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Southwest Idaho Vernal Pool and Playa Faunal Inventory and Condition Assessment

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ABSTRACT

We collected baseline information on fauna inhabiting or seasonally using vernal pools and playas in southwestern Idaho. We used a Rapid Assessment Method to evaluate the ecological condition of surveyed sites. Ecological and vegetation classification and estimates of vernal pool and playa distribution were conducted concurrently and detailed in a companion report (Murphy 2012). Our surveys targeted waterfowl, shorebirds, specific aquatic invertebrate groups, and amphibians. We estimated ecological condition by measuring the number and severity of physical disturbances within pool boundaries and in a 50-meter buffer around wetland habitats. We evaluated 90 vernal pools and playas during 2008 - 2009 and performed faunal surveys at 39 sites. Waterfowl and shorebirds were observed at 20 sites, including pools that were dry or nearly so. Invertebrate surveys focused on the large branchiopod crustaceans in the Anostracan and Notostracan orders. Anostracan (fairy) shrimp occupied nearly all inundated sites and we identified 3 *Branchinecta* and 1 *Eubranchipus* species. *Branchinecta constricta*, a new Idaho record, represents a range extension of > 500 km. Notostracan (tadpole) shrimp occurred at 9 sites. Amphibians were infrequently observed and vouchered at only 7 locations. These surveys indicate widespread occupancy of vernal pools and playas in southwest Idaho by a diverse community of aquatic invertebrates and birds, and localized but important breeding populations of amphibians. Approximately 73% of playas surveyed were minimally or lightly disturbed, compared to 32% of vernal pools. Livestock grazing was widespread. Impacts from excavated livestock water reservoirs and non-native plant invasion were locally severe.

KEYWORDS

amphibian, aquatic invertebrate, Branchiopoda, *Branchinecta*, disturbance, ecological condition, ephemeral wetland, *Eubranchipus*, *Lepidurus*, playa, shorebirds, southwest Idaho, special status species, vernal pool, waterfowl

SUGGESTED CITATION

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Introduction

Vernal pools are precipitation-filled, isolated ephemeral wetlands. They have an inundation period during the early growing season (supporting aquatic or amphibious plant growth), followed by a saturated soil stage (supporting terrestrial plant growth), and then extreme and long-lasting soil desiccation (supporting drought tolerant species) (Zedler 1987, Keeley and Zedler 1998). Though not identical, Idaho's vernal pools roughly fit this definition of vernal pools from Mediterranean-type climates and have analogous flora and fauna. Like vernal pools in California, Oregon, and Washington, many of these habitats in southwest Idaho are dominated by annual forbs adapted to ephemerally wet clay soil (Murphy 2012). Other vernal pools support perennial marsh-like communities of common spikerush (*Eleocharis palustris*). Bolander's silver sagebrush (*Artemisia cana* ssp. *bolanderi*) also dominates many vernal pools, or forms rings around herbaceous pool communities (Murphy 2012). Like vernal pools, playas also occur in closed topographic depressions. Playas, however, are more intermittently and less predictably flooded and are more likely to have alkaline water and evaporative salt deposits (Comer et al. 2003). They tend to be sparsely vegetated. Both vernal pools and playas are underlain by impermeable duripans created by clay pans or bedrock layers that impede drainage. Larger pools and playas can be aquifer recharge wetland systems filled only by precipitation and surface runoff.

Vernal pools and playas may be overlooked by resource managers because they are only seasonally productive and vegetation can be sparse. Management has historically emphasized their value as water sources for livestock and terrestrial wildlife species while disregarding their value as habitat for other taxa. In southern and west-central Idaho, these wetlands have not been systematically surveyed and information regarding their distribution, condition, and value as wildlife habitat is lacking. Vernal pool and playa habitats in arid and semi-arid regions typically support unique floral and faunal assemblages, particularly invertebrates. In certain regions, such as California's Central Valley, vernal pool complexes are also characterized by high rates of endemism and contain relatively high numbers of rare or uncommon species. It is possible that rare invertebrates occur in southwest Idaho as well, as evidenced by the recent description of a new large branchiopod crustacean from Elmore County in 2006 (Rogers et al. 2006) and the collection of a species in Camas County previously known only from southwestern and south-central Wyoming. Freshwater vernal pool crustaceans are also culturally significant. They have been documented as an aboriginal food source on the Snake River Plain (Henrickson et al. 1998). Outside California and southwest Oregon, few published inventories of vernal pool invertebrates have been conducted (e.g., eastern Washington, Kulp and Rabe 1984; central Oregon, Dlugolecki 2010).

Vernal pools and playas offer important resting and feeding stations for migratory waterfowl and wading birds (Silveira 1998). As many as 20 shorebird and waterfowl species identified as Idaho Species of Greatest Conservation Need (SGCN) are known to use these habitats. These include American avocet (*Recurvirostra americana*), black-necked stilt (*Himantopus mexicanus*), long-billed curlew (*Numenius americanus*), white-faced ibis (*Plegadis chihi*), and Wilson's phalarope (*Phalaropus tricolor*).

Vernal pools and playas provide a fishless breeding environment favorable to desert-dwelling amphibians, such as Great Basin spadefoot (*Spea intermontanus*) (Woodward 1983). They also support communities of aquatic invertebrates that have evolved life history strategies adapted to ephemeral water sources (Wiggins et al. 1980). This survey focuses on the large branchiopod crustaceans in the Anostracan and Notostracan orders. Branchiopod crustaceans are among the most conspicuous and well studied group of vernal pool and playa obligates and are often considered "flagship" organisms in these systems. The embryonic offspring of these short-lived crustaceans survive episodic desiccation in the form of hardened cysts, deposited on pool bottoms during periods of inundation (Brown and Carpelan 1971). Cysts are heat and cold resistant, and may survive for many years in this state (Belk 1998). Additionally, reemergence of the embryos is staggered, allowing cysts from a single generation to persist through multiple wet-dry cycles (Simovich and Hathaway 1997).

The goal of this study is to collect baseline information on wildlife inhabiting or using vernal pools and playas in southwestern Idaho. Resource managers will be able to use information from this inventory and assessment to (1) better understand the full breadth of biological diversity these unique habitats support; (2) be informed of rare, uncommon, or special status species inhabiting or seasonally using vernal pools; and (3) make informed decisions regarding management of ephemeral wetlands in land use planning.

The objectives of this study are to:

1. survey vernal pools and playas to document the presence of aquatic invertebrates, evidence of amphibian breeding, and waterfowl and shorebird use;
2. document impacts from livestock disturbance, excavation of water reservoirs, non-native and invasive plant species, off-highway vehicle (OHV) use, and roads;
3. in conjunction with vegetation data collected concurrently, assess ecological condition and value of vernal pools and playas for special status animals and plants.

Information from this study will also be shared with the Idaho Natural Heritage Program, in a continuing effort to identify, monitor, and protect Idaho's biological resources.

Study Area

Geography: The study area is defined by Bailey's (1980) Owyhee Uplands Ecological Section, inclusive of 6 subsections (Figure 1) (Quigley et al. 1999). From north to south, the study area stretches from the foothills of Idaho's central mountains and volcanic uplands of the Bennett Hills across the Snake River Plain to the Snake River canyon. The Snake River canyon and lowlands are the hottest and driest area in Idaho and are characterized by saltbush-dominated benches, alkaline flats, and badlands on lacustrine deposits extending from the Weiser River Basin to the Owyhee Plateau. Further south, the study area is characterized by the Owyhee Mountains and juniper and sagebrush-covered uplands of the Owyhee Plateau and Owyhee River Canyonlands. Topography is a mosaic of ridges, mesas, plateaus, tablelands, and canyons. To the southeast, the sagebrush and grass-covered plateaus of the Snake River Plain and Bruneau Desert are dissected by deep canyons of the Bruneau and Jarbidge Rivers and Salmon Falls

Creek. The plateaus stretch south to a basin-and-range landscape that includes the Bull Run, Mahogany, and Jarbidge Mountains, and Elk Mountain/Salmon Falls Highlands.

