INVENTORY AND MONITORING OF SENSITIVE SPECIES IN THE GARDNER MOUNTAIN WILDERNESS STUDY AREA, WYOMING

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Introduction

Wyoming has 42 Wilderness Study Areas (WSAs) on Bureau of Land Management (BLM) lands. As part of the National Landscape Conservation System (NLCS) these WSA's are currently managed to preserve their natural characteristics. However, basic knowledge of the natural resources within many WSA's is severely limited, impacting BLM Wyoming's ability to manage these areas. As a result, BLM Wyoming drafted a strategy for its NLCS lands in order to identify and address information needs and develop cohesive goals and guidelines for managing NLCS lands across the state (BLM 2013).

The Gardner Mountain WSA is one of BLM Wyoming's NLCS units for which very little knowledge of its biological resources exists. Additionally, part of the Dull Knife Battlefield National Historic Site extends onto the WSA. The WSA lies at the southern end of the Bighorn Mountain Range in north-central Wyoming. The unit's location and its steep, rugged terrain make access difficult. No hiking trails currently exist, limiting even primitive recreational activities in the area. Difficult access also limits BLM Wyoming's ability to reach its goal of increasing public participation in the conservation, protection, and restoration of NLCS lands in the state.

Very little is known about the biota of this WSA. Several charismatic wildlife species (Bald Eagles, Peregrine Falcons, etc.) are known to migrate through the Gardner Mountain WSA and two creeks in the WSA are classified as important trout waters and fisheries of regional importance by the Wyoming Game and Fish Department. However, almost no data exists on the vast majority of plant and other animal species likely to occupy the WSA. Many species on the BLM Sensitive Species list and Wyoming Game and Fish Department's (WGFD) Species of Greatest Conservation Need may occur in the WSA, but formal surveys have not been conducted to confirm species occurrence.

WYNDD is a service and research unit of the University of Wyoming dedicated to the collection and dissemination of unbiased data on the biology and status of sensitive species in Wyoming (http://uwadmnweb.uwyo.edu/wyndd/). Our mission is to generate information that helps organizations like the BLM make effective management decisions. Along these lines, WYNDD has worked with the Wyoming Game and Fish Department and other state and federal experts to develop revised range maps and predictive distribution maps for sensitive species in Wyoming. These projects have allowed WYNDD to identify gaps in our knowledge of sensitive species distributions across the state. The biota of the Gardner Mountain WSA is one of those information gaps.

Purpose & Objectives

The purpose of this project was to fill information gaps for Sensitive Species suspected to occur in the Gardner Mountain WSA, assist the BLM Buffalo Field Office in designing and establishing a monitoring framework for key resources in the WSA, and to provide NLCS Wyoming with public outreach materials. This was accomplished by conducting a targeted inventory of local biota using a suite of survey and monitoring methods at key locations across the Gardner Mountain WSA.

Specific objectives for the project were to:

1) Work with BLM Buffalo Field Office to develop a list of target species in order to fill gaps in our knowledge of the occurrence and status of these species in the Gardner Mountain WSA.
2) Work with the BLM Buffalo Field Office to design and establish survey and monitoring protocols for target taxa, and for water quality and riparian assessments.

3) Sample invertebrate assemblages and measure basic water quality to assess the ecosystem health of rivers and streams in the Gardner Mountain WSA.
4) Inventory pollinators across different habitats within the Gardner Mountain WSA.
5) Assess recreational and educational opportunities for the Gardner Mountain WSA.
6) Provide the Buffalo Field Office and the Wyoming State Office of the BLM with a list of sensitive species occurring in the Gardner Mountain WSA, which can be used to support informed management decisions.
7) Provide BLM Wyoming with photo documentation of biological, recreational, and aesthetic resources in the Gardner Mountain WSA to be used in future public outreach efforts.
8) Use results to update species range maps and predictive distribution models in Wyoming.

Methods

Study Area

The Gardner Mountain WSA encompasses 2,600 ha (6,423 acres) along the southern end of the Bighorn Mountain Range in north-central Wyoming (Figure 1). The WSA ranges in elevation from approximately 1,740 to 2,380m (5,700 to 7,800ft) above sea level. Several major habitat types can be found within the WSA including Douglas-fir (*Pseudotsuga menziesii*) and ponderosa pine (*Pinus ponderosa*) forests, mountain meadows, grasslands, shrublands, and riparian areas associated with two large canyons. These two steep-walled canyons are formed by Beartrap Creek and the North Fork of the Red Fork of the Powder River.

Inventory and Monitoring

The Wyoming Natural Diversity Database worked closely with the Buffalo Field Office of the BLM to develop a list of taxa to target during inventory and monitoring efforts. Together, WYNDD and the Buffalo Field Office also developed repeatable survey methodologies for the different taxa. Due to the remoteness and ruggedness of the WSA, standard methodologies often had to be modified. During this study we established repeatable survey protocols and monitoring sites, and used these protocols to collect baseline data on all target taxa. All protocols and datasheets used are documented in Appendix 1 and locations of all monitoring sites are provided in associated supplemental GIS shapefiles.

Field surveys were conducted during two trips to the WSA in the summer of 2013. Three WYNDD and two BLM personnel conducted inventory and monitoring surveys from 24-28 June. For June surveys, we targeted birds, sensitive plant species, pollinators, riparian assessments, aquatic invertebrates, recreational opportunities, and mapping of limber pine stands. We conducted a second trip to the WSA from 21-25 July. Surveyors for the July trip included four WYNDD and seven BLM personnel. We targeted bats, reptiles, pollinators, raptor nests, and limber pine stand assessments during the July trip. Copies of completed field datasheets are available in Appendix 2 and spreadsheets with results are also provided as supplemental material.

Birds

Site selection

Point count transects were established in a stratified random fashion in a Geographic Information System (GIS). First, we randomly placed three points within each GAP land-cover category polygon within the WSA boundary (Davidson et al. 2009). We then generated a 1,500m line transect oriented in a random direction so long as it remained within the WSA boundary. We placed 12 points spaced at 250m intervals along these lines. For surveys, we selected transects that would provide good spatial coverage across all habitat types within WSA (Figure 2 and supplemental GIS shapefiles). Because riparian habitats were poorly represented by our randomly placed point count transects, we conducted point counts along Beartrap Creek and the North Fork of the Red Fork of the Powder River using hand-held Global Positioning System (GPS) units to place points 250m apart (Figure 3).

Point count methodology

Point count methods were adapted from the Integrated Monitoring In Bird Conservation Regions land bird monitoring program (Hanni et al. 2013). Each point count survey consisted of a line transect with 12 points spaced at 250m. At each point, a three-minute point count was conducted. We attempted to complete all 12 points during each point count survey but were unable to in some cases due to time or terrain limitations. Point count surveys should begin one half hour before local sunrise. Due to terrain and difficulty accessing point count transects, however, we were not always able to start at the recommended time. Surveys ended no later than five hours after local sunrise. Surveyors recorded the start time for each point count conducted. For every bird detected during the three-minute point count, we recorded: species, sex, horizontal distance to the bird, minute of the point count during which the bird was detected, type of detection (i.e. call, song, visual), and whether or not the observer was able to visually identify the bird. We measured the distance to each bird detected using a laser rangefinder. If it was not possible to measure the distance to a bird, we estimated the distance by measuring the distance to an object near the bird. We also recorded any bird species not previously detected during a point count while traveling between points within a transect. At the start and end of each survey, we recorded time, ambient temperature, cloud cover, precipitation and wind speed. Before beginning each three-minute count, we collected ocular vegetation data within a 50m radius of the point (Hanni et al. 2013). Vegetation data included: dominant habitat type; relative abundance, percent cover and mean height of trees and shrubs by species, and grass height and ground cover types. These vegetation data were recorded quietly before beginning each point count to allow birds time to return to their normal habits prior to beginning each count.

In addition to formal point count surveys for birds, we also recorded any bird species not previously detected during point count surveys while conducting surveys for other taxa within the Gardner Mountain WSA.

Mammals

Bats

We conducted two types of bat surveys: active mist-netting and passive acoustic monitoring. Capturing live bats with mist nets allowed us to verify species presence, inspect individuals for disease, assess physical condition, and collect demographic information. Passive surveys allowed us to efficiently collect species presence information from multiple sites each night.

Mist Net Surveys

At suitable mist net sites, 6m mist nets[1] were suspended over water between aluminum poles in single-high arrangements to catch bats while feeding or drinking. Mist nets were opened at dusk unless nontarget taxa (e.g. birds) were active at the site. In this case, nets were opened as soon as bird activity ceased. Nets were checked for captures at least every 15 minutes and captures were removed from nets immediately to minimize injury or stress associated with being in the net. Surveyors removed bats from nets with great care to protect wing bones and patagia. All captures were removed from nets, processed and released within 30 minutes of capture. Nets were not set in high winds or temperatures below 40ºF to minimize bat stress and injury. Once removed from the net, captures were placed in a paper bag for transport and processing to minimize stress. Captured bats were measured (forearm length, ear length), weighed, sexed, aged, identified to species, and released on site (see datasheet in Appendix 1A). Additionally, the membranes of both wings and the uropatagium of each captured bat were inspected following the methods presented by Reichard and Kunz (2009). After each survey, we decontaminated all survey equipment and supplies following the National White-Nose Syndrome Decontamination Protocol Version 06.25.2012 (2012). We also followed all guidelines laid out in the Wyoming White-Nose Strategic Plan (Abel and Grenier 2011).

At each mist net survey site, acoustic monitoring equipment was also deployed to detect any additional bat species present but not captured in nets. Acoustic monitoring equipment at mist net sites included an Echo Meter 3[2] detector. Echo Meter 3 recordings were analyzed using SonoBat 3 Wyoming Species Package[3] (details in Acoustic Surveys section below).

Acoustic Surveys

Acoustic surveys were conducted using Wildlife Acoustics Song Meter SM2BAT+[4] full-spectrum recording equipment (see datasheet in Appendix 1A). Units were programed to begin recording one half hour before civil sunset and to stop recording one half hour after civil sunrise. On each recorder, one SMX-US[5] ultrasonic microphone was attached to a 3m cable and placed between 1m and 2m above the ground. All calls were analyzed using the Sonobatch automated call analysis algorithm in the SonoBat 3 Wyoming Species Package. We used an acceptable call quality threshold of 0.70 and a discriminate probability threshold of 0.80.

Other Mammals

In addition to bats, we searched for evidence of other mammals in the Gardner Mountain WSA. Animal scat and tracks were identified to species, when possible. In order to document medium and large carnivores and other secretive species, we also placed two digital infrared trail cameras at different locations in the WSA (Figure 4). Trail cameras were placed along obvious animal trails during our first visit in June and retrieved during our second visit in July.

Reptiles and Amphibians

We surveyed for reptiles on south-facing rock outcrops, where lizards and snakes often concentrate. South facing rock outcrops provide thermal cover, cover from predators, and often an

[1] Avinet bat-specific mist nets, 38mm mesh, black polyester, Dryden, NY, www.Avinet.com
[2] Echo Meter 3 Active ultrasonic monitoring unit, Concord, MA, www.wildlifeacoustics.com
[3] SonoBat 3, Wyoming species package, Arcata, CA, www.sonobat.com (Szewczak 2011)
[4] Song Meter SM2Bat+ ultrasonic monitoring unit, Concord, MA, www.wildlifeacoustics.com
[5] SMX-US ultrasonic microphone, Concord, MA, www.wildlifeacoustics.com

abundance of invertebrate and small mammal prey items. Rock outcrop surveys consist of walking along rocky slopes looking for basking reptiles in exposed areas as well as individuals resting on shaded ledges, in crevasses, or under rocks. Rocks lifted or flipped over during searching are replaced in their original position to minimize disturbance to habitat (Pike et al. 2010). Habitat, total survey time, and species detected are recorded. Datasheets and protocols are provided in Appendix 1B.

We used aerial photos and topographic maps in a GIS to locate potential amphibian habitat (ponds, marshes, and areas of slow moving water). We visited all accessible potential amphibian sites to see if they had water and would support amphibians.

Pollinators

To estimate the abundance and diversity of pollinators in the Gardner Mountain WSA, we collected insects using vane traps, bee cups, and visual encounter surveys. We placed vane traps and bee cups (Figure 5) in differing locations for about 24 hours before collecting individuals. We used yellow, blue, and white bee cups filled with soapy water. We recorded location, vegetation type, and deployment on datasheets (Appendix 1C). Other pollinating insects encountered during our excursions were captured with nets. All captured insects were preserved in ~75% ethanol until they could be processed in a laboratory.

In the lab, we hydrated bees in warm water for 30-60 minutes, washed specimens in soapy water using a stir plate, and dried individuals using tubes and forced air. For butterflies and moths, we hydrated individuals in warm water for 30-60 minutes and dried them on a spreading board. All pollinating insects were pinned, labeled, and will be stored at the University of Wyoming Insect Museum. Insects were identified using available keys (Michener et al. 1994, Johnson et al. 2005).

Plants

A botanical survey of the Gardner Mountain WSA has not been conducted and a number of plants considered species of concern are predicted to occur in the Gardner Mountain WSA based on range maps (Table 1). Several of these species prefer limestone outcrops and ridge tops, topographic features known to occur in the WSA. We used aerial imagery and bedrock layers in a GIS to identify limestone ridges and outcrops to target with field surveys. WYNDD botanists Bonnie Heidel and Joy Handley trained surveyors to identify, photograph, and collect specimens of these sensitive species. We used protocols and datasheets developed by the BLM for Sensitive plant species surveys and incidental observations (Appendix 1D). We conducted both formal and opportunistic surveys for target sensitive plant species and collected and/or photographed sensitive species for identification by WYNDD botanists. Furthermore, because survey protocols for other taxa include habitat photos and sometimes detailed habitat descriptions, we also recorded additional plant species detected in the WSA. However, because the goal of plant surveys was to conduct targeted searches for specific sensitive plant species, resulting data is not a comprehensive inventory of all plants occurring in the WSA.

Limber Pine Stand Assessments

Limber pine (*Pinus flexilis*) is a BLM Sensitive Species thought to occur in the Gardner Mountain WSA, but which previously has not been documented. The BLM requested that WYNDD survey for limber pine and conduct repeatable limber pine stand assessments to determine the health of limber

pines on the WSA. We used aerial imagery and GAP land cover layers in a GIS to locate conifer stands where limber pine might occur. WYNDD worked with Jennifer Walker (BLM High Plains District) to modify the existing Forest Vegetation Information System (FORVIS) field guide for walkthrough survey (BLM 2006; Appendix 1E) to assess the structure and health of limber pine stands. More intensive limber pine stand assessments, such as being developed by Cleaver and colleagues at Colorado State University, were considered but not implemented because the survey equipment needed was prohibitive due to the remoteness of stands and ruggedness of the terrain.

