

Assessing the Effects of Forest Management and Wildfire on Populations of New Mexico's Endemic Salamanders

NMDGF Share with Wildlife Grant, Final Project Report 2021; results through 30 May 2022

NMDGF Share with Wildlife Grant –Interim Project Report 2022; results through 15 June 2022

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Project Objectives

The primary objectives of this project are to: (1) Quantify the population demography of Sacramento Mountain salamanders (*Aneides hardii*) (population size, density, sex ratio, and age class structure) as related to forest structure, composition, and disturbance history; (2) Evaluate the impacts of wildfire, along a burn severity gradient, on occupancy of *A. hardii*; (3) Calculate detection probabilities for populations; (4) Identify the temperature and precipitation thresholds, and durations of those thresholds, that initiate or cause the cessation of surface activity in *A. hardii*; and (5) Summarize results in a way that informs land managers about the status of *A. hardii* in relation to conservation and habitat restoration needs.

This project began during the 2021 field season supported by Share with Wildlife funds and will continue in 2022. The results below represent our progress through May 2022.

Final Project Report 2021 (results through 30 May 2022)

Project status and, where relevant, results are provided below for the six primary tasks included in the project agreement.

1. To evaluate the demography of *A. hardii* populations, we established plots for mark-recapture surveys in the White and Sacramento Mountains. In each mountain range, we selected two sites and at each site delineated three 25 x 25 m plots located at least 100 m from one another. In the White Mountains (Smoky Bear District, Lincoln National Forest), plots were established at Big Bear Canyon and Ski Apache; in the Sacramento Mountains (Sacramento District, Lincoln National Forest), plots were established at Lightning Lake and Russia Canyon (Figure 1). Sites were located at least 5 km from one another. We were unable to establish plots in the Capitan Mountains because of their remoteness, challenging driving terrain, lengthy time required to reach suitable habitat, and concerns about our ability to resurvey these sites regularly within the optimal survey timeframe for *A. hardii*.