Geology: The Owyhee Uplands Section is geologically diverse and includes the loess-covered basaltic plateau of the western Snake River Plains and Bruneau Desert and the alluvium filled lower Boise, Payette, and Snake River valleys. It also includes the Snake River canyon and surrounding low-lying badlands and benches of lacustrine deposits. The fault-block Owyhee Mountains, with their granitic core and the volcanic escarpments of the Owyhee Plateau (to the south) and Bennett Hills (to the northeast), rise from the desert-like setting along the Snake River. The Owyhee Plateau and Bennett Hills are mainly rhyolite and welded tuff layers that are often capped by basalt flows. Erosion and fault blocking have formed high mesas, tablelands, and plateaus interspersed by basins and cut by deep, narrow canyons carrying numerous perennial and intermittent streams. Numerous seeps and springs occur throughout the region.

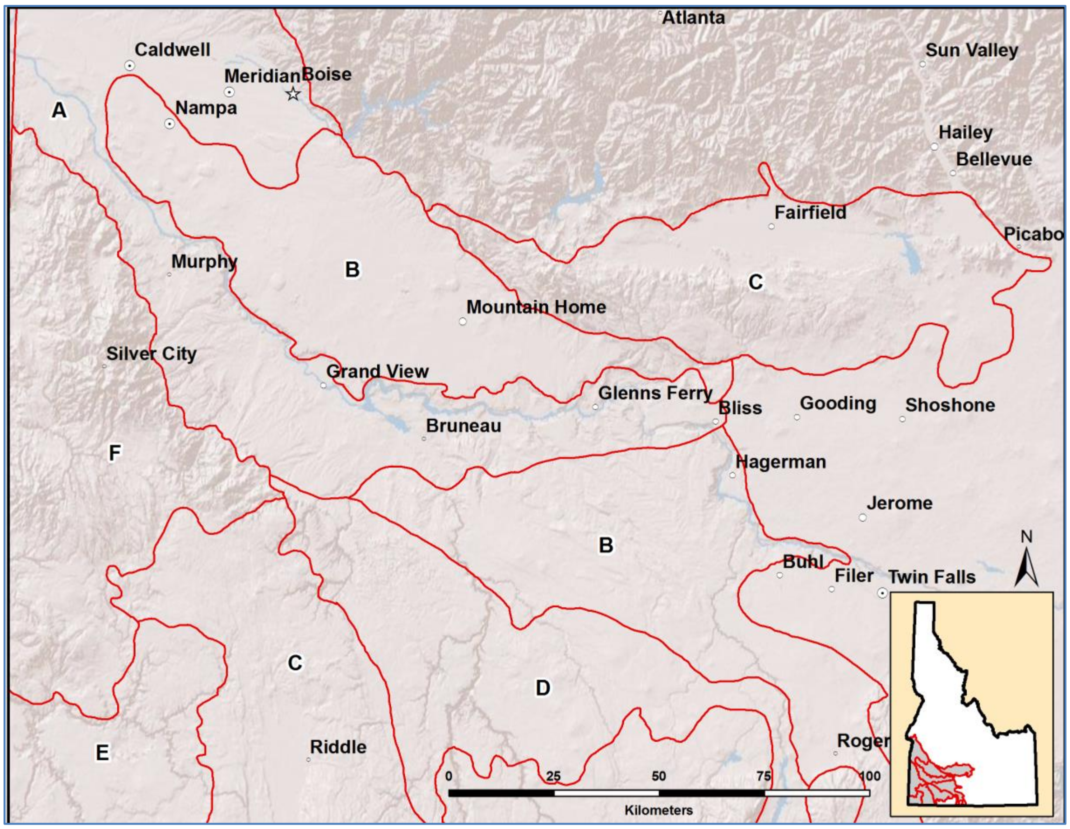


Figure 1. Owyhee Uplands Section in southwest Idaho. Subsection outlines in red: A) Boise–Payette–Snake River Valleys Lacustrine Deposits, B) Snake River Plains, C) Bennett Hills–Owyhee Plateau, D) Bruneau Desert, E) Owyhee River Canyonlands, F) Owyhee Mountains.

Climate: While total relief ranges from as low as 640 m (2,100 ft) on the Snake River to as high as 2,560 m (8,400 ft) in the Silver City Range of the Owyhee Mountains, the majority of the Owyhee Uplands Section occurs between 853 and 1890 m (2,800 and 6,200 ft). Throughout the area at lower elevations, precipitation generally averages 229 to 305 mm (9 to 12 inches) (Idaho State Climate Service 2008). Winters are generally moderately cold and moist, and summers hot and dry. Average winter low temperatures range from -8.9 to -5.0 degrees C (16 to 23 F) while average summer high temperatures range from 29.4 to 33.9 degrees C (85 to 93 F) (Idaho State Climate Service 2008). At elevations above 1,829 m (6,000 feet), in the juniper and mountain big sagebrush zones, precipitation is about 406 to 508 mm (16 to 20 inches) per year, the majority from snow accumulation. In contrast, the low elevation shadscale – greasewood zone along the Snake River, stretching from about Marsing to Hammett has mild winters (low temperatures averaging between -6.7 to -4.4 degrees C [20 to 24 F]), very hot summers (average high temperatures 32.8 to 35.6 C [91 to 96 F]), and very low precipitation (only 178 to 203 mm [7 to 8 inches] per year). Precipitation in the Owyhee Uplands Section generally has a dual peak, one in January and another lesser peak in May and June when thunderstorms tend to develop.

Though total precipitation is generally low, drainage on the shallow and eroded plateau soils can be impeded by sub-soil clay-pans or bedrock. As a result, numerous ephemerally moist drainages, vernally wet pools or lakes, and playas collect snowmelt and rainfall runoff. In order for water to pool, drainage-resistant geology, clay-rich soil, and topographic closed-depressions (often formed in collapsed craters and flow features or from other volcanic and tectonic activity) must all be present. Whether or not pooling is intermittent and less predictable (e.g., playa-like) or temporary but more predictable (e.g., vernal pool-like) depends on the timing, duration, and amount of precipitation, combined with the rate of evaporation, basin size, and presence of specific geologic and soil types (Zedler 1987, Keeley and Zedler 1998). Much of the study area is capable of supporting vernal pools or playas, with the exception of low elevation lacustrine deposit landforms. These are apparently too porous and sloped, precipitation events too few and small, and evaporation too rapid to support even playa ecosystems. Likewise, mountainous areas with granitic soils are too steep and well-drained, or too cold to support vernal pools. These areas have ample water and low evaporation potential, but typically exhibit perennial or semi-permanent flooding (versus temporary flooding) if wetlands are present in depressions.

Methods

Vernal pool and playa sample selection: We examined the feasibility of using various modeling and feature extraction GIS tools (e.g., eCognition) to identify potential vernal pool and playa locations. The time and effort to complete this task was greater than anticipated and we were unable to use this method. Alternatively, we selected potential sample sites using multiple spatial data sources. We considered all BLM and state of Idaho-managed lands within the Owyhee Uplands Ecological Section as the sample frame. This approach decreased the likelihood of omitting sites with the potential to support vernal pools and playas. Township/ranges with greater than 20% of their area in BLM and state management were chosen as the sampling unit. This approach maximized both geographic and environmental variation in the study area while increasing the likelihood of public access. We stratified the sample frame by subsection, with the number of randomly selected township/ranges proportionate to the total available in each subsection as follows:

Subsection	Potential Sample Sites Randomly Selected # (% of total)	Sites Surveyed 2008 - 2009 # (% of total)
• Bennett Hills–Owyhee Plateau	21 (20)	51 (58)
• Boise–Payette–Snake River Valleys Lacustrine Deposits	15 (15)	6 (7)
• Bruneau Desert	15 (15)	13 (15)
• Owyhee Mountains	18 (18)	1 (1)
• Owyhee River Canyonlands	9 (9)	0 (0)
• Snake River Plains	24 (23)	17 (19)

We scrutinized each randomly selected township/range for potential vernal pools and playas to sample by examining aerial photos (NAIP imagery), U. S. Geological Survey (USGS) topographic maps, National Wetland Inventory (NWI) maps, National Hydrographic Dataset maps, geologic formations, soils, and known occurrences of vernal pool and playa-dependent rare plant species. Numerous vernal pool-like depressions have been created by hydrologic alterations of springs and ephemeral drainages, including livestock reservoirs, ditches and dikes, and roadbeds. We did not include human-created pools unless they were excavated within a naturally formed vernal pool or playa.