We conducted field surveys for limber pine stands during the June survey. Stands detected were recorded on aerial imagery maps while in the field. We then digitized stands in a GIS to create a limber pine polygon layer (Figure 6). Limber pine polygons were used to guide formal stand assessments during our July survey. Jennifer Walker trained WYNDD and BLM personnel to conduct the FORVIS-based limber pine stand assessments in July. Surveyors worked in teams of 2 or more individuals to conduct stand assessments.

Water Quality

To assess stream water quality, we collected aquatic invertebrates from Beartrap Creek and the North Fork of the Red Fork of the Powder River. We measured dissolved oxygen, temperature, specific conductivity, pH, and oxidation-reduction potential using a Professional Plus[6]. The sensors were calibrated before departing from the vehicles, but dissolved oxygen was calibrated on-site immediately before collecting measurements. We measured stream width, depth, and mean particle size of the substrate (n = 20; gravelometer), and recorded the information on a datasheet (Appendix 1F). We collected aquatic invertebrates using a Surber[7] sampler with 250 µm mesh. The substrate within the Surber sampler was scrubbed with a brush and the sediment was disturbed to at least 5 cm depth. We preserved samples with ~75% ethanol in the field to preserve them until they could be processed in a laboratory.

Once in the laboratory, we sorted invertebrates from debris, counted, and identified individuals under a dissecting microscope using available keys (Smith 2001, Merritt et al. 2008, Thorp and Covich 2010) and recorded on a datasheet (Appendix 1G). We then analyzed invertebrates using accepted bioassessment metrics and the program R (R Core Development Team) to estimate ecosystem health. To compare the streams in Gardner Mountain WSA to other streams in the bioregion, we used the Wyoming Stream Integrity Index (Hargett 2011).

Riparian Assessments

We assessed the riparian habitat using proper functioning condition (PFC; Prichard et al. 1998). PFC uses hydrologic, vegetation, erosion, and deposition to assess conditions. We filled out the PFC standard checklist (Appendix 1H) after discussing each statement with the group of observers.

Recreational and Educational Opportunities

No hiking trails exist in the Gardner Mountain WSA. The only public land access is an approximately 11.3 km (7 mile) hike in from the north, from the Mayoworth Slope Road, along Gardner Mountain

[6] Yellow Springs Instruement, Yellow Springs, OH, www.ysi.com
[7] Wildlife Supply Company, Yulee, FL, www.wildco.com

proper, then bushwacking down Gardner Mountain and into the canyon. We were granted access across private land to the east rim of the Beartrap Creek canyon and most of our efforts to find feasible hiking routes were concentrated along Beartrap Creek. We scanned aerial imagery and topographic maps to find feasible routes to hike in and out of the Wilderness Study Area. Once in the canyon, we hiked along Beartrap Creek searching for additional access points between the canyon and both the east and west rims. We were unable to search along the North Fork of the Red Fork of the Powder River due to time constraints.

Results

Characterization of the Gardner Mountain WSA

The Gardner Mountain WSA contains a mix of upland, canyon, and canyon bottom ecosystems. The geology of the Gardner Mountain WSA includes various limestone and sandstone formations (Case et al. 1998; Figure 7). Vegetation varies considerably based on topographic position, slope, and bedrock substrate. Upland vegetation types include cool temperate northern Rocky Mountain lower montane and foothill forests, as well as intermountain mountain big sagebrush shrubland and steppe (Table 2), according to the U.S. National Vegetation Classification (USNVC) Hierarchy Explorer (http://usnvc.org/explore-classification/). Uplands on the east rim are dominated by mixed conifer forests comprised of ponderosa pine, Douglas fir, and limber pine. Big sagebrush shrubland and steppe dominate the western rim of the WSA with stringers and pockets of mixed conifer forest. Canyon walls and slopes typically are intermountain basins curl-leaf mountain-mahogany scrub and woodland. Rocky Mountain and Great Basin lowland and foothill riparian forest dominated canyon bottoms along Beartrap Creek and the North Fork of the Red Fork of the Powder River (Table 2). The riparian forest here is dominated by box elder and Rocky Mountain maple, with scattered ponderosa pine and Douglas fir. The southern portion of the WSA also has narrowleaf cottonwood along the river corridor. The understory in the riparian forest is diverse and a full botanical inventory is warranted to gain a better understanding of plant biodiversity in this WSA.

Birds

We surveyed a total of 10 transects (eight randomly placed line transects and two riparian transects). We conducted a total of 86 point counts (70 point counts on randomly placed line transects and 16 point counts on riparian transects). We recorded 726 individuals representing 65 bird species (Table 3). The most frequently detected bird species was Green-tailed Towhee followed by American Robin (Table 3). We documented two bird species listed as Sensitive by Wyoming BLM. These included Sage Thrasher and Brewer's Sparrow (Table3). In addition, we documented five bird species listed as Species of Greatest Conservation Need (SGCN) by the WGFD. These included Brewer's Sparrow, Merlin, Pygmy Nuthatch, Sage Thrasher, and Willow Flycatcher. A total of six raptor species were observed within the WSA (Table 3). We also observed one unidentified falcon (Prairie Falcon or Peregrine Falcon). Our observations suggested that this was a Peregrine Falcon but we were unable to confirm species identity due to poor lighting conditions. Despite ample nesting substrate in the form of cliff walls and large snags, we only observed one raptor nest within the WSA. This nest was most likely a Golden Eagle nest and was located high on a cliff wall along Beartrap Creek.

Mammals

Bats

A total of eight nights of acoustic recordings were conducted at three sites (Figure 8). From these recordings, we were able to identify a total of eight bat species (Table 4). The most frequently detected species was the Western Small-footed Myotis, followed by the Long-eared Myotis (Table 4). Only one species, Silver-haired Bat, was documented from acoustic recordings alone. While echolocation calls of Silver-haired Bat and Big Brown Bat are very similar, we did record long, flat calls at 25 kHz that are diagnostic of the Silver-haired Bat (Adams 2003). As a result, we are quite confident that this species occurs within the WSA despite the fact that we were unable to confirm species presence with mist net captures.

A total of three mist net surveys were conducted (Figure 8). We captured a total of 29 bats representing seven species (Table 4). The most frequently captured species was the Long-legged Myotis followed by the Big Brown Bat (Table 4).

For most species, sex ratios were heavily skewed with males being more frequently captured than females. The exception to this was the Long-legged Myotis (Table 5). We observed evidence of breeding for two species, the Western Small-footed Myotis and the Long-legged Myotis. We captured one juvenile Western Small-footed Myotis and seven female Long-legged Myotis that showed evidence of current lactation or past lactation (Table 5).

We documented two bat species listed as Sensitive by Wyoming BLM. These included Townsend's Big-eared Bat and Long-eared Myotis (Tables 4 and 5). In addition, we documented six bat species listed as SGCN by the WGFD. These included: Big Brown Bat, Little Brown Myotis, Long-eared Myotis, Long-legged Myotis, Townsend's Big-eared Bat, and Western Small-footed Myotis (Tables 4 and 5).

Inspection of the wing and tail membranes of all bats captured did not reveal any signs of White-nose Syndrome (WNS).

Other Mammals

We detected evidence of at least 12 mammal species in addition to the 8 bat species (Table 6). Although we were unable to obtain visual observations of all species, we were able to identify several species based on scat, including black bear (*Ursus americanus*). We identified other species based on diagnostic sign such as teeth marks on trees by beaver (*Castor canadensis*), and nests in rock crevasses by bushy-tailed woodrats (*Neotoma cinerea*). Trail cameras confirmed the presence of several species also identified by sign, such as elk (*Cervus canadensis*; Figure 9a). Trail cameras also photographed other species not detected by other means, such as bobcat (*Lynx rufus*; Figure 9b).

Reptiles and Amphibians

The Gardner Mountain WSA has limited amphibian habitat. The rivers in the WSA are fast moving, have trout, and do not appear to provide breeding habitat for amphibians. We visited the three stock ponds located on the east rim of the WSA (Figure 10) but all were dry. It is possible that these stock ponds provide habitat for certain amphibian species in wet years. We were unable to survey stock ponds on the west rim due to time constraints.

We looked for reptiles using three formal reptile visual encounter surveys (VES) on south-facing rock outcrops (Figure 10; Appendix 2A) as well as opportunistic searches conducted while surveying for other taxa. No reptiles were detected during rock outcrop surveys. Due to the need to survey for other taxa, however, the time of day we were able to conduct rock outcrop surveys was not ideal for detecting basking reptiles (i.e. temperatures were too hot). Using opportunistic searches, we documented wandering garter snakes (*Thamnophis elegans vagrans*) and northern sagebrush lizards (*Sceloporus graciosus*) in the WSA (Table 7). We also detected a prairie rattlesnake (*Crotalus viridis*) on BLM lands just outside the eastern boarder of the WSA. Other reptile species likely occur in the Gardner Mountains WSA. The area has abundant rock outcrops, cliffs, scree slopes, and moist riparian areas. Dedicated reptile searches with adequate time allocated to finding reptiles during morning basking behavior will likely result in a much larger species list.

Pollinators

We collected insects from 24 vane traps and 72 bee cups placed in 6 areas during June and July 2013 (Figure 11; Appendix 2B). From these traps, we collected insects from 7 orders (Coleoptera, Diptera, Hemiptera, Hymenoptera, Lepidoptera, Neuroptera, and Orthoptera) and 19 families (Andrenidae, Apidae, Braconidae, Buprestidae, Cerambycidae, Chrysididae, Colletidae, Crabronidae, Erebidae, Halictidae, Lycaenidae, Megachilidae, Nymphalidae, Papilionidae, Pieridae, Saturniidae, Sphecidae, Sphingidae, and Vespidae). We identified 66 different insects at the genus, species, or sub-species level. Fourty-one of these taxa were bees, 22 taxa were butterflies and moths, and 3 were wasps (Table 8; see Figure 12 for photos of representative individuals). *Bombus centralis, Bombus flavifrons, Lasioglossum, Dufourea maura,* and *Agapostemon femoratus* were the most abundant bees that we collected. *Speyeria coronis/zerene*, *Cercyonis*, and *Callophrys gryneus* were the most abundant butterflies and moths, and *Pseudomarasis vespoides* was the most abundant wasp collected. On average, we captured 0.33 insects per hour. We captured a similar number of insects in vane traps (0.34 insects/hr) compared to bee cups (0.32 insects/hr). More insects were captured in July (0.40 insects/hr) compared to June (0.29 insects/hr).

Plants

We detected 2 forb species of concern in the Gardner Mountain WSA. We collected specimens of any potential sensitive species. Specimens were identified in the lab by WYNDD botanists Bonnie Heidel and Joy Handley using Dorn (2001). Specimens were collected for identification purpose and are not suitable for incorporation into the Rocky Mountain Herbarium, however, they currently are stored at WYNDD should the BLM be interested in obtaining them for voucher specimens. We also took voucher photos of a number of individual plants. All voucher photos are included with photocopied datasheets in Appendix 2C and are provided in supplemental photo resources. Plant location information, including approximate area of occurrence and phenology, also is provided in supplemental spreadsheets and GIS shapefiles.

William's Springparsley (*Cymopterus williamsii*) is a BLM Sensitive Species that was found during formal surveys and opportunistic sightings (Figure 13). Habitat ranged from relatively bare ridges with no overstory vegetation to mixed conifer forest with a limestone substrate. This species was often locally common in areas where it was detected on both the east and west rims of the WSA.

We also detected the Woolly (Common) Twinpod (*Physaria didymocarpa* var. *lanata*), a U.S. Forest Service Sensitive Species that is less common on BLM lands due to its habitat preferences. We detected

this species at several locations east of Beartrap creek on rocky hillsides with mountain mahogany and also on an east-facing more heavily vegetated slope near the bottom of the drainage (Figure 13).

We also documented a number of other plant species during surveys for other taxa. Habitat data and photographs were reviewed by Joy Handley, resulting in a list of over 70 plant species documented in the Gardner Mountain WSA (Table 9). However, this list is not comprehensive and an intensive inventory of plants of the Gardner Mountain WSA has not been conducted. Our surveys for sensitive plant species primarily targeted several limestone ridges in the middle portion of the WSA. Due to logistical constraints, we were unable to survey areas in the north-central or far southern portions of the WSA.

Limber Pine Stand Assessments

We documented and mapped limber pine on the Gardner Mountain WSA (Figure 6). We detected limber pine in June using both targeted field surveys and opportunistic searches. Limber pine tended to occur individually or in mixed conifer stands along with ponderosa pine and Douglas fir. Because we only surveyed a portion of conifer stands on the WSA, limber pine likely are distributed over a larger portion of the WSA than documented during this study.

In mixed conifer settings on northerly slopes, limber pine was found to represent 10% to 15% of all structural stages, with Douglas-fir at 80% to 90% of all structural stages. Ponderosa pine was found mostly in the overstory and mid-layers, at 0% to 5%. On southerly slopes and ridges limber pine was found up to 20% of all structural stages, with ponderosa pine representing 75% to 90% of all structural stages. Douglas-fir on southerly aspects was found in trace amounts up to 5% in the mid and lower layers. *Juniperus scopulorum* was occasionally found in the mid and lower canopy layers.

Stand assessments conducted in July in mapped stands revealed that limber pine in the Gardner Mountain WSA are infected with white pine blister rust, caused by the Asian fungus *Cronartium ribicola*. White pine blister rust was widespread in the WSA, occurring in 100% of surveyed stands. On northerly aspects, about 80% or more of the overstory and mid-layer limber pine were affected by blister rust and bark beetles. Of those affected, over 90% were dead, mostly from bark beetles. For lower layers, blister rust infection/mortality was found to be quite variable but usually over 30%. On southerly aspects, overstory and mid-layer infection was found to be variable from 20% to 80%, where mortality ranged from 10% to 50%. Beetle activity appears to be less on southerly aspects as compared to northerly aspects. For mid layers, infection/mortality was found to be variable on southerly aspects.

For conifers in general, large tree mortality from bark beetles was found to be very common, including some Douglas-fir beetle pockets. Stem decay and root rot was found in association with wind-thrown pockets on north-facing slopes. Some pockets were fairly large (> 5 acres).

General age and disturbance information was casually sampled for mixed conifer stands on the east side of the Gardner Mountain WSA. Oldest trees ranged from 325 years old to 465 years old, and many had multiple fire scars. Most dead trees in this age class died in the past decade from bark beetle activity. Middle aged trees were commonly aged from 120 to 130 years. Younger age classes were variable, ranging from 30 to 100 years. Douglas-fir seedling thickets occur on northerly or flat conifer/meadow ecotones. *Juniperus communis* was common in the understory of northerly aspects. Fuel loading was generally high in mixed conifer settings and future fires are likely to occur in stand-replacement patterns.