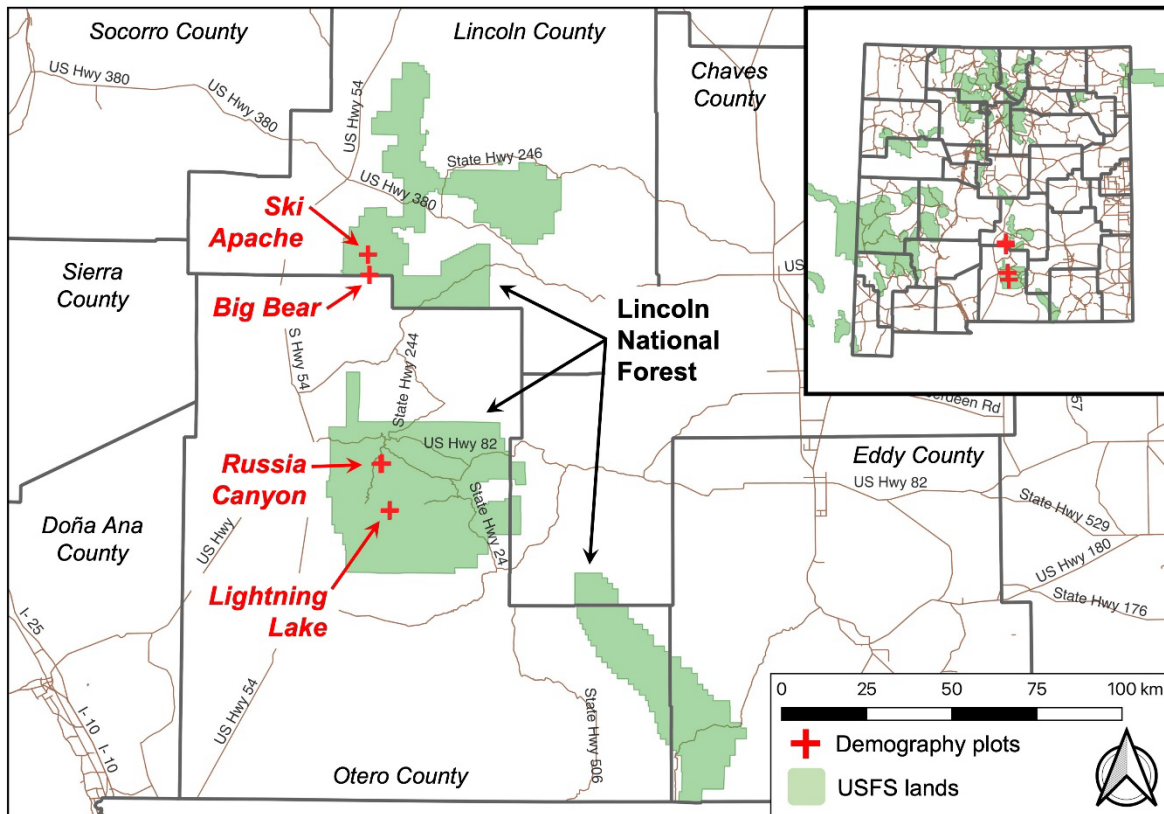


Figure 1. Locations of demography plots for the Sacramento Mountain salamander (*Aneides hardii*) at two sites in the Smokey Bear District and two sites in the Sacramento District on the Lincoln National Forest.

We surveyed plots every two weeks during the monsoon season (end of June through August 2021) for salamanders by turning over all rock and wood cover objects and searching other suitable microhabitats, including bark, leaf litter, and moss mats. We weighed, measured, and determined the sex of all captured salamanders; most captured salamanders were swabbed for pathogens. Salamanders with a trunk length >30 mm (adults) were anesthetized using tricaine methanesulfonate (MS-222). Adult salamanders were then injected (subcutaneously on the right lateral side of the body) with a 9 mm passive integrated transponder (PIT) tag containing a unique numeric code. After PIT tag implantation, salamanders recovered in fresh water. Smaller salamanders were injected subcutaneously on the venter with visual implant elastomer, a fluorescent polymer applied in unique locations and color combinations to identify individuals. After processing, salamanders were released beneath the detection cover object.

We captured 625 salamanders in demography plots during the 2021 field season (Table 1). Of these, 24% were marked with PIT tags and the remainder were marked with visual

implant elastomer. We recaptured 13% of marked salamanders once, and three salamanders were recaptured more than once. Based on data collected from the first season, 55% of salamanders captured were subadults and 51% of adults were females.

Table 1. Sacramento Mountain salamanders (*Aneides hardii*) captured in demography plots by site in 2021. These numbers do not include recaptures of marked salamanders.

Mountain range Site	Number subadults	Number females	Number males	Number unknown sex	Total salamanders
White Mountains					
Big Bear	5	2	0	0	7
Ski Apache	112	41	48	1	202
Sacramento Mountains					
Lightning Lake	130	50	47	1	228
Russia Canyon	97	50	41	0	188
Total	344	143	136	2	625

We swabbed 40% of salamanders in demography plots for pathogens, and these samples will be analyzed by Pisces Molecular (Boulder, CO) for chytrid fungi (i.e., *Batrachochytrium dendrobatidis* and *Batrachochytrium salamandrivorans*) and ranavirus with funding from the New Mexico Department of Game and Fish (provided by Leland Pierce). Standard biosecurity and disease protocols were followed for all sampling: boots and equipment that contacted soil or salamanders at a site were decontaminated with Virkon after each visit to a site, and a new pair of nitrile gloves and bag were used to handle or contain each salamander.

2. To evaluate the impacts of wildfire severity on salamander occupancy, we conducted two-hour time-constrained surveys for *A. hardii* in areas that were unburned, burned at low/moderate severity, or burned at high severity within the Capitan (n = 21), White (n = 48), and Sacramento (n = 37 sites) Mountains of the Lincoln National Forest. To select survey sites, we used spatial data available on the Monitoring Trends in Burn Severity website (<https://burnseverity.cr.usgs.gov/products/mtbs>). Each site was surveyed once, and measurement and release of salamanders followed the methods described above. No salamanders were marked during occupancy surveys.

Table 2. Sacramento Mountain salamander (*Aneides hardii*) detections by burn severity class at sites in the Capitan, White, and Sacramento mountains, Lincoln National Forest, New Mexico in 2021.