To maximize sampling efficiency, sites that occurred in clusters or were in close proximity to one another were favored over individual or isolated sites. Randomly selected sites in the Owyhee Mountains subsection lacked vernal pools. Vernal pools and playas were not common in the Boise–Payette–Snake River Valleys Lacustrine Deposits. In contrast, vernal pools were abundant in the Bennett Hills–Owyhee Plateau subsection. The Owyhee River Canyonlands subsection was not sampled due to time and accessibility constraints. Sampling site selection resulted in 6 broad groupings (Figure 2). Finer scale maps of these groupings and labeled survey sites are shown in Appendix 1.

Vernal pool and playa sampling: We conducted vernal pool and playa surveys in May and June, 2008 and between March and June, 2009 as weather and road conditions permitted. When pools were at least partially inundated, we focused on wildlife surveys and preliminary environmental and condition description. During late winter and early spring, when pools are most likely to be inundated, roads accessing many sites were impassable. Consequently, many of the smaller and mid-sized pools were dry or nearly dry at the beginning of the survey period. We attempted to access sites earlier (during March and April) in 2009. During both years, surveys continued through early June at progressively higher elevation sites as access allowed. The number of sites surveyed per township/range was limited by time and access.

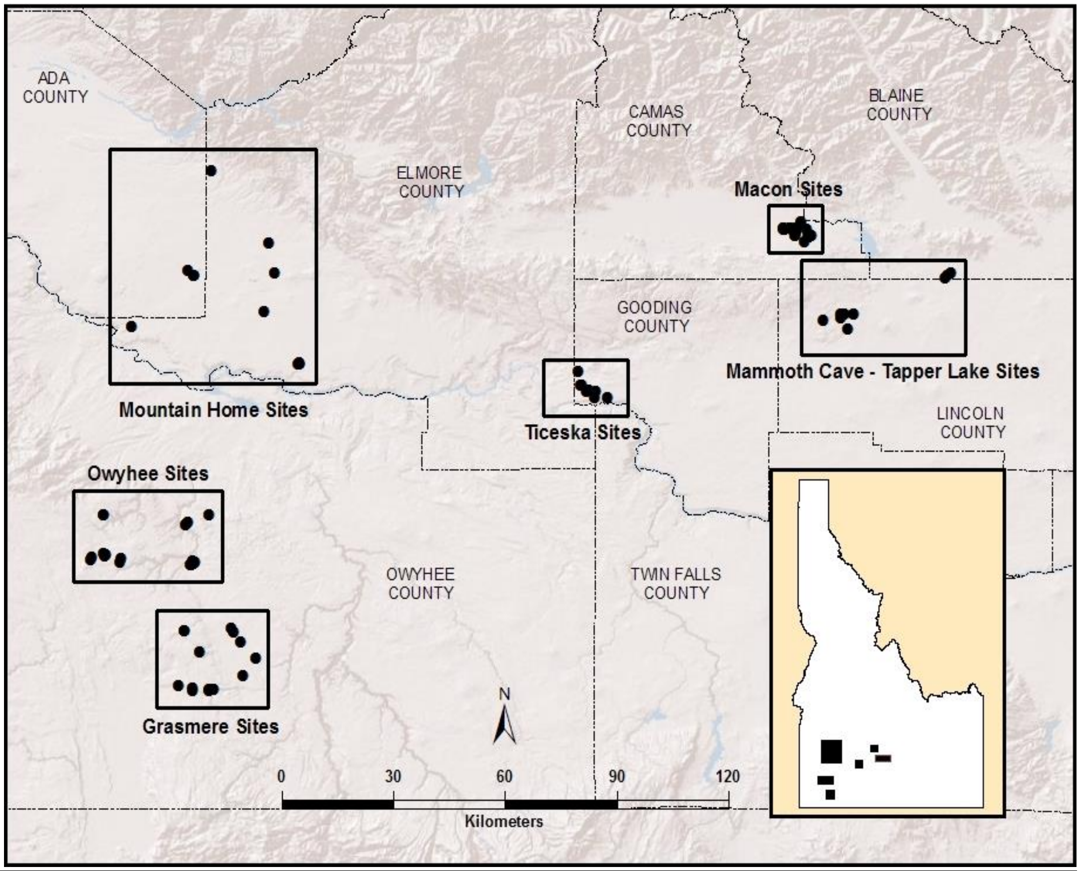


Figure 2. Distribution of vernal pool and playa sites surveyed in 2008 - 2009.

Shorebird/waterfowl surveys: We adapted our survey protocol from USGS Western Shorebird Survey protocols and Unasch et al. (2003). Surveys consisted of observation point counts and shoreline walking surveys, as appropriate for site conditions. Point count observation was the primary survey method. We conducted point counts from an elevated position if possible or a position that was minimally obstructed by vegetation. We determined the starting points for surveys by examining site characteristics, such as extent and depth of surface water, presence of emergent vegetation for optimal locations. Binoculars were sufficient for all shorebird and waterfowl surveys. Observers scanned open water and visible shore areas for a total of 10 survey minutes per point. We recorded the start and stop times of the survey, GPS coordinates of the point count location, and the species and number of birds observed.

Shoreline walking was used during periods of relatively low bird activity (mid-morning through mid-afternoon) or to observe additional open water areas that were not visible from observation points. Walking shoreline surveys were time or area limited and most effective along shorelines containing minimal amounts of emergent vegetation that could be traversed efficiently.

Amphibian surveys: We used visual encounter surveys to detect amphibian eggs, larvae, and mating adults, if conditions suitable for amphibian reproduction were present. Potentially occurring species included, but were not limited to, Great Basin spadefoot (*Spea intermontana*), western toad (*Anaxyrus boreas*), Woodhouse's toad (*Anaxyrus woodhousii*), and Northern Pacific chorus frog (*Pseudacris regilla*).

The observer determined the survey route based on site characteristics, but generally focused on shallow water habitats likely to support breeding amphibians. We recorded site data, vernal pool and playa description, and start time prior to the survey. The observer slowly searched shallow water habitats, scanning the shoreline and water. We collected adults and larvae in dipnets for positive identification. After identification, we released the specimens. If field identification was uncertain, we collected voucher specimens for laboratory identification. We tallied egg masses and recorded stage of development. If water turbidity was high, we performed dipnet sweeps at regular intervals along the survey route. Sweeps were transverse to the direction of travel and covered 1 to 2 m on either side of the observer. We examined and emptied the contents of the net after each sweep. We recorded the species, life stage and number of animals observed during the survey. The survey was not timed, but all suitable habitats were sampled.

<u>Invertebrate surveys</u>: We targeted Anostracan (fairy) and Notostracan (tadpole) shrimp. The adult morphological characters of these taxa make species-level identification possible with stereo dissecting scopes. In inundated playas and vernal pools, invertebrate sampling consisted of dipnet sweeps in wetted habitats. Merickel and Wangberg (1981) found the highest proportion of invertebrates in shallow (≤ 0.3 m depth) water with emergent vegetation. Dip net searches followed the same sampling protocol used for larval amphibians. In small pools, these surveys were conducted concurrently. In larger pools, we conducted amphibian and invertebrate surveys separately, in different locations and at different times. In shallow pools where use of a dipnet was not feasible, invertebrates were captured using a pipette or small aquarium net (Figure 3). Invertebrates in remnant pools were typically quite visible and captured as they were observed. We vouchered representative invertebrates for later lab identification. Invertebrate taxonomic expert, D. Christopher Rodgers assisted with identification of specimens.

We collected one-liter soil samples from most dry playas and vernal pools with bare soil. Where possible, we took samples from depressions or the lowest identifiable surface. We stored samples in re-sealable plastic bags for future laboratory specimen culture. In 2009, we cultured soil samples from 9 sites and vouchered 4 Anostracan shrimp grown from this effort. Methods for storing dormant cysts and culturing freshwater crustaceans are detailed by Moore (1957) and Prophet (1963).