Water Quality

Basic water quality of both streams flowing through Gardner Mountain WSA was similar (Table 10; Appendix 2D). Both streams had high dissolved oxygen concentrations, relatively low specific conductivity, and reducing condition (oxidation-reduction potential <200 mV). The pH of both streams was basic, which is commonly found throughout Wyoming. Furthermore, mean stream width, mean stream depth, and mean particle size were similar between streams (Table 11). We collected 5 replicate Surber samples from Beartrap Creek and 5 replicate Surber samples from the North Fork of the Red Fork of the Powder River (Figure 11). Both streams had high densities of invertebrates, including taxa that are considered sensitive to water and habitat quality. Aquatic invertebrates are the main source of food for fish. The high densities of aquatic invertebrates may at least partially explain the abundant rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*) and brook trout (*Salvelinus fontinalis*) we observed in these streams (Table 7).

The densities of aquatic invertebrates in the North Fork of the Red Fork of the Powder River were high and averaged 19,655 individuals/m^2 (range 9830 to 45,900 ind/m^2). Insects were much more dense (19,530 ind/m^2; 99%) compared to non-insect invertebrates (130 ind/m^2; <1%). The order Diptera (trueflies; 11,630 ind/m^2) had the highest densities followed by Ephemeroptera (mayflies; 6160 ind/m^2), and Coleoptera (beetles; 910 ind/m^2). We collected an average of 15 taxa per sample, but we identified 21 taxa in the stream (Table 12; see Figure 14 for photos of representative individuals; Appendix 2E). Simulium (black flies; 10,585 ind/m^2) were the densest taxa followed by *Baetis* (blue-winged olive mayflies; 4360 ind/m^2), *Epeorus* (little maryatts mayflies; 1465 ind/m^2), and Chironomidae (non-biting midges; 1015 ind/m^2). Filtering insects were the most dense functional feeding group (11,255 ind/m^2), followed by gatherers (5455 ind/m^2), and scrapers (1750 ind/m^2). Clinger was the dominant habit of invertebrates in the stream (14,180 ind/m^2), followed by swimmer (4360 ind/m^2), and burrower (1035 ind/m^2). Only 7.4% of the invertebrates in the assemblage were Chironomidae, but 46% of the invertebrates by density were mayflies, caddisflies, and stoneflies, groups which are considered sensitive to changes in ecosystem quality. We collected 12 taxa on average from the orders mayfly, caddisfly, and stonefly, and 85% of taxa collected were in these orders. Taxa diversity (Shannon's diversity) averaged 1.96 (range 1.55 to 2.10). Taxa evenness averaged 0.74 (range 0.55 to 0.84), indicating that the taxa were fairly evenly distributed. The average tolerance value of an invertebrate in the assemblage was 4.8 on a scale of 0 (most sensitive to pollution or habitat degradation) to 10 (most tolerant of pollution habitat degradation). Fifty-three percent of individuals collected had a tolerance value of ≤5.0 and only 0.24% of individuals had tolerance values >7.0, indicating that the assemblage was composed of taxa largely intolerant to pollution and habitat degradation. Seven-six percent of taxa had tolerance values ≤5.0 and only 4.9% of taxa had tolerance values ≥7.0.

The densities of aquatic invertebrates in the Beartrap Creek were high and averaged 12,900 individuals/m^2 (range 6030 to 24,155 ind/m^2). Insects were much more dense (12,150 ind/m^2; 94%) compared to non-insect invertebrates (760 ind/m^2; 6%). The order Diptera (trueflies; 7400 ind/m^2) had the highest densities followed by Ephemeroptera (mayflies; 3135 ind/m^2), and Coleoptera (beetles; 950 ind/m^2). We collected an average of 15 taxa per sample, but we collected 22 taxa within the stream (Table 12; Appendix 2F). Chironomidae (non-biting midges; 5865 ind/m^2) were the most abundant taxa followed by *Baetis* (blue-winged olive mayflies; 3060 ind/m^2), *Antocha* (crane fly; 950 ind/m^2), and *Cleptelmis addenda* (riffle beetle; 950 ind/m^2). Gathering insects were the most dense functional feeding group (11,800 ind/m^2), followed by filterers (755 ind/m^2), and predators (195 ind/m^2). Burrowing was the dominant habit of invertebrates in the stream (6555 ind/m^2), followed by clinger (3230 ind/m^2), and swimmer (3060 ind/m^2). Forty-seven percent of the invertebrates in the assemblage were Chironomidae by density, and 30% of the invertebrates by density were mayflies, caddisflies, and

stoneflies, groups which are considered sensitive to changes in ecosystem quality. We collected 9.2 taxa on average from the orders mayfly, caddisfly, and stonefly, and 62% of taxa collected were in these orders. Taxa diversity (Shannon's diversity) averaged 1.88 (range 1.51 to 2.29). Taxa evenness averaged 0.70 (range 0.59 to 0.79), indicating that the taxa were fairly evenly distributed. The average tolerance value of an invertebrate in the assemblage was 5.1 on a scale of 0 (most sensitive to pollution or habitat degradation) to 10 (most tolerant of pollution habitat degradation). Forty-seven percent of individuals collected had a tolerance value of ≤5.0 and only 0.47% of individuals had tolerance values >7.0, indicating that the assemblage was composed of taxa largely intolerant to pollution and habitat degradation. Sixty-nine percent of taxa had tolerance values ≤5.0 and only 7% of taxa had tolerance values ≥7.0.

The invertebrates in the North Fork of the Red Fork of the Powder River and Beartrap Creek both suggest that these streams are in good condition. The invertebrate assemblages were dominated by sensitive taxa (mayflies, caddisflies, stoneflies, and taxa with tolerance values ≤5.0), and the North Fork of the Red Fork of the Powder River tended to have better metrics than Beartrap Creek. To compare the ecosystem quality of these streams to other streams in the area, we used the Wyoming Stream Integrity Index (Hargett 2011). Streams in Gardner Mountain WSA were located either in the sedimentary mountains or the Bighorn Basin foothills bioregion. Surprisingly, the streams were not ranked high using this index. The high densities of blackflies in the North Fork of the Red Fork of the Powder River resulted in most metrics falling below the threshold of fully supporting the stream designation (Table 13). When blackflies were removed from the analysis, metrics tended to improve. The metrics calculated for Beartrap Creek indicated that the stream is not supporting it's designated use according to the Wyoming Stream Integrity Index.

Oreohelix

We discovered Oreohelix (mountainsnails) in Beartrap Canyon in at least two locations. Sixty percent of taxa within this genus are considered rare (NatureServe; www.natureserve.org). Based on shell morphology and penial characteristics, the snails at Gardner Mountain WSA are O. subrudis (Table 14). O. subrudis is the most widely distributed species in the genus ranging from British Columbia to New Mexico. However, the genus is in need of taxonomic revision.

Riparian Assessments

We assessed the riparian habitat of the North Fork of the Red Fork of the Powder River along 3 reaches and Beartrap Creek along 1 reach (Appendix 2G). All stream reaches were properly functioning according to the criteria on the checklist and there was no apparent trend. The steep-walled canyon dominated the hydrology of the streams and the vegetation growing along the stream was diverse and abundant. Stream substrate was dominated by gravel, cobble, and boulders which reduced erosion in the ecosystem. Beartrap Creek was lined by boxelder, chokecherry, currents, wood rose, and rocky mountain maple. Riparian vegetation along the North Fork of the Red Fork of the Powder River was dominated by narrow-leaf cottonwoods, rocky mountain maple, Douglas fir, box elder, wild rose, and cedar.

Recreational and Educational Opportunities

Limited public access to the WSA restricts recreational opportunities. Permission must be obtained from private landowners to access any of the roads that approach the WSA from the west, south, or east. The jeep trail to the east rim near Fraker Mountain that we used to access the WSA for this study is rough and requires a high clearance vehicle. Routes scouted and used by surveyors during this project (Figure 15) generally were not ideal for most recreational use. We first descended route 1. This route was extremely steep in many sections and dense vegetation made hiking difficult. Surveyors had to slide down several steep drops, and ascent of this route would not be possible without removing and hoisting backpacks. We used route 2 to climb out of the canyon during our first trip to the study area. This route was extremely steep and strenuous and had dense patches of mountain mahogany. Route 3 was used to descend and ascend from the east rim on the second trip. This route also was strenuous with steep sections, but was easier to navigate than either routes 1 or 2.

To access the west rim from Beartrap Creek, surveyors used a short steep game trail up a side canyon (Figure 15, Route to West Rim). The trail cut through a mature conifer stand and though steep, was easy to navigate with very little understory vegetation. From the top, it is a several mile hike through rolling sagebrush to an access road (private) on the west side of the WSA. We would rate this route as 'moderately difficult'.

For those who do brave the rugged terrain to access the Gardner Mountain WSA, there are a number of recreational opportunities in the canyons as well as the uplands. The area offers excellent bird watching, photography, backcountry camping, scenic vistas and solitude. Despite the dense riparian vegetation, the creeks offer outstanding trout fishing. Excellent antler hunting opportunities also exist in the uplands, especially on the west rim.

Despite the remoteness of the WSA, the boundary can be accessed by several dirt roads, all of which cross private property. Although use of motorized vehicles is restricted to the few dirt roads along the boundary, evidence of off-road motor vehicle use in the Gardner Mountain WSA was apparent on the west rim. We documented motor vehicle use in several portions of the west rim (Figure 16). Motor vehicle use ranged from single ATV tracks to lightly used 2-tracks (see Figure 16 photos). Trails used during this study and locations where evidence of motor vehicle use was found are available in supplemental GIS shapefiles.

Conclusion

The Gardner Mountain WSA is a hidden gem on the Wyoming landscape. Tucked away in the arid canyon country west of Kaycee, very few people would guess that the WSA shelters such an amazingly diverse riparian ecosystem. This diversity is not apparent in GIS layers or aerial imagery. Surveyors expecting to see the typical willow/cottonwood riparian corridor in the canyon bottoms were awed by lush box elder and Rocky Mountain maple-dominated foothills riparian woodland along Beartrap Creek and other creeks in the WSA (Figure 17). The final wilderness Environmental Impact Statement for the Gardner Mountain WSA (1986) accurately portrays this unique landscape in its statement, "(t)he canyons are excellent examples of land that has retained its 'primeval character'."

This study was the first effort to inventory biodiversity in the Gardner Mountain WSA. Although we conducted targeted surveys for sensitive species during our two short visits to the WSA, we kept track of all species encountered. Our final species list included over 235 birds, mammals, reptiles, fish, invertebrates, and plants within the Gardner Mountain WSA. The canyon walls and riparian woodland in the WSA provide important habitat for multiple species of bats. Diverse vegetation communities and

varied habitat types in close proximity also support a diverse bird community. The riparian area appears to be in good condition despite a history of cattle grazing, and the creeks appear to support a high density of aquatic invertebrates sensitive to water and habitat quality. Efforts by WYNDD and BLM surveyors also resulted in the first documentation and assessment of limber pine on the WSA. This species is locally common in parts of the WSA's uplands; however, it appears to be heavily impacted by non-native blister rust.

Undoubtedly, the extreme ruggedness of the terrain and limited public access has helped the Gardner Mountain WSA retain its 'primeval character' by severely limiting recreational use of the area. Trails are limited to those made by cattle and game. The only human we documented during the study was a rancher on horseback tracking cattle along Beartrap Creek. Unless access from private landowners on the south or west of the WSA is granted, the ruggedness of the terrain severely limits recreational use of this area to all but the most determined backpacker. This study provides an inventory of species present in the WSA and photos of its many beautiful and unique resources. These products should prove valuable tools for the BLM to educate the public about this amazing area that most people would otherwise never have the chance to visit.

Acknowledgements

We sincerely thank the NLCS Research and Science Program for funding this project. Dennis Saville, Adrienne Pilmanis, Bill Ostheimer, Sherry Lahti, and a number of other Wyoming BLM personnel were integral in obtaining support for this project. Allison Barnes was crucial to obtaining access to the WSA across private lands. We sincerely thank the Red Fork Ranch for allowing us access through their land to the WSA. Charlotte Darling, Chris Sheets, and Scott Jawors (BLM) were hardy (and crazy) enough to join us on our excursions into the canyons. We also thank the many BLM personnel and interns, and WYNDD intern Neomi Rao. We thank WYNDD botanist Bonnie Heidel for training surveyors to identify sensitive

plants and for identifying plant species from specimens. We are grateful to Cody Bish of WYNDD for the photographing the insects. Lastly, we thank WYNDD ecologist George Jones for helping classify the vegetation types that occur in the Gardner Mountain WSA.

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Figures

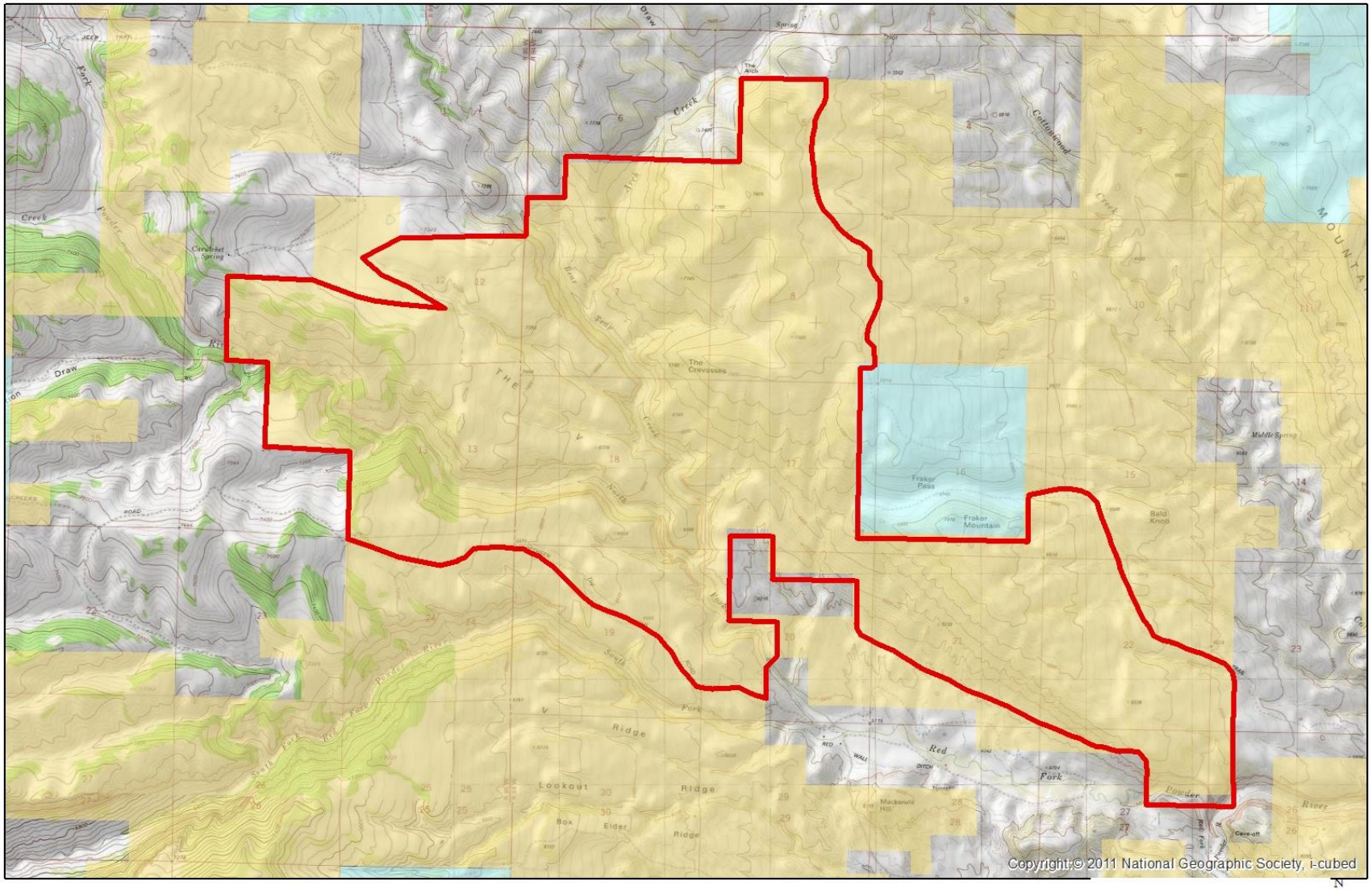

Figure 1. Map of the Gardner Mountain Wilderness Study Area in Wyoming.

