental community and fulfill NNSA/NSO's site sustainability goals for site "reuse" in the arena of ecological research whenever such research does not conflict with current site missions. A major key to successful monitoring of the site ecology is developing partnerships with other agencies and non-Federal entities. This includes sharing inventory, monitoring, research and study data with national repositories such as other Federal and State agencies as appropriate, universities, and among DOE offices. NNSA/NSO as a federal agency and landlord of a significant piece of land is committed to working collaboratively with other agencies to provide research opportunities that benefit ecological and conservation science.

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