<u>Ecological condition assessment</u>: In wetlands, ecological condition is defined as "the relative ability of a wetland to support and maintain its complexity and capacity for self-organization with respect to species composition, physicochemical characteristics and functional processes as compared to wetlands of a similar class without human alterations" (Karr and Dudley 1981). It describes the degree of departure from full ecological integrity, the state expected to occur in a natural, non-impacted site (Fennessy et al. 2004).

Figure 3. Typical late-spring remnant water on a playa on the Snake River Plain. Branchiopod crustaceans were collected here, although water depth was < 2 cm.

Three hierarchical levels of assessment procedures are commonly recognized. Level 1 landscape-scale assessments are the coarsest, relying almost entirely on GIS and remote sensing technologies. Any Level 2 Rapid Assessment Method (RAM) is semi-quantitative and uses relatively simple, field-based metrics observable. This type of assessment often focuses on observable stressors known to impact wetland function. These methods are demonstrably effective at assessing impacts to wetlands (e.g., Fennessy et al.1998, Mack, 2001). Level 3 intensive site assessments integrate biological, physical, and chemical indicators of ecological function. Both Level 2 and 3 methods numerically rank sites on a continuum ranging from unimpacted (full ecological integrity) to highly impaired (completely disturbed).

We assessed ecological condition at two spatial scales. We used a GIS analysis (Level 1 method) for preliminary assessment of ecological condition at a landscape scale, overlaying spatial layers of commonly used indicators of ecological condition (e.g., land use, road density, utility corridors, etc.) on areas of potential vernal pool and playa occurrence (Murphy 2012, Murphy et al. 2012 in progress). The primary assumption with this method is that human impacts degrade wetland habitats and/or function and the effects are typically proportional to the magnitude and extent of disturbance(s). This premise is well supported in the literature (Roccio 2006, Murphy et al. 2012 in progress). The Level 1 analysis provided a cost-effective means to quickly evaluate a large geographic area and the ability to be updated as spatial data are improved. Analysis at this scale provided context for the study area, and was relevant and useful in developing the Level 2 analysis. Results of Level 1 GIS analysis can be verified with site-specific data gathered during the Level 2 assessment.

We used a simplified Level 2 RAM to conduct condition assessment at the vernal pool and playa scale. We evaluated only anthropogenic impacts observed at our survey sites for the purpose of providing a rapid evaluation of land management practices, prioritizing resource management decisions, and potentially serving as a baseline for future restoration or mitigation projects. We used rapid field-based metrics with a narrative rating modified from Rocchio (2006) and Collins et al. (2008) and documented observable indicators of condition on soils and the physical environment, hydrological regime, and vegetation. We assessed conditions within the pool boundaries and within a 50-meter buffer surrounding the pool margins. Buffers either ameliorate impacts from adjacent uplands if upland habitats are intact and ecological integrity is high or exacerbate impacts to wetlands if they are degraded. The most commonly observed indicators throughout the study area were livestock grazing impacts, hydrologic modifications, and the presence of non-native plant species.

At each site we recorded all stressors observed in the pool boundary and the 50-m buffer and rated the overall severity of the impacts as light, moderate, or heavy. The severity ratings were based on a mix of qualitative and quantitative criteria developed using best scientific judgment and literature review (Roccio 2006, Collins et al. 2008, Dlugolecki 2010). Light severity is characterized by minimal physical disturbance to wetland soils, low cover of invasive plants (≤ 10%), and no visible alterations to site hydrology. There may be evidence of grazing, but not of pugging (indicated by hoof penetration into moist soil > 50 mm [2 inches] in depth). Site disturbance of moderate severity included alteration of pool structure and hydrology, generally from multiple stressors. Pugging is common, indicating livestock use pools during periods of inundation or when soils were saturated. Roads in upland habitats and relatively high cover (>10%) of non-native plants are characteristic of moderately disturbed sites. Heavily disturbed sites are typically marked by severe alteration of hydrologic regime, usually from excavated livestock reservoirs but also from roads in upland or wetland habitats, widespread pugging, trampling of perennial vegetation, and high cover of non-native plants.

We assigned a coefficient to each stressor that reflected impact severity, area affected, and location within the survey site (Table 1). The values range from 0.01 to 0.20 (the higher the value, the larger the magnitude of the stressor's impact on pool hydrology, soil integrity, and biological communities). Values were assigned using best scientific judgment and literature review (Roccio 2006, Collins et al. 2008, Dlugolecki 2010). We tallied the coefficients for each site and totaled the results for a single ecological condition score (Table 5). The ecological condition scores were then scaled from 0 to 1.00 and divided into the following classes (as in Murphy et al. 2012, in progress):

- Minimally Disturbed 0.01 – 0.05
- Lightly Disturbed 0.06 – 0.10
- Moderately Disturbed 0.11 – 0.35
- Severely Disturbed 0.36 – 0.50
- Completely Disturbed 0.51 – 1.00

A score of 1.0 represents the maximum attainable score from a completely disturbed site (one containing all stressors). The scores are not explicit measures of wetland condition or function, but rather a relative measure permitting comparisons between surveyed sites.

Results

We surveyed 90 vernal pool and playa sites in 2008 - 2009 (Table 2) at which 36 invertebrate vouchers were collected (Table 3). Thirty-one sites were dry at the time of survey and we collected soil samples at 15 of these. Wetted pools and playas varied widely in size and quantity of water remaining (Figures 4 and 5). Nine sites held enough water to permit waterfowl/shorebird surveys and we made incidental observations at an additional 12 sites. We vouchered amphibians at 7 locations. Pools that had been created through excavation were not surveyed, although we incidentally observed and collected one larval Great Basin spadefoot at a livestock reservoir in Elmore County and branchiopod crustaceans at another reservoir in Owyhee County. We did survey natural vernal pools and playas that were partially excavated but still retained natural characteristics (e.g., natural topographic depression, shallow-water habitats, evidence of native wetland vegetation, etc.).

We determined that 7 sites were not vernal pools or playas. A large closed depression on the Owyhee Plateau contained a wet meadow fed by toeslope springs. Two sites were located in shallow, dendritic drainage channels not confined to a closed basin, one of which contained an ephemeral spring. Groundwater supported wetland vegetation at both sites. Another site was identified on NWI maps as a palustrine scrub-shrub temporarily flooded wetland but contained no evidence of being recently wetted. This site was in a poorly defined depression dominated by mature Wyoming big sagebrush (*Artemisia tridentata* var. *wyomingensis*). A fifth site received water from an irrigation ditch and was being used as a livestock reservoir. The only site we visited in the Owyhee Mountain subsection was a highly trampled cattle salt block location that occasionally puddles water. Additionally, three more sites lacked definitive edaphic or vegetative characteristics and were not surveyed. We were unable to sample one site in Elmore County because access to public lands was blocked by private property.

<u>Shorebird/waterfowl surveys</u>: We conducted shorebird/waterfowl surveys at 8 sites and recorded incidental observations at 12 additional locations (Table 4). Opportunities for surveys were generally limited to larger pools with elevated viewing locations. Incidental observations typically occurred at small pools where all birds flushed on approach or where birds were observed while conducting surveys for other taxa. We only observed waterfowl at inundated sites. Shorebirds typically occurred at wetted sites, with the exception of long-billed curlew. This species was commonly observed near sites that were dry or nearly so. Most birds detected during the surveys are known to be either short- or long-distance migrants in Idaho, and their use of vernal pools and playas is thought to be largely transitory. In general, shorebirds were observed actively feeding and waterfowl were observed either resting or feeding where food items were available.

Figure 4. A fully inundated small vernal pool (< 40 m^2) in the Bennett Hills.