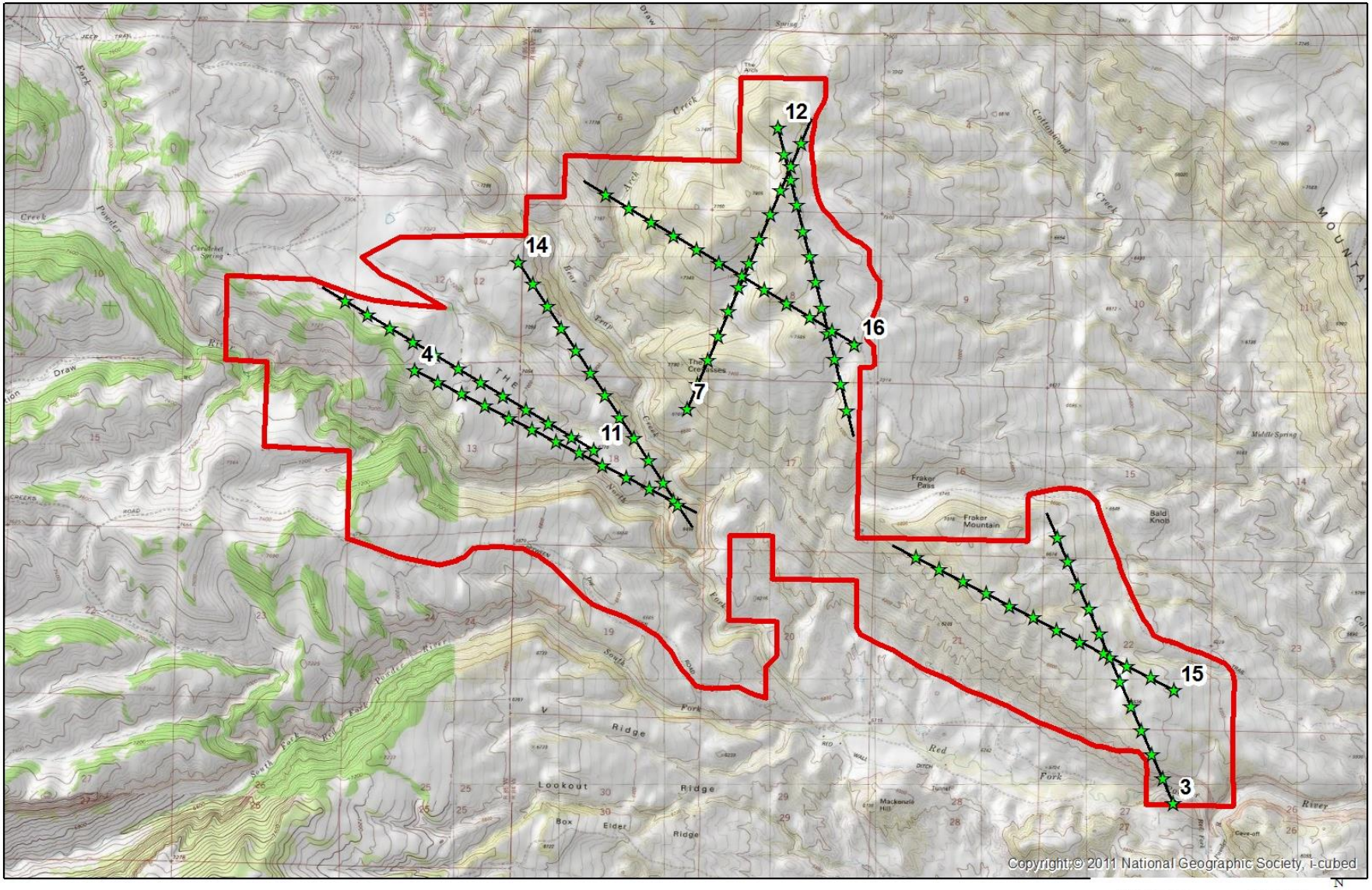

Figure 2. Locations of point count transects established in 2013 to survey for birds in the Gardner Mountain WSA.

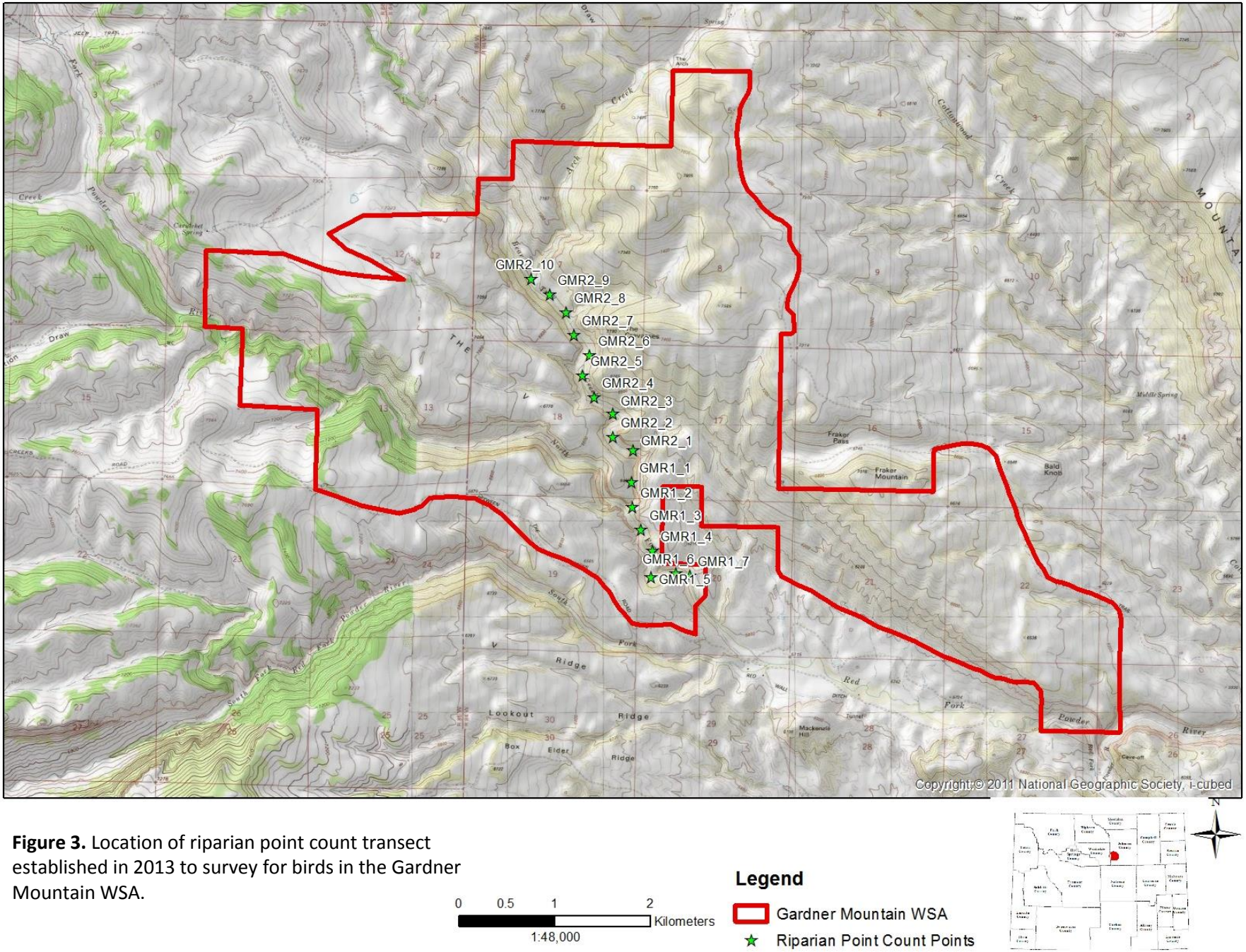

Figure 3. Location of riparian point count transect established in 2013 to survey for birds in the Gardner Mountain WSA.

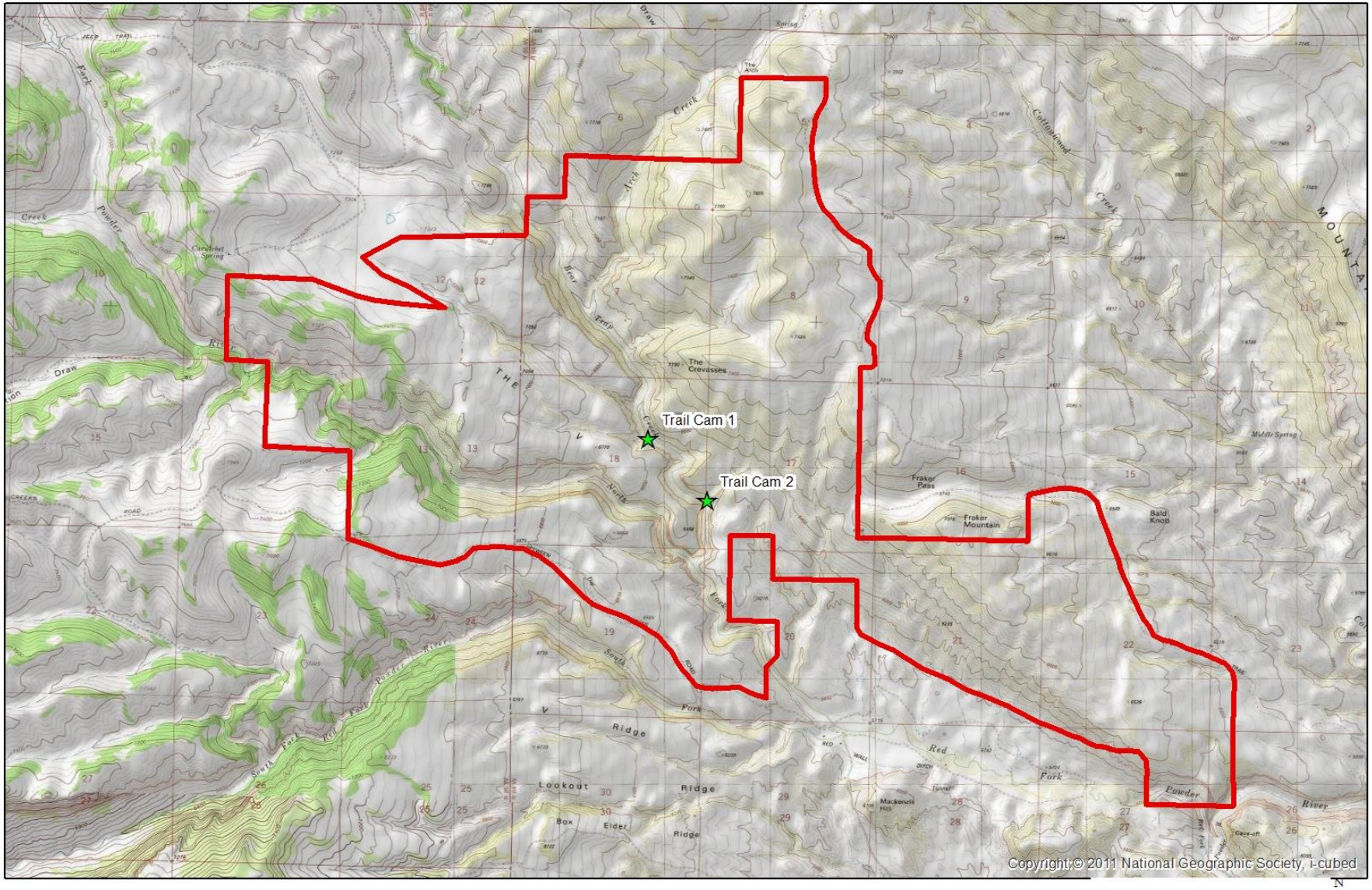

Figure 4. Locations of remote wildlife trail cameras set for approximately 30 days from June to July, 2013 in the Gardner Mountain WSA.

Figure 5. Photo of vane trap (top portion) and bee cups (bottom portion) used to collect pollinators.