Mountain range	Number of sites surveyed	Percent of sites occupied	Percent of sites historically occupied	Number of salamanders detected
Burn severity at surveyed sites				
Capitan Mts.				
Unburned	7	14	57	2
Low-moderate severity	8	25	63	2
High severity	6	17	33	2
White Mts.				
Unburned	11	27	45	205
Low-moderate severity	27	44	78	57
High severity	10	40	70	38
Sacramento Mts.				
Unburned	21	71	100	588
Low-moderate severity	9	0	33	0
High severity	7	0	71	0
All mountains				
Unburned	39			795
Low-moderate severity	44			59
High severity	23			40

- During the 2021 field season, we collected microhabitat data for most captured *A. hardii*. However, because we repeatedly surveyed the demography plots, and thus recaptured salamanders and resampled microhabitats, and only surveyed occupancy sites once, we report here (1) microhabitat data for all salamanders captured in demography plots on the single day during the season with the highest number of salamanders captured, and (2) most salamanders captured during occupancy surveys. We recorded geographic coordinates and characteristics of the rock or woody cover object under which a salamander was found (rock:

geologic type, dimensions, percent embedded in soil, and whether it was layered with other rocks; log: species, dimensions, decay class, percent char on log surface, and whether the log had fallen or had been cut). We also recorded percent ground cover by rock, wood, or vegetation (herbaceous and woody) and canopy cover in a 1 x 1 m plot centered on the point of capture. These data have been entered into a database for all salamander observations (captures and recaptures) and are currently being error-checked before data summary can be completed.

Of 711 salamanders captured in the White and Sacramento Mountain ranges for which microhabitat data were collected, 56% of salamanders were found under or within logs and 44% were found under rocks, but cover object association differed between mountain ranges. In the White Mountains, 9% of salamander detections were associated with logs and 91% were associated with rocks. In the Sacramento Mountains, 81% of salamander detections were associated with logs and 19% of detections were under rocks. Because of time constraints, we were unable to collect data on availability of cover object types around salamander capture locations. Thus, we cannot make a comparison of use versus availability of cover objects.

For the 2022 field season, we plan to quantify stand-scale characteristics. To do this, we will establish 20 x 25 m forest inventory and fuels plots within our salamander demography plots using standard fire ecology monitoring protocols outlined in the National Park Service Fire Monitoring Handbook (<https://www.nps.gov/orgs/1965/upload/fire-effects-monitoring-handbook.pdf>) to collect information on canopy composition and structure, understory composition and structure, and surface fuels. We will also measure leaf area index (LAI), a key forest structural characteristic and a measure that scales from stand to landscape levels (Roberts et al. 2004), using a LI-COR LAI-2200C Plant Canopy Analyzer. After the field season, we will compile information on the history of wildfire, timber harvest, thinning, and prescribed burns at each site.



Figure 2. HOBO weather station monitoring environmental variables in a Sacramento Mountain salamander (*Aneides hardii*) demography plot. Orange flagging indicates the location of the instrumented rock.

4. To understand the environmental conditions that influence vertical (from below ground to surface) and horizontal (across the ground surface) salamander movements, we combined bi-weekly surveys of PIT-tagged salamanders, using enhanced detection technology, with environmental monitoring by weather stations. Prior to initiating surveys, we installed HOBO weather stations (Figure 2) in each plot that record ambient temperature, precipitation, and relative humidity just above ground level; soil temperature and moisture beneath one log and temperature within the center of the log; and soil temperature and moisture beneath one rock. Instrumented logs and rocks are of dimensions and types commonly used by salamanders. Weather stations were surrounded in hardware cloth and wiring was buried below ground to protect sensitive instruments from damage by rodents or other small animals. Weather stations were set to record measurements continuously every 30 minutes for the duration of the study.