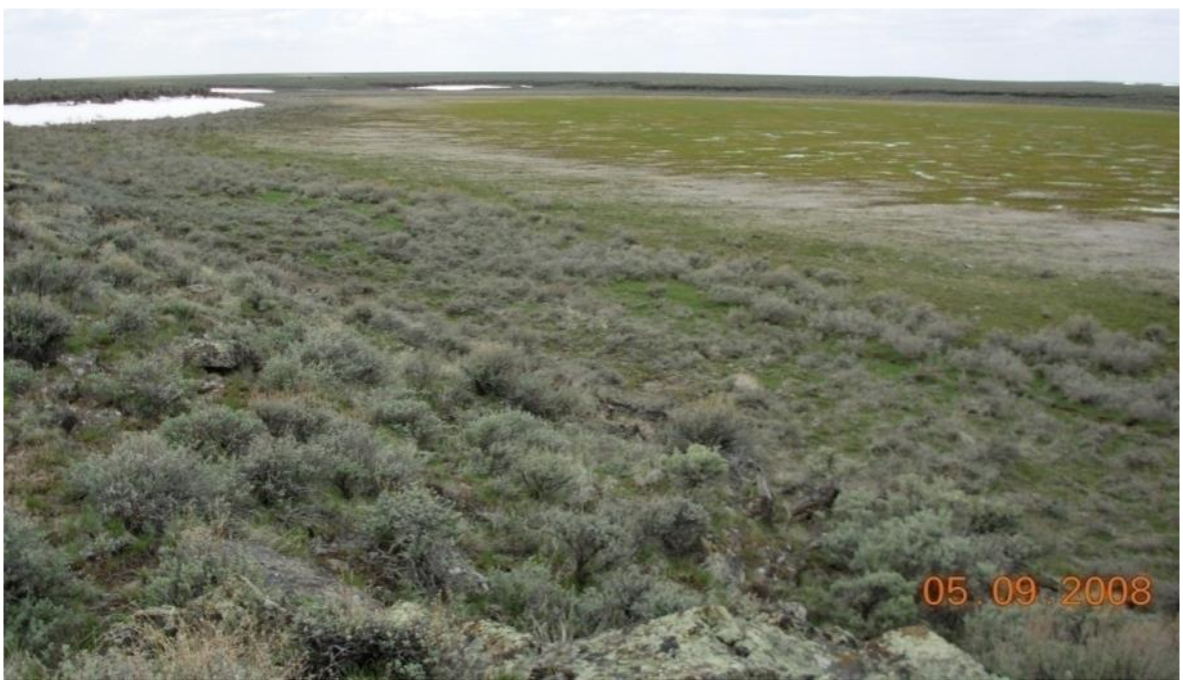


Figure 5. A large vernal pool (approximately 15 ha) on the Owyhee Plateau. Note the presence of snow banks in the basin.

We confirmed waterfowl reproduction at a single site. Macon Lake, a large excavated livestock reservoir surrounded by an extensive emergent vernal pool produced at least 4 broods of waterfowl, 2 each of northern shoveler (*Anas clypeata*) and blue-winged teal (*Anas discors*). We observed approximately 40 adult and juvenile birds. Reproduction by killdeer (*Charadrius vociferus*) and willet (*Tringa semipalmata*) is also suspected at this site, as 12 and 4 individuals, respectively were counted. All of these appeared to be adults. We also found 2 empty egg shells in shallow water at Little Blue Table #3, and observed a single adult willet. We observed no juveniles at this site.

We recorded 10 species of waterfowl during the surveys. Mallard (*Anas platyrhynchos*) was the most widespread and abundant species observed. We counted 56 individuals at 10 different locations. Counts of northern shoveler, northern pintail (*Anas acuta*) and blue-winged teal all exceeded 20 individuals but at far fewer locations (4, 7, and 3, respectively). We found 14 cinnamon teal (*Anas cyanoptera*) at 3 sites. Ten or fewer individuals were recorded for Canada goose (*Branta canadensis*), redhead (*Aythya americana*), American wigeon (*Anas americana*), lesser scaup (*Aythya affinis*), and American coot (*Fulica americana*). Of these, we recorded Canada goose at 5 sites and the other species at 2 or fewer sites.

We recorded 8 species of shorebirds during the surveys. Wilson's phalarope (*Phalaropus tricolor*) was the most abundant shorebird observed, but it was not widespread. We observed 40 individuals at only 3 locations. Of these, 36 individuals occurred in a single flock at the Grasmere Reservoir #3 site (Figure 6).

Figure 6. A mixed flock of black-necked stilt and Wilson's phalarope over Grasmere Reservoir #3 site, Owyhee Plateau.

Killdeer and American avocet were relatively abundant and more widely distributed; 22 and 25 individuals observed at 9 and 6 locations, respectively. Although black-necked stilt appear to be moderately abundant (13 individuals), this species was detected at only 2 locations and on the same day. The sites, Grasmere Reservoir #3 and Grasmere Reservoir #4 are separated by approximately 200 meters and were surveyed in succession. It is possible that some birds were counted twice. We observed 10 individuals each of willet (4 sites), marbled godwit (*Limosa fedoa*) (4 sites), and long-billed curlew (5 sites). The least commonly encountered shorebird was white-faced ibis (*Plegadis chihi*), observed at a single site.

<u>Amphibian surveys</u>: We visited 13 sites that appeared capable of supporting amphibian reproduction. We vouchered larval amphibians at 6 sites and heard adults calling at 4. We found no egg masses at any sites. Five of the occupied sites occurred at 2 pool complexes in the Bennett Hills subsection, one near Macon Flats and the other near Mammoth Cave. The other occupied site, Little Blue Table #1 was near Grasmere on the Owyhee Plateau. We identified larva at 3 sites as Pacific chorus frog (*Pseudacris regilla*); the remaining vouchered specimens were immature and not identified. We heard an adult Pacific chorus frog calling at one site where unidentified larva were collected, and it is likely that the juvenile vouchers were the same species. All adults

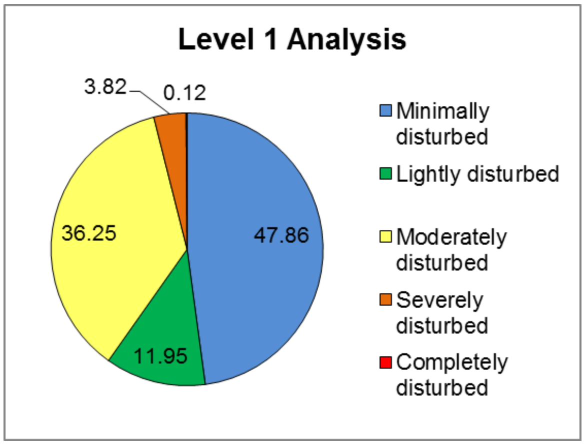
heard calling were Pacific chorus frog, as was the lone individual sighted, a dead adult in a cattle dugout at Mammoth #2. Adult chorus frogs were heard calling in meadows, away from standing water in the Macon Flats complex in 2009. The only other amphibian species observed, a larval Great Basin spadefoot (*Spea intermontanus*) was incidentally observed and collected at a livestock reservoir in Elmore County in 2008.

Invertebrate surveys: Invertebrates were the most commonly encountered vernal pool and playa inhabitants. We vouchered specimens at 36 sites. We found Anostracan (fairy) shrimp at 26 sites (Table 3). We collected 3 species from the *Branchinecta* genus in a variety of habitats; *B. coloradensis* (8 sites), *B. constricta* (3 sites)*, and B. mackini* (1 site). This is the first collection of *B. constricta* in Idaho. The species was previously thought to be endemic to Wyoming. We collected *Eubranchipus serratus* (also an Anostracan shrimp) at 3 sites and unidentified *Eubranchipus* species at an additional 2 sites. We collected Notostracan (tadpole) shrimp at 10 sites. Many Notostracans were immature and we only positively identified a single species from a single location, the cryptic tadpole shrimp (*Lepidurus cryptus*) from Sugarloaf #6. Branchiopod crustaceans persisted where surface water remained, including some sites with high levels of livestock use. In one instance, adult Notostracan shrimp were collected from muddy hoof prints after cattle had stopped using the pool as a water source.

Although diminutive, amphipods, cladocerans, copepods, gastropods, and ostracods form an important invertebrate community occurring in all aquatic habitats. Collection of these organisms was incidental to targeted invertebrates and amphibians. We also found exoskeletal remains of copepods at several dry sites. Aquatic Coleoptera were collected at 13 sites, including the large predatory diving beetle (family Dytiscidae), an important predator on larval amphibians and crustaceans. Identification of these classes of organisms is based on microscopic features; we did not identify them to a taxonomic level higher than order.