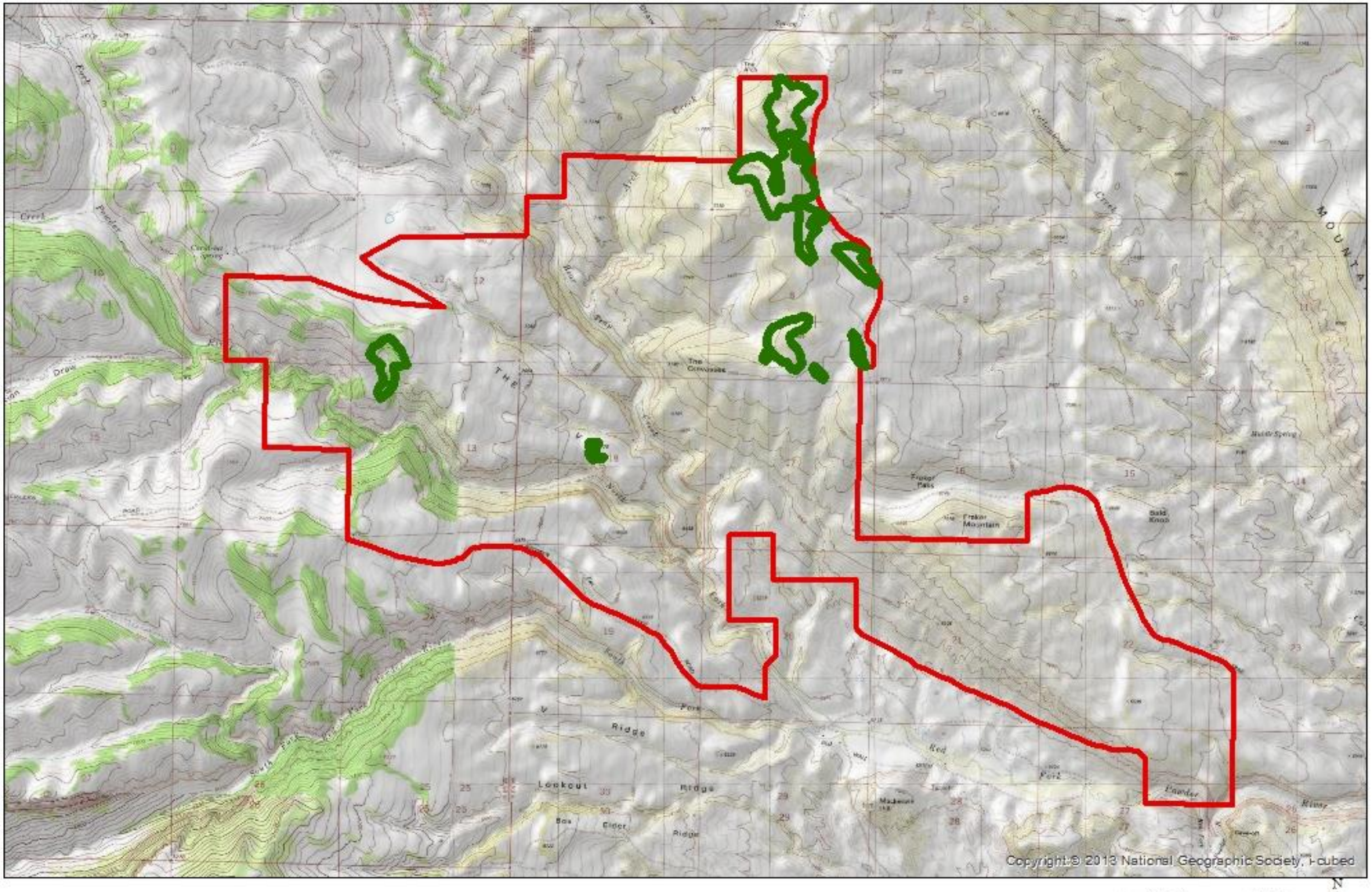

Figure 6. Locations of conifer stands in the Gardner Mountain WSA searched in June 2013 and which contained limber pines. Mapped limber pine stands were used to guide stand assessments in July 2013.

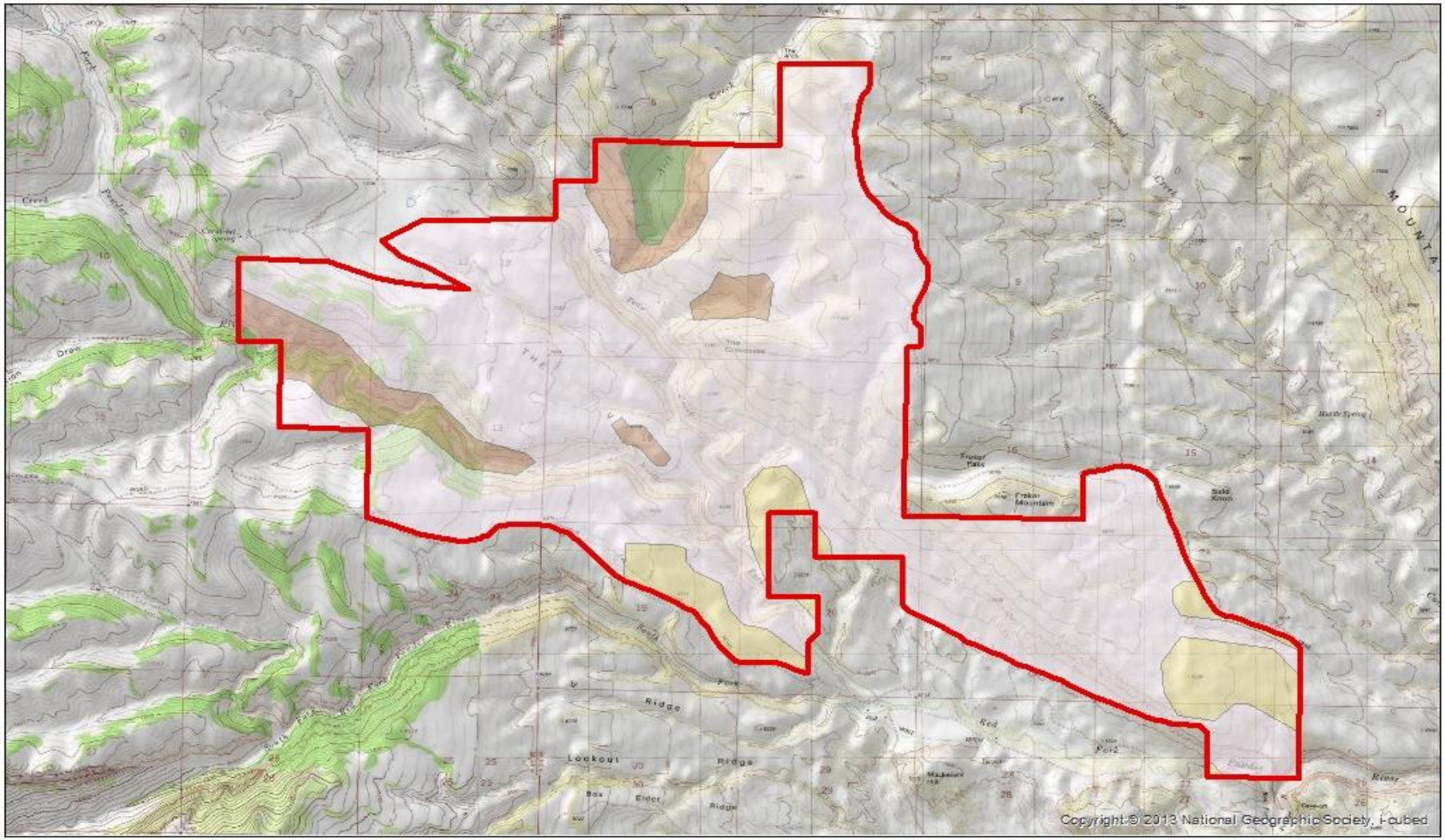

Figure 7. Geology of the Gardner Mountain WSA (Case et al. 1998).

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Kilometers
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Legend

Gardner Mountain WSA

Bed Rock Formation

Bighorn dolomite, Gallatin limestone, GrosVentre formation, and Flathead sandstone

Chugwater and Goose Egg formations

Madison limestone or group

TenSleep sandstone and Amsden formation

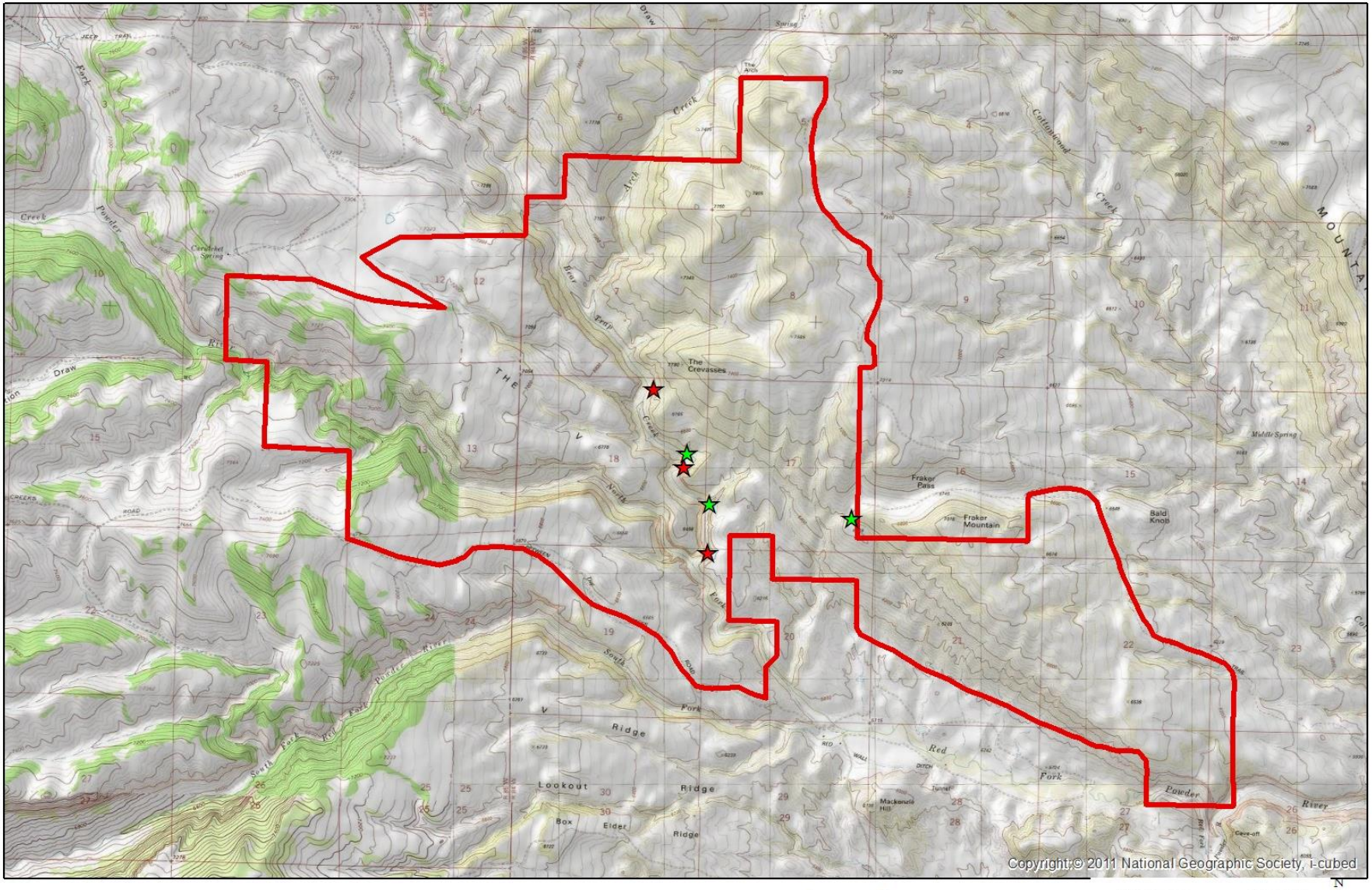

Figure 8. Locations of acoustic and mist net surveys for bats in the Gardner Mountain WSA in 2013.

a)

b)

Figure 9. Trail camera photos documenting a) elk (*Cervus canadensis*), and b) bobcat (*Lynx rufus*) in the Gardner Mountain WSA in 2013.

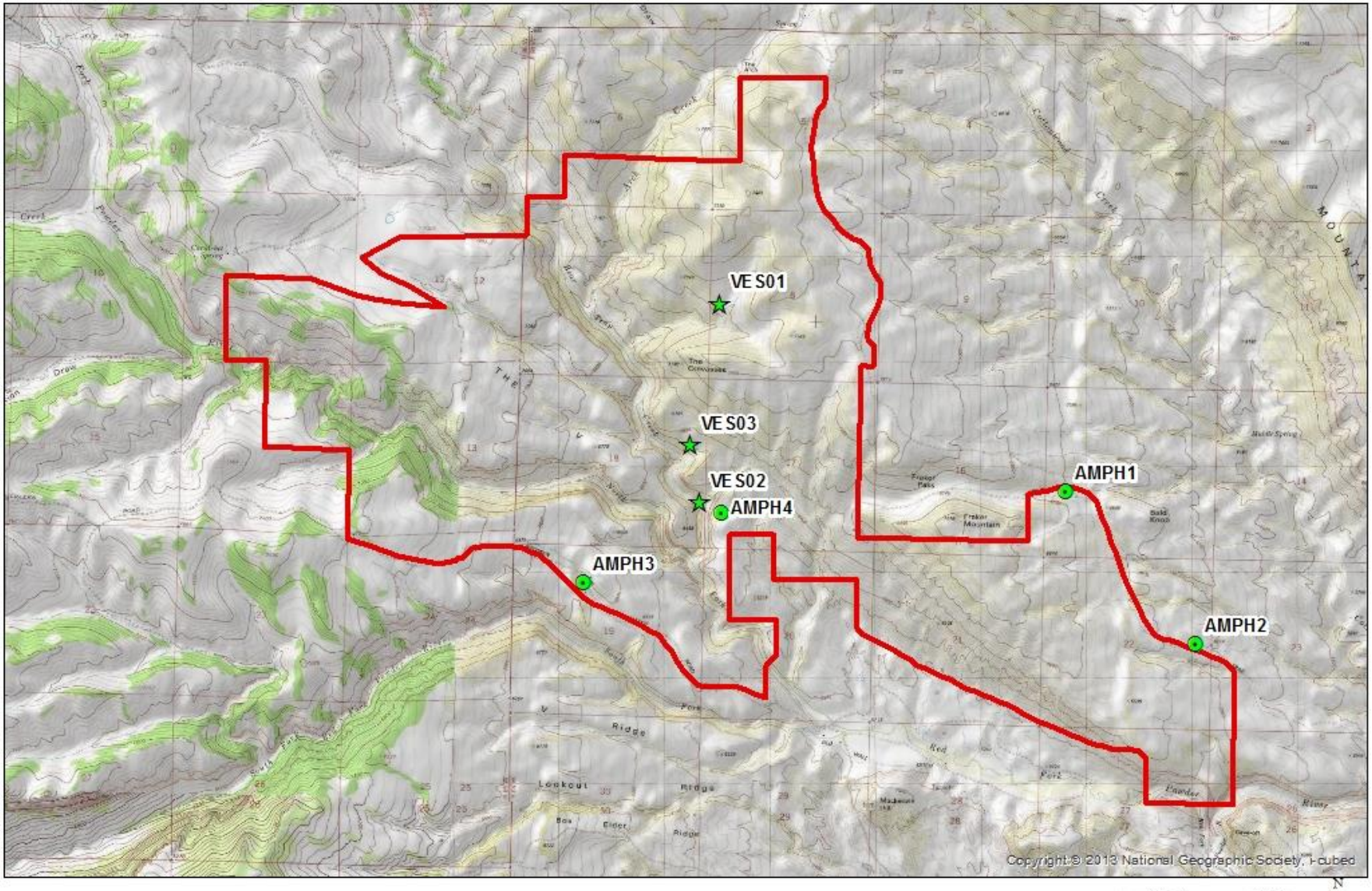

Figure 10. Locations of rock outcrop VES surveys for reptiles and potential survey locations for amphibians in the Gardner Mountain WSA in 2013.