Models relating the location of salamanders to aboveground microenvironmental characteristics and to soil moisture and thermal conditions provide important information that can guide the timing of management treatments relative to seasonal conditions and within-season weather events based on likely salamander activity patterns. For example, model results can be used to determine the timing of treatments after weather events or within soil moisture and temperature thresholds such that salamanders are likely underground and

deleterious impacts to salamanders are minimized. Model independent variables include precipitation amount, air temperature, relative humidity, and soil moisture and temperature at the surface and at varying depths below cover objects, all assessed at varying intervals preceding salamander detections and movements (e.g., in the preceding 24-, 48-, or 72-hrs). Model covariates include variables that may influence aboveground microenvironments and soil moisture and thermal regimes, including topography (e.g., elevation, slope, and aspect), soil type, and forest structure and composition. Our data will also allow us to evaluate whether and how salamander cover objects (logs and rocks) respond to seasonal and event-scale weather, including whether they differentially retain moisture based on cover object type, condition, and dimensions. This information is important for understanding how natural disturbances (e.g., wildfires and beetle outbreaks) and management treatments (i.e., thinning and prescribed fire) that affect the presence and characteristics of cover objects may influence salamander habitat and for developing guidelines for restoration treatments that can include intentional provisioning of cover objects.

During bi-weekly visits to demography plots, the entire plot area was scanned for PIT-tagged salamanders using a PIT tag reader (Biomark HPR Plus) and antenna (Biomark BP Plus). The antenna permits detection of tagged salamanders beneath rocks, logs, and other cover objects and up to about 25 cm below ground (Figure 3). Upon detection of a PIT-tagged salamander, the reader emits a beep and the unique PIT tag code of the salamander is displayed on the screen. For salamander detections using the antenna, we recorded geographic coordinates at the point of detection and the cover object type associated with the detection.



Figure 3. Intern searching for PIT-tagged salamanders in and around cover objects. Orange flags show the previous survey's locations of a male and a female salamander detected within the log.

Of 148 salamanders PIT-tagged in demography plots, we redetected 58% during scanning of plots. Most salamanders did not move between scans of plots. For individuals that changed locations between scans, salamanders moved, on average, 1.1 m. The longest distance a salamander moved between scans was 28 m.

5. We plan to use Cormack-Jolly-Seber models and open population Jolly Seber models to estimate apparent survival and recapture probabilities and population size, respectively, for the *A. hardii* populations for each site from data collected in our demography plots. We will generate density estimates and compare densities, sex ratios, and age class structures among sites. We will use microhabitat data collected at each salamander detection location to interpret differences in size and structure among populations.

We plan to use data collected from repeated surveys of demography plots to model detection probabilities for *A. hardii* and evaluate whether these probabilities vary between the surveyed mountain ranges. We will use the detection probability estimates for each site to calculate how many surveys are needed to determine, with 95% confidence, that salamanders are not present at a given site.

6. We plan to summarize the results from all five tasks above to develop conservation guidelines and actions to inform the protection of remaining *A. hardii* populations and the restoration of habitats within their geographic range

Interim Project Report 2022 (results through 15 June 2022)

From 15 April through 15 June 2022, in preparation for the 2022 field season, we undertook the following tasks related to this project:

1. We selected sites along a burn severity gradient (unburned, burned at low/moderate severity, burned at high severity) as target sites for occupancy surveys in 2022. Although we conducted occupancy surveys in the Capitan Mountains in 2021, the roads into these mountains are steep and dangerous, particularly during a monsoon precipitation event, and it can take three hours or more to reach a single site for a survey. We do not expect to continue occupancy surveys in the Capitan Mountains for safety reasons and time constraints. However, we have selected 42 sites in the White Mountains (19 unburned, 3 burned at low/moderate severity, and 20 burned at high severity) and 53 sites in the Sacramento Mountains (9 unburned, 21 burned at low/moderate severity, and 23 burned at high severity) at which we intend to conduct occupancy surveys. These numbers will ensure that occupancy surveys will be distributed across 30 sites in each burn severity class on each mountain range.
2. We began preparing gear for the 2022 field season, including printing data sheets, purchasing consumable field supplies, updating maps, and replacing batteries in electronics. We hired a

new graduate student (Marissa Ardovino) to lead the field work and two undergraduate students (Noah Goldthwait and Lily Collyer) to assist; submitted travel authorizations for each hired student; coordinated with the Smokey Bear District wildlife biologist (Larry Cordova) and Sacramento District wildlife biologist (Phillip Hughes); and located housing for the field crew in Ruidoso.