Ecological condition: Forty of the 90 survey sites were covered in the Level 1 analysis (Appendix 2) making the results less useful for evaluating ecological condition at individual sites. The spatial datasets used to estimate extent of vernal pools and playas (see Murphy 2012) used in the Level 1 analysis did not depict many of the small wetland features identified using aerial imagery. This was especially true at Macon Flats. Because GIS layers were lacking, the Level 1 could not evaluate localized impacts from site-specific stressors, such as livestock grazing and cover of non-native vegetation, the effects of which were pronounced at many of the sites we visited. The results did provide a coarse view of ecological condition across the entire survey area however, describing the effects of mapped human activity on a regional scale. The Level 1 analysis could also be used to evaluate the condition of portions of the study area that were not surveyed due to logistical difficulties, especially the Owyhee River Canyonlands (Appendix 2). As expected, the majority of vernal pools and playas in this remote and mostly undeveloped landscape were estimated to be in the minimally disturbed condition class. Most of the remaining pools and playas were lightly disturbed. However, occasional moderately disturbed patches were predicted where roads traversed in, or adjacent to pools and playas. A comparison of the ecological condition classifications of both Level 1 and Level 2 analysis showed a surprising level of consistency, considering the differences in scale, indices, and methodology (Figure 7).

We identified and categorized physical stressors at all surveyed sites and qualitatively rated disturbance severity within both vernal pool and playas and in surrounding upland habitats using a simplified Level 2 RAM (Table 5; Figure 7). We found 11 of the 15 playas to be minimally impacted; in 4 of those sites we recorded no visible impacts within the playa boundary. Three playas were in the moderately disturbed condition class. No playas were in the severely disturbed class. One playa contained multiple impacts, including a road and an excavated livestock reservoir; it was classified as completely disturbed. The clay soils in dry playas are typically quite hard and resistant to physical disturbances when dry, except where hydrology has been modified.



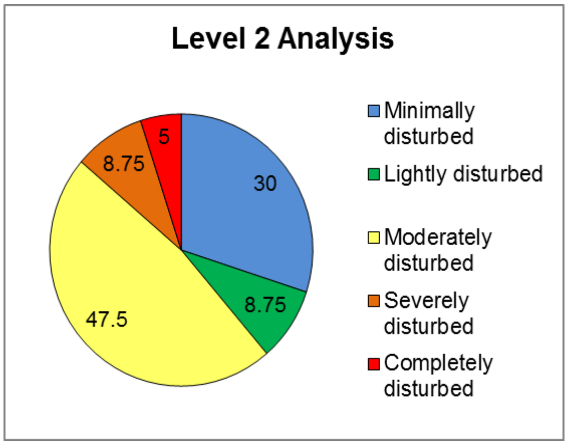


Figure 7. Percent of vernal pools and playas in each condition class. Level 1 analysis covered all of southwest Idaho using 30 x 30 m pixels as the analysis unit. Level 2 analysis was conducted at the site scale (n= 80).

Ecological condition at vernal pool sites was more variable than the condition at playas. We determined that 24 of the 65 vernal pool sites were in the minimally disturbed condition class. Seven were found to be lightly disturbed, 35 moderately disturbed, and 7 severely disturbed. An additional 3 sites were in the completely disturbed condition class. These completely disturbed vernal pools had multiple impacts, including excavated livestock reservoirs, roads, and heavy livestock use.

Livestock grazing was the principal land use activity at most sites surveyed. Livestock use of vernal pools, playas, and adjacent upland habitats produces a variety of effects ranging from light vegetation utilization to severe soil disturbance as animals concentrate near remnant pools for water (Figures 8 - 10). In some playas, a lack of palatable forage in pool bottoms and a rocky substrate appeared to deter use by livestock. Large amounts of cattle scat were observed in standing water at heavily used sites, but the effects of this nutrient enrichment on vernal pool inhabitants are unknown. Impacts from mechanical disturbances and non-native invasive plant invasion also affected ecological condition. Eighty-two percent of vernal pool and playa sites showed disturbance within the wetland perimeter; the upland buffer surrounding vernal pool and playa habitats was disturbed at all survey sites.

Landscape-scale conversion of Wyoming big sagebrush communities to non-native annual grass and forb-dominated communities (Figure 11) has occurred around the majority of vernal pools and playas observed on the Snake River Plain. The following data were summarized from vegetation sampling conducted in vernal pools and playas (Murphy 2012). Non-native species were well represented in both vernal pools and playas. Cover and constancy of non-native plant species was typically higher in vernal pools than playas due to the higher inherent productivity of vernal pools. Approximately 14% of the documented vernal pool and playa flora in southwest Idaho were non-native species. The most abundant and commonly occurring non-native species were:

Common name	**Scientific name**	**Vernal Pools**		**Playas**	
		constancy %	**mean cover %**	**constancy %**	**mean cover %**
prostrate knotweed	*Polygonum aviculare*	30	0.9	24	0.6
Japanese brome	*Bromus japonicus*	15	2.4		
cheatgrass	*Bromus tectorum*	15	0.6	19	0.4
bulbous bluegrass	*Poa bulbosa*	13	4.9		
clasping pepperweed	*Lepidium perfoliatum*	13	2.2	29	0.5
prickly lettuce	*Lactuca serriola*	13	0.1		
bur buttercup	*Ceratocephala testiculata*	8	2.6	10	0.1
medusahead	*Taeniatherum caput-medusae*	5	2.3	5	0.1
tall tumblemustard	*Sisymbrium altissimum*	5	0.7	10	0.1
prickly Russian thistle	*Salsola tragus*	3	0.1	29	1.6
annual wheatgrass	*Eremopyrum triticeum*	3	0.1	5	0.1
saltlover	*Halogeton glomeratus*			24	1.8
burning bush	*Bassia scoparia*			19	0.7

The most frequently observed, and potentially most serious impact to playas and larger vernal pools was the presence of excavated livestock water reservoirs (Figure 12 and 13). Alteration of playa or vernal pool hydrology results when reservoir elevation is lower than the playa/vernal pool surface elevation. This causes erosion of the playa or pool bottom from water draining into the reservoir (Figure 13). It also potentially accelerates playa and vernal pool desiccation. Other observed impacts within pool boundaries were from roads or bladed tracks used to access reservoirs (Figures 13 and 14). Road development and non-native plants were common stressors in the surrounding uplands.

Figure 8. Sheep grazing adjacent to vernal pools in the Macon Flats complex. This area is also grazed by cattle.

Figure 9. Cattle congregating in and near an excavated reservoir in large silver sagebrush-dominated vernal pool, Ox Lake, Owyhee Plateau.

Figure 10. Cattle trampling in a remnant puddle within a larger vernal pool, Ox Lake, Owyhee Plateau. This pool had numerous scat piles and likely elevated nutrient input.

Figure 11. Vernal pool in burnt Wyoming big sagebrush habitat now dominated by non-native grasses (crested wheatgrass and cheatgrass) and forbs (bur buttercup). This site is also grazed by cattle.

Figure 12. Typical excavated livestock water reservoir in playa, Bruneau Desert.

Figure 13. Severe erosion of playa surface caused by runoff into excavated reservoir. Reservoir elevation is approximately 1 m lower than playa surface elevation.

Figure 14. Severe mechanical disturbance within a rocky Davis' peppergrass playa. The track was created to give cattle and motor vehicles a navigable trail to the excavated reservoir in the distance.

Discussion and Management Implications

Data from our surveys indicate widespread occupancy of vernal pools and playas in southwest Idaho by a diverse community of aquatic invertebrates. These habitats are also seasonally important for a variety of shorebirds and waterfowl. We documented amphibian reproduction at several locations, usually in larger pool complexes but also in excavated livestock reservoirs. Other wildlife, including pronghorn (*Antilocapra americana*) were frequently observed in or near the pools, as were domestic livestock. Dried pools often contained tracks of both wild and domestic ungulates and other vertebrates. Greater sage grouse (*Centrocercus urophasianus*), a candidate species for listing under the Endangered Species Act was encountered intermittently. The principal threat to vernal pools and playas was hydrologic change resulting from excavation of pool bottoms for livestock reservoirs. Balancing the needs of public lands users and habitat needs for wildlife will be the primary management challenge for maintaining vernal pool and playa integrity in southern Idaho.