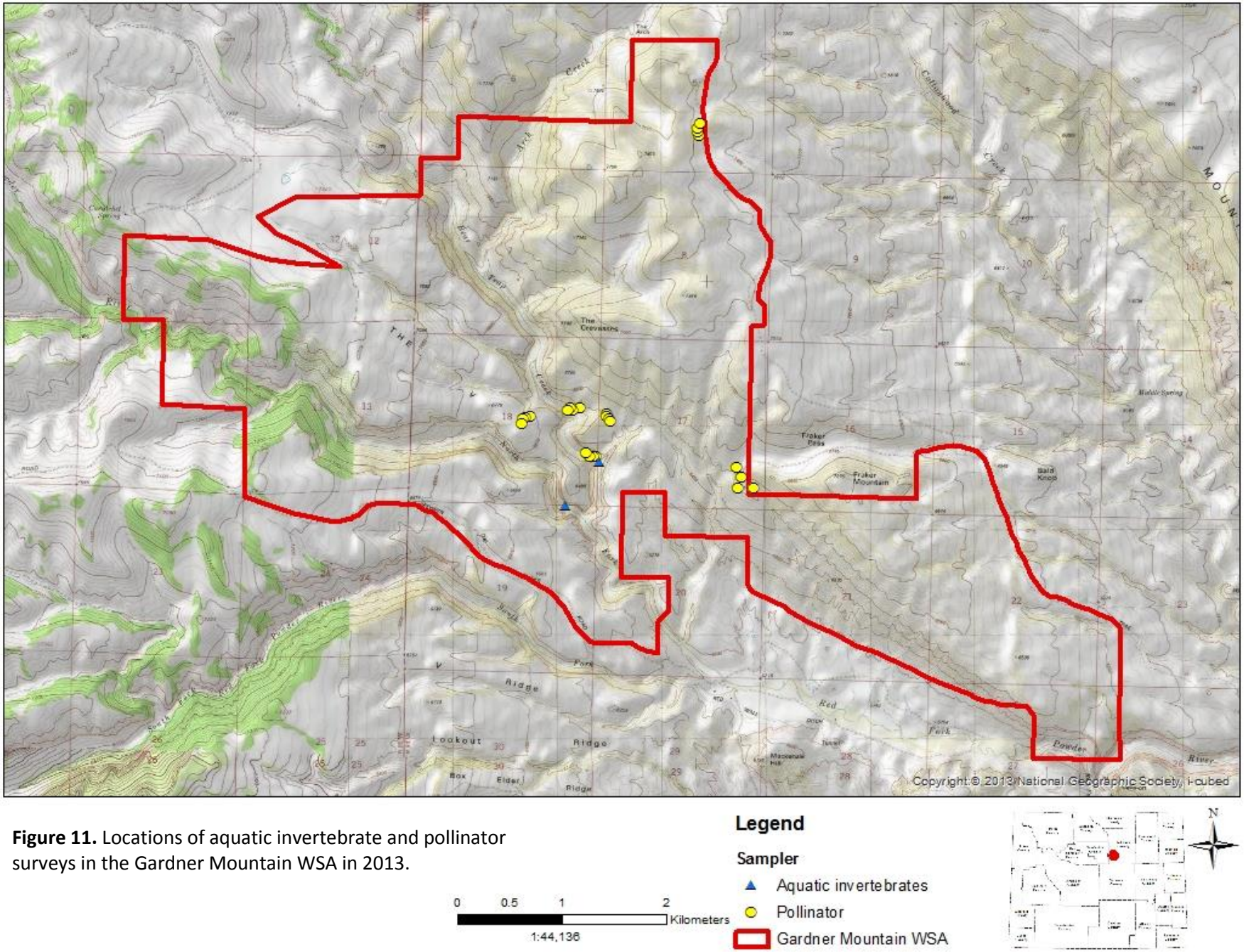

Figure 11. Locations of aquatic invertebrate and pollinator surveys in the Gardner Mountain WSA in 2013.

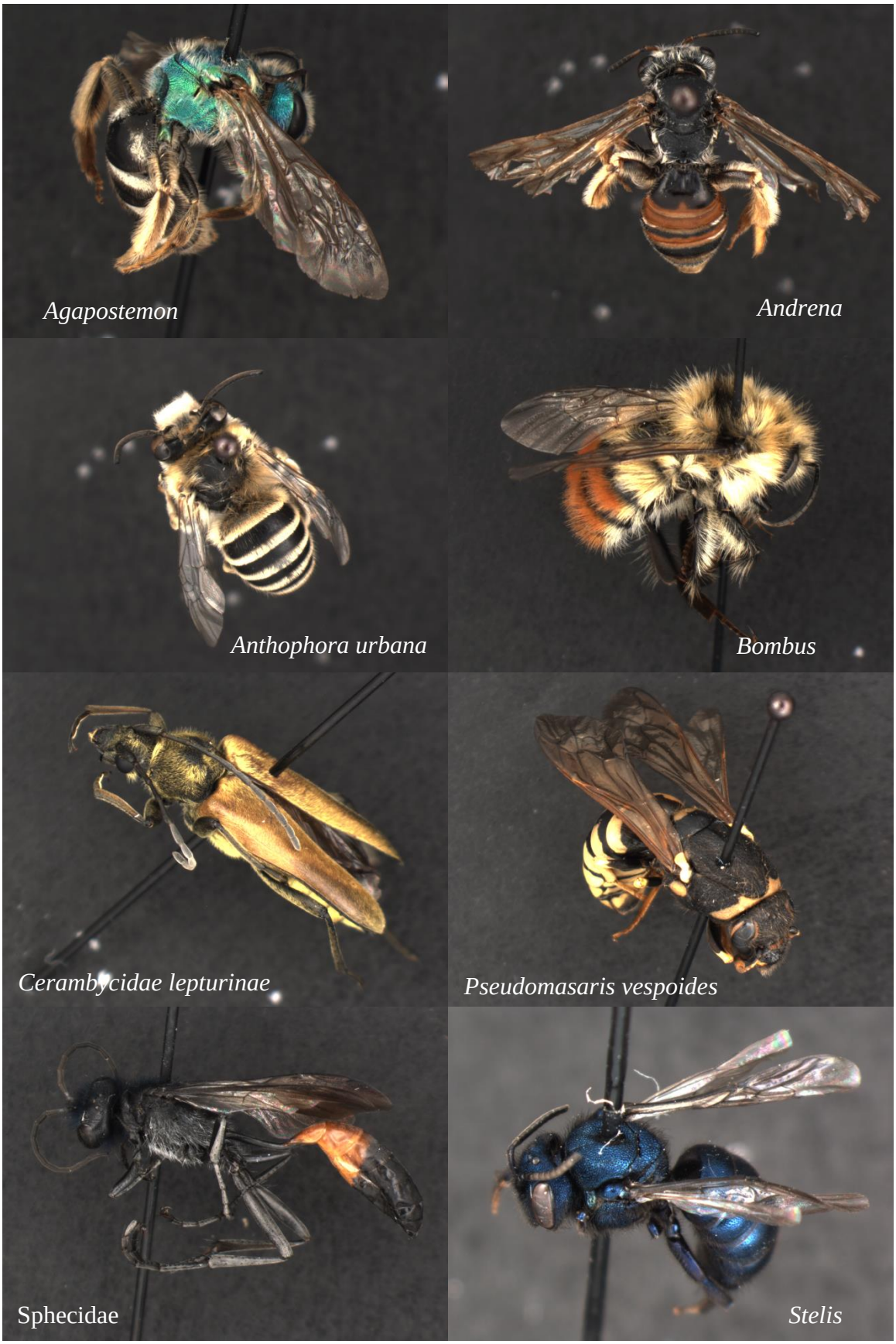

Figure 12. Insects collected in pollinator traps in the Gardner Mountain WSA in 2013.

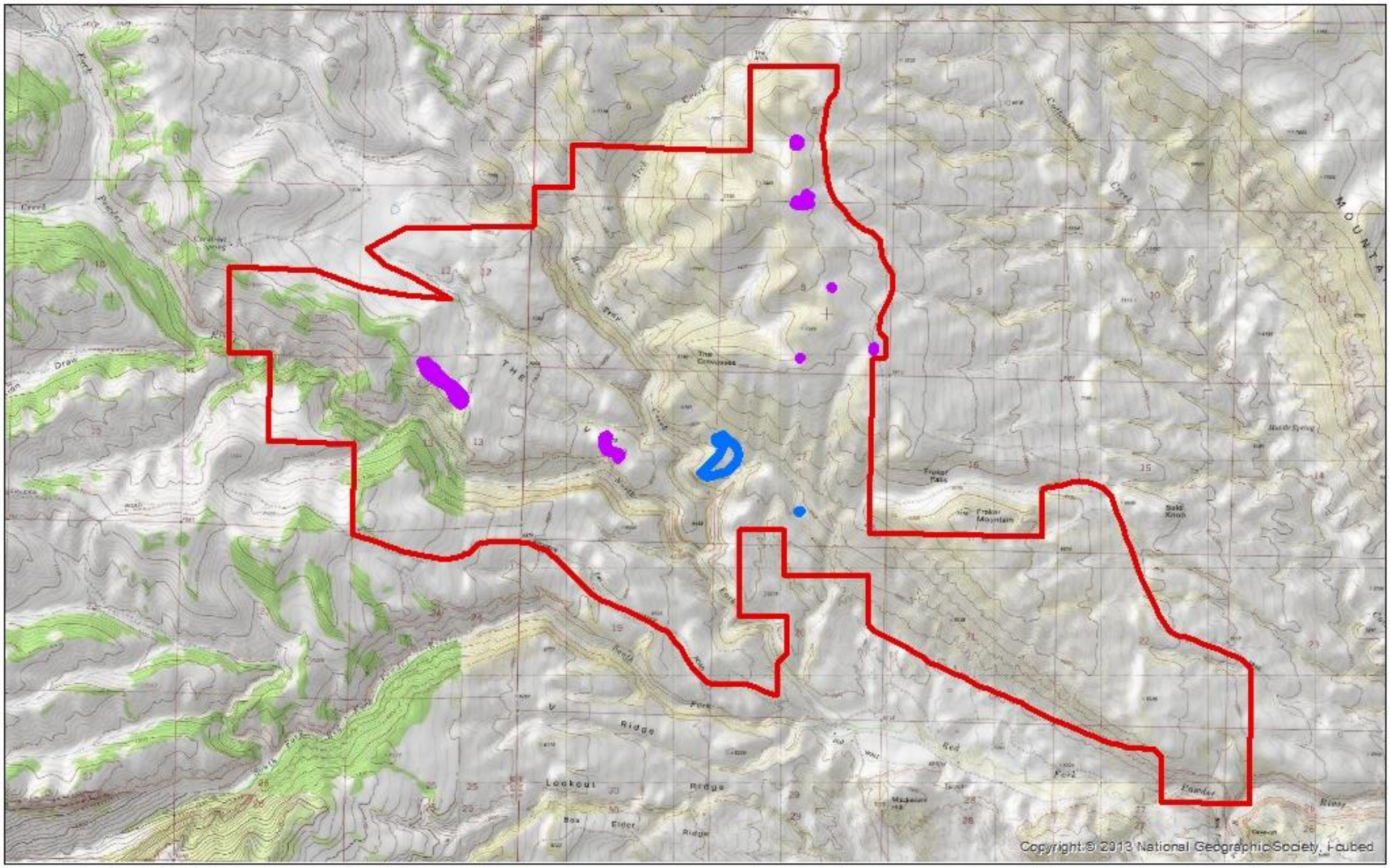

Figure 13. Locations for two sensitive plant species documented in the Gardner Mountain WSA.

Figure 14. Insects collected in the streams of Gardner Mountain WSA in 2013.

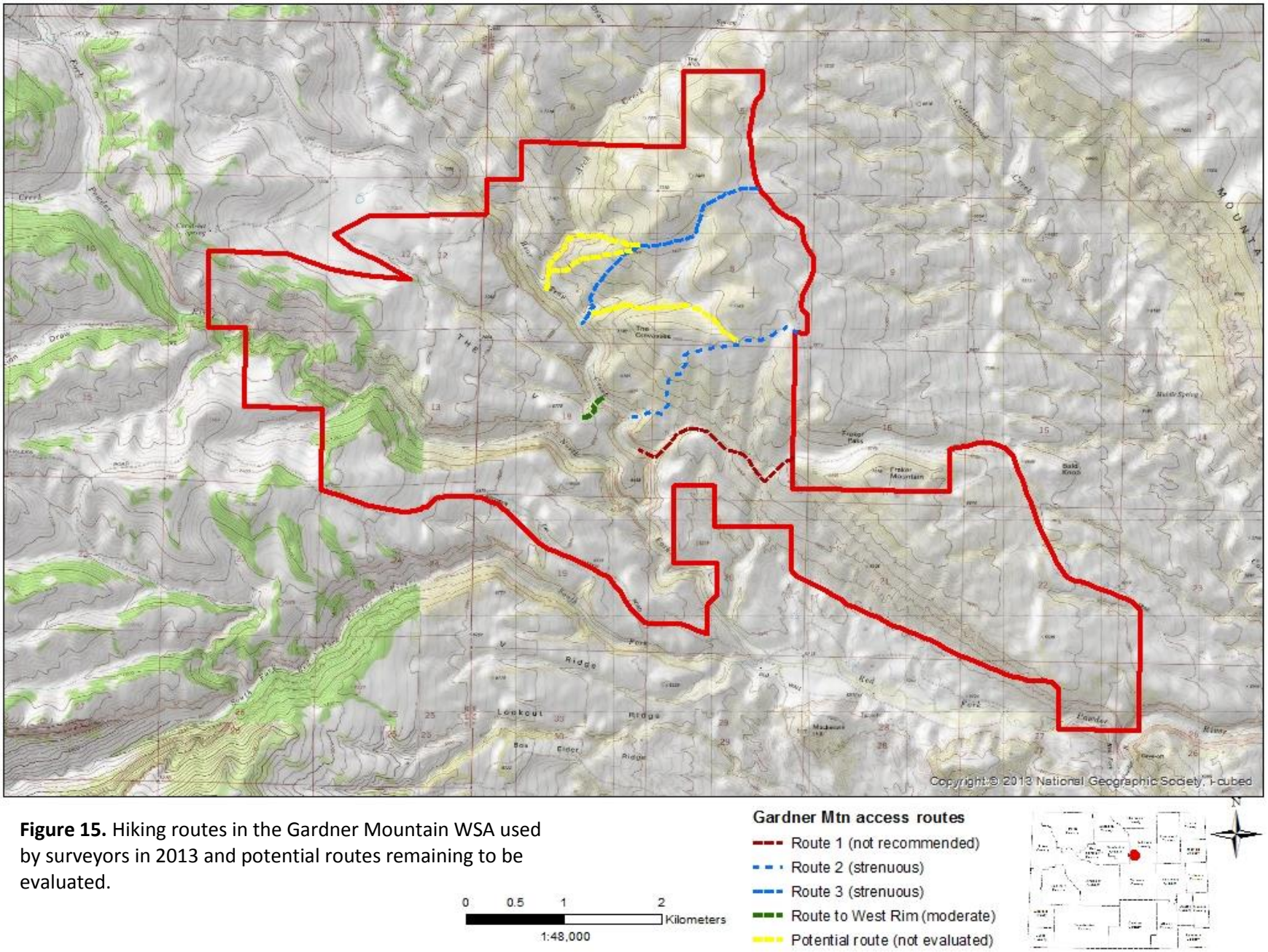

Figure 15. Hiking routes in the Gardner Mountain WSA used by surveyors in 2013 and potential routes remaining to be evaluated.