<u>Aquatic invertebrates</u>: The distribution of aquatic invertebrates in southern Idaho's ephemeral wetlands is poorly understood and basic biological information regarding these species is limited. The few systematic vernal pool invertebrate surveys conducted in the region have been restricted to military lands on the Snake River Plain. Our survey was the first attempt to describe the occurrence and diversity of this little known fauna on a regional scale. The resulting species list is most certainly incomplete, as our single sampling approach could not account for temporal variation in species occurrence and the discontinuous (non-annual) emergence of cysts from the egg bank. Additionally,

numerous small isolated pools throughout the region are inaccessible during their inundated stage and are difficult to effectively sample.

The need for more detailed information regarding species life histories and habitat requirements of invertebrates was one of the most revealing aspects of our study. Although several branchiopod species we collected are wide-ranging and have been documented from vernal pools in eastern Washington (e.g., *Eubranchipus serratus*, Kulp and Rabe 1984) and elsewhere, others are either rare or have poorly understood distributions. In addition, surveys of vernal pools in eastern Washington (Kulp and Rabe 1984) and central Oregon (Dlugolecki 2010) found these habitats to support a diverse community of insects and other crustaceans (e.g., Ostracoda, Copepoda) which were not the focus of our surveys. Interesting, these surveys yielded far fewer Anostraca and Notostraca species than we collected in southwestern Idaho. It is possible that invertebrate communities in our study area may represent unique assemblages. We also lack knowledge of the ecology and dynamics of invertebrate communities in vernal pools and playas, particularly trophic interactions and their vulnerability to human-caused disturbance and habitat loss.

This study initiated the tracking of selected vernal pool branchiopod crustaceans by the Idaho Natural Heritage Program, a first step towards preparing conservation assessments for these and other unique invertebrates, but substantial data needs exist. Data from our surveys indicate that at least 2 of the documented Anostracan species in Idaho satisfy one or more criteria for consideration as a Species of Greatest Conservation Need (SGCN). All criteria for determining SGCN status are listed in Idaho's Comprehensive Wildlife Conservation Strategy (IDFG 2005).

Vernal pool surveys for invertebrates have been conducted on the Orchard Training Area, a military facility south and east of Boise for a number of years. While geographically limited, these surveys did identify a new species of Anostracan, *Branchinecta raptor*, in 2006 (Rogers et al. 2006). Since then, *B. raptor* has been found at two additional locations in southern Idaho, including one site in the northern Bruneau Desert subsection (Rudeen, personal communication with the author; unreferenced, see acknowledgments 2011) about 75 kilometers south-southeast of the other 3 known sites on the Snake River Plain. This confirms that the species is more widespread than previously thought and that the prospect of locating additional populations is probably quite high. Rudeen (2011) also collected *Branchinecta lindahli*, a wide ranging species, from 2 playas on the Snake River Plain. This species was not detected during our survey. Our findings dramatically expanded the known range of another Anostracan, *Branchinecta constricta*. That these findings occurred in a relatively small area (Macon Flat) and over a short period of time attests to our limited knowledge of ephemeral pools and their inhabitants. Given the high rate of endemism characterizing some vernal pool complexes (e.g., in California's Central Valley), it is suspected that more intensive surveys may yield additional undescribed or disjunct species in southern Idaho.

The most significant finding of our study was the documentation of *B. constricta* in Idaho. At the time, the species was known only from a few locations in south-central

Wyoming and was believed to be endemic to that region. Our specimens were identified by D. Christopher Rodgers, who initially described the species in 2006 after examining specimens residing in the collection of the late invertebrate expert Denton Belk. The new Idaho locations represent a range expansion of more than 500 km and suggest that *B. constricta* may be much more widely distributed than previously thought. There is a need to address inventory gaps by surveying vernal pools and playas in south-central and eastern Idaho (e.g., Shoshone and Upper Snake BLM Field Offices) for this and other invertebrates of potential conservation concern.

Vernal pool and playa invertebrates may be an important food resource for migrating waterfowl and shorebirds in southern Idaho, although their use of ephemeral wetlands in this region is not well studied. Vernal pool crustacean abundance can be quite high and has even been documented as a food resource for aboriginal humans in the region. One study involving *Branchinecta mackini* calculated maximum biomass at 580 mg of dry weight per m^2 of pool surface, or approximately 2,700 kilocalories per m^2 (Henrikson et al. 1998). Another study calculated populations of selected European branchiopoda as high as 25.0×10^5 per m^2 (Hairston 1996).

The primary threat to vernal pool and playa invertebrate communities in southern Idaho appears to be the alteration or loss of habitat from excessive livestock use and mechanical disturbance. The dormant cysts of branchiopods are amazingly resistant to the effects of desiccation and environmental extremes, but are highly susceptible to crushing (Hathaway et al. 1996). Impacts from both sources were observed at many locations. The highest magnitude impacts, such as from excavation and trampling by livestock, have altered site hydrology. In extremely disturbed sites with dugouts, water was confined to the excavated reservoir, leaving the remainder of the pool completely dry. Hydrological disturbance in vernal pool systems has been shown to dramatically affect many aspects of invertebrate physiology and ecology including growth and survival, reproduction, and species composition and richness (Euliss and Mushet 2004).

<u>Waterfowl and Shorebirds</u>: Southern Idaho represents the northern terminus of the Great Basin through which vast numbers of waterfowl and shorebirds annually migrate. Large lakes and wetlands are scarce and widely spaced in the Great Basin and migrating waterbirds are highly dependent on small ephemeral pools and playas for feeding and resting habitat. Several species, including long-billed curlew and killdeer are known to nest in upland habitats adjacent to vernal pools. Few studies have accurately estimated the contribution of vernal pools and playas as habitat for migrating waterfowl, but in general, the value of ephemeral wetlands to avian communities has historically been underestimated (Silveira 1998). In one California study, 81 species from 24 families were documented using vernal pools for foraging, including 10 special status species (Silveira 1998).

Waterfowl and shorebirds were observed feeding and resting at many pools during our surveys. Our observations suggest that vernal pools are likely important breeding locations for willets in southwest Idaho. Broken eggshells were observed at one site and breeding confirmed at another. Site use did not seem limited by pool size, but proportionally more birds were observed at larger pools. The largest concentration of shorebirds, a mixed flock of Wilson's phalarope and black-neck stilts, was observed feeding in the vernal pool at the Grasmere Reservoir #3 site. This large pool appeared to have the highest concentration of branchiopod crustaceans of any site visited during the survey. In several locations, waterfowl were also observed actively feeding on emergent vegetation.

Waterfowl and shorebirds are effective dispersers of plant seeds and the diapausing eggs (cysts) of various freshwater crustaceans. They are thought to be integral in maintaining genetic variability in freshwater crustacean populations as migration in this group is entirely passive and genetic exchange is limited. Management of ephemeral wetlands for migratory waterfowl and shorebird habitat should focus on minimizing impacts from grazing and mechanical disturbances that alter pool structure and disrupt proper hydrologic function.

Amphibians: Few of the natural playas or vernal pools we visited were suitable for amphibian reproduction and few amphibians were observed. Only Pacific chorus frog was found breeding in natural pools. The short duration of many pools is apparently insufficient to support successful breeding and many sites are wet only during the winter months, before amphibian breeding commences. Additionally, terrestrial habitat surrounding the pools may not be suitable for terrestrial forms of amphibians, particularly the more xeric locations. At the larger pool complexes where successful breeding is possible, our surveys may have been too early to detect breeding activity. For instance, a July 16 visit to Macon Lake to perform vegetation surveys revealed tadpoles and metamorphs that were not observed during the initial site survey conducted on June 10. Most amphibian breeding was documented at the large pool complexes near Macon Flats and Mammoth Cave. These sites are at higher elevation than others we visited in southwest Idaho and may benefit from higher water inputs during years with abundant snowfall. Successful breeding in higher elevation sites may be dependent on winter precipitation. The effects of land use practices, especially livestock grazing, on breeding amphibians in vernal pools and playas, are not well known outside central California.