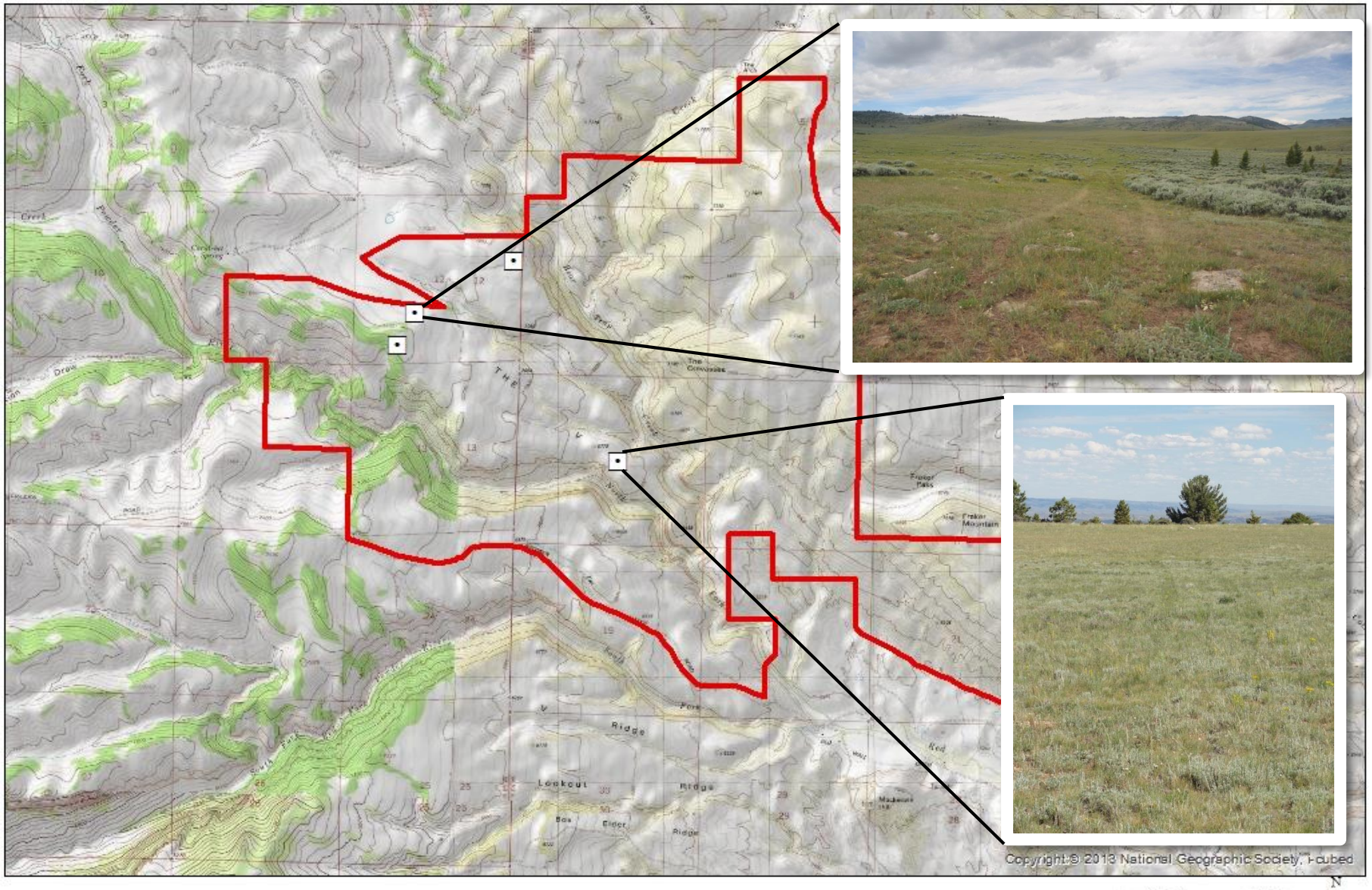

Figure 16. Evidence of motor vehicle use on the west rim of the Gardner Mountain WSA.

Figure 17. Foothills riparian woodland along Beartrap Creek in the Gardner Mountain WSA.

Tables

Table 1. Sensitive plant species predicted to occur in or near the Gardner Mountain WSA, Wyoming (B. Heidel, personal communication). WYNDD botanists trained surveyors to identify all species on the list in the field. Surveyors also collected and pressed samples of all potential sensitive species for identification by botanists at WYNDD.

Scientific name	Common name	Status	Phenology
Astragalus barrii	Barr's milkvetch	WYNDD tracked	Finished flowering by the middle of June or earlier.
Cymopterus williamsii	Williams' springparsley or waferparsnip	BLM Sensitive	Identifiable in flower or fruit, but easier to locate in flower.
Eritrichium howardii	Howard's forget-me-not	WYNDD tracked	This species is not readily identifiable except in flower. It may or may not be finished flowering in late June.
Pedicularis contorta* var. *ctenophora	Pink coil-beaked lousewort	WYNDD tracked	Identifiable in flower, usually in June-early July.
Penstemon caryi	Cary's beardtongue	USFS sensitive	Identifiable in flower, usually in June-early July.
Physaria didymocarpa* var. *lanata	Common (Woolly) twinpod	USFS sensitive	Identifiable in late flowering or fruit (most of June-July)
Pinus flexilis	Limber Pine	BLM Sensitive	Identifiable year-round
Sullivantia hapemanii* var. *hapemanii	Hapeman's sullivantia	WYNDD tracked	Can be identified throughout growing season if there is any stage of inflorescence (in bud/during/after flowering)

Table 2. Bold type-face shows the 4 general vegetation types from Gardner Mountain. Below each general vegetation type are shown the types from first 6 levels of the National Vegetation Classification. These national classification types were assigned based on information obtained January 31, 2014 from: The U.S. National Vegetation Classification Hierarchy Explorer (http://usnvc.org/explore-classification/).

UPLANDS

1. Mixed-conifer forests

CLASS. 1: Forest & Woodland
SUBCLASS. 1.C: Temperate Forest
FORMATION. 1.C.2: Cool Temperate Forest
DIVISION. D009: Western North American Cool Temperate Forest
MACROGROUP. M017: Northern Rocky Mountain Lower Montane & Foothill Forest
GROUP. G215: Middle Rocky Mountain Montane Douglas-fir Forest & Woodland

2. Sagebrush/grass

CLASS. 3: Semi-Desert
SUBCLASS. 3.B: Cool Semi-Desert Scrub & Grassland
FORMATION. 3.B.1: Cool Semi-Desert Scrub & Grassland (this is not a mistake)
DIVISION. D040: Western North America Cool Semi-Desert Scrub & Grassland
MACROGROUP. M169: Great Basin & Intermountain Tall Sagebrush Shrubland & Steppe
GROUP. G304: Intermountain Mountain Big Sagebrush Shrubland & Steppe

CANYON SIDES

3. Mountain mahogany shrub stands

CLASS. 1: Forest & Woodland
SUBCLASS. 1.C: Temperate Forest
FORMATION. 1.C.2: Cool Temperate Forest
DIVISION: D009: Western North American Cool Temperate Woodland & Scrub
MACROGROUP. M026: Intermountain Singleleaf Pinyon - Western Juniper Woodland
GROUP. G249: Intermountain Basins Curl-leaf Mountain-mahogany Scrub & Woodland

CANYON BOTTOMS

4. Riparian forest/woodland

CLASS. 1: Forest & Woodland
SUBCLASS. 1.C: Temperate Forest
FORMATION. 1.C.3: Temperate Flooded & Swamp Forest
DIVISION: D012: Western North American Flooded & Swamp Forest
MACROGROUP. M304: Rocky Mountain & Great Basin Flooded & Swamp Forest
GROUP. G503: Rocky Mountain & Great Basin Lowland & Foothill Riparian Forest

Table 3. All birds detected in 2013 using formal point count transects as well as opportunistic sightings in the Gardner Mountain WSA, Wyoming.

Common Name	Scientific Name	Detections
American Crow	*Corvus brachyrhynchos*	3
American Dipper	*Cinclus mexicanus*	2
American Goldfinch	*Spinus tristis*	1
American Kestrel	*Falco sparverius*	3
American Robin	*Turdus migratorius*	70
Brown-headed Cowbird	*Molothrus ater*	7
Black-headed Grosbeak	*Pheucticus melanocephalus*	1
Brewer's Sparrow	*Spizella breweri*	48
Cassin's Finch	*Carpodacus cassinii*	3
Chipping Sparrow	*Spizella passerina*	31
Clark's Nutcracker	*Nucifraga columbiana*	22
Cliff Swallow	*Petrochelidon pyrrhonota*	10
Cooper's Hawk	*Accipiter cooperii*	1
Cordilleran Flycatcher	*Empidonax occidentalis*	8
Common Nighthawk	*Chordeiles minor*	1
Common Raven	*Corvus corax*	9
Dark-eyed Junco	*Junco hyemalis*	16
Downy Woodpecker	*Picoides pubescens*	1
Dusky Flycatcher	*Empidonax oberholseri*	1
Dusky Grouse	*Dendrapapus obscurus*	4
Golden Eagle	*Aquila chrysaetos*	1
Gray Jay	*Perisoreus canadensis*	1
Green-tailed Towhee	*Pipilo chlorurus*	84
Hairy Woodpecker	*Picoides villosus*	1
Hammond's Flycatcher	*Empidonax hammondii*	1
Hermit Thrush	*Catharus guttatus*	8
House Wren	*Troglodytes aedon*	17
Lark Sparrow	*Chondestes grammacus*	5
Lazuli Bunting	*Passerina amoena*	17
Black-billed Magpie	*Pica hudsonia*	1
MacGillivray's Warbler	*Geothlypis tolmiei*	2
Merlin	*Falco columbarius*	1
Mountain Bluebird	*Sialia currucoides*	48
Mountain Chickadee	*Poecile gambeli*	29
Mourning Dove	*Zenaida macroura*	20
Northern Flicker	*Colaptes auratus*	6
Pine Siskin	*Spinus pinus*	2
Plumbeous Vireo	*Vireo plumbeus*	1
Pygmy Nuthatch	*Sitta pygmaea*	1

Common Name	Scientific Name	Detections
Red-breasted Nuthatch	*Sitta canadensis*	22
Ruby-crowned Kinglet	*Regulus calendula*	19
Red Crossbill	*Loxia curvirostra*	6
Red-headed Woodpecker	*Melanerpes erythrocephalus*	1
Rock Wren	*Salpinctes obsoletus*	19
Red-tailed Hawk	*Buteo jamaicensis*	3
Sage Thrasher	*Oreoscoptes montanus*	1
Sharp-shinned Hawk	*Accipiter striatus*	1
Song Sparrow	*Melospiza melodia*	1
Spotted Sandpiper	*Actitis macularia*	2
Spotted Towhee	*Pipilo maculatus*	9
Townsend's Solitaire	*Myadestes townsendi*	10
Tree Swallow	*Tachycineta bicolor*	2
Turkey Vulture	*Cathartes aura*	1
Vesper Sparrow	*Pooecetes gramineus*	36
Violet-green Swallow	*Tachycineta thalassina*	4
Warbling Vireo	*Vireo gilvus*	24
White-breasted Nuthatch	*Sitta carolinensis*	3
Western Meadowlark	*Sturnella neglecta*	5
Western Tanager	*Piranga ludoviciana*	10
Western Woodpeewee	*Contopus sordidulus*	7
Willow Flycatcher	*Empidonax traillii*	1
Williamson's Sapsucker	*Sphyrapicus thyroides*	4
White-throated Swift	*Aeronautes saxatalis*	16
Yellow Warbler	*Setophaga petechia*	13
Yellow-rumped Warbler	*Setophaga coronata*	18

Table 4. Number of mist-net captures and acoustic recordings for bat species in the Gardner Mountain WSA in 2013.

Common Name	Scientific Name	Mist-net Captures	Acoustic Recordings
Townsend's Big-eared Bat	*Corynorhinus townsendii*	1	1
Big Brown Bat	*Eptesicus fuscus*	5	6
Hoary Bat	*Lasiurus cinereus*	1	7
Western Small-footed Myotis	*Myotis ciliolabrum*	3	46
Long-eared Myotis	*Myotis evotis*	1	35
Little Brown Myotis	*Myotis lucifugus*	3	3
Long-legged Myotis	*Myotis volans*	15	1
Silver-haired Bat	*Lasionycteris noctivagans*	0	5
Total	**8**	**29**	**104**

Table 5. Demographic parameters for bats captured using mist nets in the Gardner Mountain WSA in July 2013.

Common Name	Males	Females	Juveniles	Reproductive
Townsend's Big-eared Bat	1	0	0	0
Big Brown Bat	5	0	0	3
Hoary Bat	0	1	0	0
Western Small-footed Myotis	2	1	1	1
Long-eared Myotis	1	0	0	0
Little Brown Myotis	3	0	0	0
Long-legged Myotis	4	11	0	7

Table 6. All mammal species detected in the Gardner Mountain WSA in June and July 2013. Detections included visual detections as well as species-specific sign (scat, chewing, nests, etc.).

Common Name	Scientific Name	How detected?
Townsend's Big-eared Bat	*Corynorhinus townsendii*	Visual, Acoustic
Big Brown Bat	*Eptesicus fuscus*	Visual, Acoustic
Hoary Bat	*Lasiurus cinereus*	Visual, Acoustic
Western Small-footed Myotis	*Myotis ciliolabrum*	Visual, Acoustic
Long-eared Myotis	*Myotis evotis*	Visual, Acoustic
Little Brown Myotis	*Myotis lucifugus*	Visual, Acoustic
Long-legged Myotis	*Myotis volans*	Visual, Acoustic
Silver-haired Bat	*Lasionycteris noctivagans*	Acoustic
Least Chipmunk	*Tamias minimus*	Visual
Yellow-bellied marmot	*Marmota flaviventris*	Visual
Red squirrel	*Tamiasciurus hudsonicus*	Visual
Pocket Gopher	*Thomomys sp.*	Sign (mounds)
Beaver	*Castor canadensis*	Sign (chewed trees)
Bushy-tailed Woodrat	*Neotoma cinerea*	Sign (nests)
Black Bear	*Ursus americanus*	Scat
American Badger	*Taxidea taxus*	Visual
Bobcat	*Lynx rufus*	Remote Camera
Elk	*Cervus canadensis*	Remote Camera, scat
Mule Deer	*Odocoileus hemionus*	Visual
Pronghorn	*Antilocapra americana*	Visual

Table 7. Other species (reptiles and fish) detected in the Gardner Mountain WSA in June and July 2013.

Common Name	Scientific Name
Reptiles	
Northern Sagebrush Lizard	*Sceloporus graciosus*
Prairie Rattlesnake*	*Crotalus viridis*
Wandering Gartersnake	*Thamnophis elegans vagrans*
Fish	
Rainbow Trout	*Oncorhynchus mykiss*
Brown Trout	*Salmo trutta*
Brook Trout	*Salvelinus fontinalis*

*Detected on BLM land just outside the eastern border of the Gardner Mountain WSA.

Table 8. Pollinators captured at Gardner Mountain Wilderness Study Area.

Common Name	Scientific Name	Number captured
Sweat bees	*Agapostemon femoratus*	1
Sweat bees	*Agapostemon angelicus/texanus*	5
Sweat bees	*Agapostemon femoratus*	15
Sweat bees	*Agapostemon sericeus*	2
Sweat bees	*Agapostemon virescens*	7
Mining bees	*Andrena*	4
Mason bees	*Anthidium*	3
Anthophorine bees	*Anthophora bomboides*	10
Anthophorine bees	*Anthophora urbana*	1
Leaf-cutter bees	*Ashmeadiella*	1
Bumble bees	*Bombus appositus*	6
Bumble bees	*Bombus bifarius*	1
Bumble bees	*Bombus californicus*	12
Bumble bees	*Bombus centralis*	34
Bumble bees	*Bombus fervidus*	7
Bumble bees	*Bombus flavifrons*	22
Bumble bees	*Bombus rufocinctus*	4
Bumble bees	*Bombus sylvicola*	1
Juniper hairstreak	*Callophrys gryneus*	2
Small carpenter bees	*Ceratina nanula*	3
Small carpenter bees	*Ceratina neomexicana*	5
Small wood-nymphs	*Cercyonis oetus charon*	3
Parasitic wasps	*Chelonus (Chelonus)*	1
Parasitic wasps	*Chelonus (Microchelonus)*	1
Common ringlet	*Coenonympha tullia ochracea*	3
Solitary bees	*Diadasia*	6
Yellowjackets	*Dolichovespula arenaria*	1
Sweat bees	*Dufourea marginata*	1
Sweat bees	*Dufourea maura*	15
Long-horned bees	*Eucera*	5
Rocky Mountain dotted-blue	*Euphilotes ancilla*	Observed
Police-car moth	*Gnophaela vermiculata*	1
Sweat bees	*Halictus farinosus*	3
Sweat bees	*Halictus rubicundus*	3
Sweat bees	*Halictus tripartitus*	7
Mason bees	*Hoplitis*	2
Mason bees	*Hoplitis fulgida*	4
Cecropia moth	*Hyalophora columbia*	1
Yellow masked bees	*Hylaeus*	2
Sweat bees	*Lasioglossum (Dialictus)*	16
Sweat bees	*Lasioglossum (Evylaeus)*	8

Sweat bees	*Lasioglossum (Lasioglossum)*	12
Sweat bees	*Lasioglossum (Sphecodogastra)*	9
Blue copper	*Lycaena heteronea*	1
Solitary bees	*Megachile*	6
Digger bees	*Melecta*	2
Long-horned bees	*Melissodes*	14
Mason bees	*Osmia*	13
Indra swallowtail	*Papilio indra indra*	1
Two-tailed swallowtail	*Papilio multicaudata*	2
Rocky Mountain swallowtail	*Parnassius smintheus sayii*	11
Crescentspots	*Phyciodes tharos complex*	1
Garden whites	*Pieris rapae*	2
Ranchman's tiger moth	*Platyprepia virginalis*	2
Boisduval's blue	*Plebejus icarioides lycea*	2
Pollen wasps	*Pseudomarasis vespoides*	5
Flower moth	*Schinia jaguarina*	1
Hawkmoths	*Smerinthus cerisyi kirby*	1
Coronis fritillary	*Speyeria coronis*	5
Great spangled fritillary	*Speyeria cybele leto*	2
Zerene Fritillary	*Speyeria zerene garretti*	1
Zerene Fritillary	*Speyeria zerene platina*	1
Solitary parasitic bee	*Sphecodes*	3
Sphinx moth	*Sphinx vashti*	1
Crownbees	*Stelis*	1
Moth	*Ulolonche disticha*	4

Table 9. Species, habit, and special status designations (if any) for plants detected during surveys in the Gardner Mountain WSA in 2013.

Habit	Scientific Name	Common Name	Status
cactus	*Escobaria vivipara*	spinystar	
cactus	*Opuntia polyacantha* var. *polyantha*	hairspine pricklypear	
forb	*Achillea millefolium*	common yarrow	
forb	*Allium* sp.	onion	
forb	*Antennaria* sp.	pussytoes	
forb	*Arenaria hookeri*	Hooker's sandwort	
forb	*Arnica* sp.	arnica	
forb	*Artemisia frigida*	prairie sagewort	
forb	*Astragalus hyalinus*	summer milkvetch	
forb	*Astragalus spatulatus*	tufted milkvetch	
forb	*Balsamorhiza sagittata*	arrowleaf balsamroot	
forb	*Calochortus gunnisonii* var. *gunnisonii*	Gunnison's mariposa lily	
forb	*Calochortus nuttallii*	sego lily	
forb	*Campanula rotundifolia*	bluebell bellflower	
forb	*Castilleja flava* var. *flava*	yellow Indian paintbrush	
forb	*Chamerion angustifolium*	fireweed	
forb	*Cirsium arvense*	Canada thistle	
forb	*Crepis* sp.	hawksbeard	
forb	*Cymopterus williamsii*	Williams' springparsley	BLM Sensitive
forb	*Cynoglossum officinale*	gypsyflower	
forb	*Equisetum* sp.	horsetail	
forb	*Erigeron* sp.	fleabane	
forb	*Hackelia deflexa* var. *americana*	American stickseed	
forb	*Heterotheca villosa*	hairy false goldenaster	
forb	*Heuchera parviflora*	littleflower alumroot	
forb	*Lewisia rediviva* var. *rediviva*	bitter root	
forb	*Lupinus* sp.	lupine	
forb	*Mertensia ciliata* var. *ciliata*	tall fringed bluebells	
forb	*Mimulus guttatus*	seep monkeyflower	
forb	*Osmorhiza depauperata*	bluntseed sweetroot	
forb	*Penstemon angustifolius*	broadbeard beardtongue	
forb	*Penstemon laricifolius* ssp. *laricifolius*	larchleaf beardtongue	
forb	*Phlox hoodii*	spiny phlox	
forb	*Physaria didymocarpa* var. *lanata*	common twinpod	USFS Sensitive
forb	*Sedum* sp.	stonecrop	
forb	*Solidago* sp.	goldenrod	
forb	*Taraxacum officinale*	common dandelion	
forb	*Tragopogon dubius*	yellow salsify	

Habit	Scientific Name	Common Name	Status
forb	*Verbascum thapsus*	common mullein	
forb	*Viola* sp.	violet	
forb	*Zigadenus venenosus* var. *gramineus*	grassy deathcamas	
grass	*Bromus tectorum*	cheatgrass	
grass	*Calamagrostis canadensis*	bluejoint	
grass	*Festuca idahoensis*	Idaho fescue	
grass	*Hesperostipa comata*	needle and thread	
grass	*Leymus cinereus*	basin wildrye	
grass	*Poa secunda*	Sandberg bluegrass	
grass	*Pseudoroegnaria spicata*	bluebunch wheatgrass	
shrub	*Acer glabrum* var. *glabrum*	Rocky Mountain maple	
shrub	*Artemisia tridentata* ssp. *vaseyana*	mountain big sagebrush	
shrub	*Artemisia tridentata* ssp. *wyomingensis*	Wyoming big sagebrush	
shrub	*Cercocarpus ledifolius* var. *ledifolius*	curl-leaf mountain mahogany	
shrub	*Juniperus communis* var. *depressa*	common juniper	
shrub	*Mahonia repens*	creeping barberry	
shrub	*Prunus virginiana* var. *melanocarpa*	black chokecherry	
shrub	*Purshia tridentata*	antelope bitterbrush	
shrub	*Rhus trilobata* var. *trilobata*	skunkbush sumac	
shrub	*Ribes cereum*	wax currant	
shrub	*Rosa* sp.	rose	
shrub	*Rubus idaeus* ssp. *strigosus*	grayleaf red raspberry	
shrub	*Symphoricarpos* sp.	snowberry	
tree	*Abies lasiocarpa*	subalpine fir	
tree	*Acer negundo*	boxelder	
tree	*Betula occidentalis*	water birch	
tree	*Juniperus scopulorum*	Rocky Mountain juniper	
tree	*Pinus flexilis*	limber pine	BLM Sensitive
tree	*Pinus ponderosa*	ponderosa pine	
tree	*Populus angustifolia*	narrowleaf cottonwood	
tree	*Pseudotsuga menziesii* var. *glauca*	Rocky Mountain Douglas-fir	
tree	*Salix fragilis*	crack willow	
vine	*Clematis ligusticifolia*	western white clematis	

Table 10. Basic water quality measured using a Yellow Spring Instrument in the 2 streams flowing through Gardner Mountain WSA.

Parameter	Unit	Beartrap	NF Red Fork Powder
Date		26-Jun-13	25-Jun-13
Water temperature	C	12.5	12.2
Dissolved oxygen	% saturation	101	104
Dissolved oxygen	mg/L	10.4	10.7
Specific conductivity	µS/cm	289.6	393
pH		8.65	8.79
ORP	mV	142.4	133
Air temperature	C	24	20

Table 11. Physical description of the streams where aquatic invertebrates were sampled in Gardner Mountain WSA.

	Unit	Beartrap Creek	NF Red Fork of Powder
Elevation	m	1865	1855
Mean stream width	m	3.4	3.6
Mean stream depth	mm	261.7	258.3
Mean particle size	mm	59.3	70.4
Aspect	degrees	320	286
Slope	degrees	4	4

Table 12. Density and standard error of aquatic invertebrates collected in the North Fork of the Red Fork of the Powder River (NF RF Powder River) and Beartrap Creek in Gardner Mountain WSA.

Scientific Name	Common Name	NF RF Powder River	Beartrap Creek
Acroneuria	Stonefly	17±10	97±45
Antocha	True fly (Crane fly)	28±11	952±281
Arctopsyche	Caddisfly	0±0	22±15
Baetis	Mayfly	4357±940	3059±939
Brachycentrus	Caddisfly	2±2	11±8
Chironomidae	True fly (Midges)	1014±200	5864±1588
Cinygmula	Mayfly	265±130	0±0
Cleptelmis addenda	Riffle beetle	908±346	949±313
Epeorus	Mayfly	1464±380	75±42
Hydrocarina	Mites	24±16	41±33
Hydropsyche	Caddisfly	648±155	95±39
Lepidostoma	Caddisfly	62±57	0±0
Micrasema	Caddisfly	0±0	17±5.5
Nematoda	Roundworms	84±30	26±12
Ochrotrichia	Caddisfly	0±0	310±140
Oligochaeta	Worms	0±0	657±377
Oligophlebodes	Caddisfly	2±2	0±0
Ostracoda	Seed shrimp	0±0	6±6.5
Pericoma/Telmatoscopus	True fly (Moth fly)	0±0	0±0
Physidae	Bladder snails	0±0	2±2
Rhyacophila arnaudi	Caddisfly	39±10	2±2
Rhyacophila brunnea/vemna	Caddisfly	4±4	62±17
Rhyacophila coloradensis	Caddisfly	6±6	30±18
Rithrogena	Mayfly	17±17	0±0
Serratella	Mayfly	54±51	0±0
Simulium	True fly (Black fly)	10,585±6398	583±204
Sphaeriidae	Fingernail clams	19±17	26±21
Suwallia	Stonefly	54±21	2±2

Table 13. Metrics included in the Wyoming Stream Integrity Index for the sedimentary mountains and Bighorn Basin foothills bioregions, the expected trend in relation to stream impairment, the threshold values for least disturbed sites, and metrics calculated for the North Fork of the Red Fork of the Powder River (NFRF) and Beartrap Creek (BT). Metrics from the streams were electronically composited to simulate field composite samples used to develop the metrics. EPT stands for the orders mayfly, stonefly, and caddisfly. Bold values indicate that the metric surpasses the threshold value.

Metric	Trend	Threshold	NFRF	NFRF (excluding blackflies)	BT
Sedimentary Mountains					
Number of EPT (excluding Arctopsychidae and Hydrosychidae)	-	>16	14	14	11
% Ephemeroptera (excluding Baetidae and *Tricorythodes*)	-	>14.8	9.2	**29**	0.6
% Collector-gatherers	+	<46.4	**28**	60	91.5
% Scrapers	-	>13	8.9	**19**	0.6
Number of scraper taxa	-	>5	4	4	2
HBI	+	<3.4	4.9	4.5	5.1
Bighorn Basin Foothills					
Number of EPT taxa (excluding Baetidae and *Tricorythodes*)	-	>13	**13**	**13**	11
% EPT (excluding Baetidae and *Tricorythodes*)	-	>31.5	13	29	6
% Scrapers	-	>18.7	8.9	**19**	0.6
HBI	+	<4.2	4.9	4.5	5.1

Table 14. Diagnostic measurements of *Oreohelix* (mountainsnails) collected in Beartrap Canyon. Based on these measurements, *Oreohelix subrudis* lives in the canyon.

Characteristic	Individual 1	Individual 2	Individual 3
Shell diameter (mm)	16.34	15.75	16.64
Shell height (mm)	10.45	8.46	10.31
Height/width ratio	0.64	0.54	0.62
Umbilicus (mm)	2.17	2.76	2.76
Umbilicus/diameter ratio	0.13	0.18	0.17
Whorls	4.75	4.75	4.75
Number of shell bands	4	2	4
Penis length	NA	5	8
Ribbed penis length	NA	3	4.5
Ribbed penis ratio	NA	0.60	0.56
Number of penis ribs	NA	4	6
Notes	Not preserved well	Median of penis swollen	Median of penis swollen
Location	13 4849023N 582116E	13 4848213N 341209E	13 4848213N 341209E