Great Basin spadefoot was found in a single location in an excavated livestock reservoir in Elmore County. The observation and collection of that individual was unique, as excavated reservoirs were not sampled. This specimen was observed while taking field notes, and was subsequently captured. The extent to which reservoirs are used by breeding Great Basin spadefoot in the study area has not been assessed. Like many desert-dwelling amphibians, explosive spadefoot breeding episodes following spring or summer rain events are common, but the species will also breed in semi-permanent or permanent water sources. Excavated sites may provide suitable breeding habitat for some amphibians (Euliss and Mushet 2004).

Ecological Condition: Our observations of disturbances to pool structure and hydrology may provide some insight to conservation and management of vernal pools and playas. Our intent was to describe the disturbances impacting wetland condition, particularly those activities affecting soils, hydrology, and native flora and fauna. We suspected that disturbance might be a factor explaining distribution or abundance of certain taxa, but our survey results did not reveal any discernible patterns. We did not attempt to assess wetland function or evaluate chemical or biological changes (with the exception of vegetation) related to site disturbance, as this was beyond the scope of this study.

Livestock grazing is ubiquitous throughout the study area and produces a wide variety of direct and indirect effects in wetland habitats. Direct effects we observed included alteration of vegetation composition and structure, soil compaction and churning, and elevated nutrient inputs from scat piles into water bodies. Indirect effects included increased erosion and channeling and the establishment or spread of non-native plants. Disturbance severity was highly variable, affected by the species of grazer, stocking rates, distribution of animals across the landscape, timing of grazing and the presence or absence of excavated reservoirs in vernal pools and playas. Management practices that direct livestock away from pools during periods of inundation and saturated soil conditions would minimize direct physical effects trampling on ephemeral wetlands. However, in California, light grazing in vernal pools prolonged hydrological conditions for fairy shrimp and amphibian reproduction and reduced competition from non-native vegetation (Pyke and Marty 2005). Because dormant branchiopod cysts are susceptible to crushing (Hathaway et al. 1996), management that minimizes livestock trampling of vernal pools during dry periods is recommended.

We observed the highest degree of disturbance in vernal pools and playas containing excavated livestock reservoirs. Permanent surface water in the region is scarce, and livestock are supplemented with water retained in catchments and reservoirs, and to a lesser extent, development of groundwater resources. Playas and vernal pools are favored for excavation due to their topographic positions in shallow basins. Excavation mechanically disturbs pool bottoms, disrupts pool hydrology, promotes predatory aquatic species, and may lead to the establishment and spread of invasive non-native plants (Euliss and Mushet 2004). Hydrological modifications affect wetland plant and animal communities by reducing the extent and duration of pool inundation, altering infiltration rates and saturated soil conditions, and increasing soil erosion and gully formation in pool bottoms. Reservoirs may offer short term benefits to amphibians where inundation duration is lengthened sufficiently to accommodate successful metamorphosis of larvae. The effects of reservoirs on invertebrate and avian communities are complex and warrant further study. In central Oregon, Dlugolecki (2010) documented the possibility of restoring vernal pool hydrology by filling in excavated livestock reservoirs with soil.

Soil disturbance in vernal pools and playas frequently promotes the establishment and spread of non-native plant species (Moseley 1995). The impact of non-native vegetation on vernal pool and playa animal communities has not been evaluated, but impacts to native vegetation have been documented in southern Idaho. Litter from annual non-native plants has been shown to accumulate on playas and reduce cover of native plants, most notably Davis' peppergrass (*Lepidium davisii*), an at-risk globally rare species (Moseley 1995). Additionally, sediment from wind and water erosion on degraded rangelands can deposit on playas, creating habitat for xeric perennial species and invasive annuals while decreasing habitat for native playa vegetation.

Site disturbance from vehicle use of roadways occurred largely in the upland habitat surrounding ephemeral wetlands and was seldom observed in pool bottoms. Road surfaces and frequency of use were variable, ranging from lightly used, unimproved dirt surfaces in remote locations to regularly driven paved surfaces in more developed areas. Primary impacts associated with roads include localized soil compaction, increased soil erosion, and modifications to site hydrology (e.g., alteration of surface flow patterns). Portions of the Black Rock Playa in Nevada with repeated vehicle travel and prolonged recreational use had 30% to 50%, respectively, fewer intact branchiopod egg cysts than non-impacted sites (Adams and Sada 2010). Additionally, roads function as a vector for non-native plant dispersal and promote a prolonged, but intermittent source of disturbance. As with other types of disturbances, impacts from unimproved road surfaces most often occur when soil is wet or saturated. Many roadways in the study area are impassable when wet and may preclude vehicle traffic near wetlands when soils are vulnerable to damage. Problems resulting from off-highway vehicle (OHV) use on vernal pools and playas has been documented in some locations, but was not observed during our surveys. It may be that after soils have dried and wetland vegetation is dormant, OHV use in playas and vernal pools is difficult to detect and may have few direct negative effects.

The information gained from inventory and classification of ephemeral wetlands in Southwest Idaho is necessary for evaluation of conservation priorities and for guiding management and restoration efforts. It can be used by BLM managers to assess the environmental impacts of livestock grazing, water management, post-wildfire vegetation restoration, noxious weed control, and OHV use. This information can also be used to develop long-term monitoring strategies and Resource Management Plan revisions.

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Table 1. Stressors observed during the vernal pool and playa surveys and scores used to determine ecological condition.

Stressor	Severity	Pool Score	Buffer Score	Area Affected	Rationale
Livestock Grazing	Light	0.02	0.01	≤ 25%	Light utilization; minor soil compaction
Livestock Grazing	Moderate	0.05	0.03	25 - 50%	Observable reduction in graminoids/forbs; localized soil compaction or damage to cryptobiotic soil crust
Livestock Grazing	Heavy	0.07	0.05	≥ 50%	Marked reduction in graminoids/forbs; widespread soil compaction or damage to cryptobiotic soil crust; trampling of shrub layer
Pugging (penetrating tracks)	Light - Moderate	0.08	0.07	≤ 25%	Localized hoof-caused soil disturbance; livestock dispersed
Pugging (penetrating tracks)	Heavy	0.10	0.08	≥ 25%	Widespread soil disturbance; livestock concentrated in or near pools
Non-native Species	Light - Moderate	0.02	0.01	<10%	Indicates minimal ground disturbance
Non-native Species	Heavy	0.04	0.02	>10%	Indicates moderate or severe ground disturbance
Roadbed	Heavy	0.15	0.12	100%	This stressor rarely occurs singly; always indicates severe disturbance
Excavation	Heavy	0.20	0.17	100%	This stressor never occurs singly; always indicates severe disturbance

Table 2. Vernal pool and playa sites sampled during 2008 - 2009 faunal surveys.

SITE NAME	DATE	WETLAND CLASS*	SURVEYS**	VOUCHERS	SOIL SAMPLE
BUSTER BUTTE	5/5/08	PEMA/PUSC	VEG	NO	NO
GRASMERE RESERVOIR 1	5/5/08	PEMC	NO: NOT A VERNAL POOL	NO	NO
LITTLE BLUE TABLE 2	5/5/08	PEMC	INV	YES	NO
TICESKA 1	5/7/08	PEMC	NO: NOT A VERNAL POOL	NO	NO
TICESKA 2	5/7/08	PEMC	INV, AMP, VEG	YES	NO
TICESKA 3	5/7/08	PEMC	VEG	YES[1]	YES
GRASMERE RESERVOIR 3	5/9/08	PEMC	INV, WFL, AMP, VEG	YES	NO
GRASMERE RESERVOIR 4	5/9/08	PEMC	INV, VEG	YES	NO
MAYFIELD	6/5/08	PUSCh	NO: INACCESSIBLE	NO	NO
MAYFIELD SE	6/5/08	N/A	NO: EXCAVATED	YES[2]	NO
CRATER RINGS 1	6/5/08	PUSA	NO: EXCAVATED	NO	NO
CRATER RINGS 2	6/5/08	PUSC	INV	YES	YES
MACON LAKE	6/10/08	PEMF	INV, WFL[3], AMP, VEG	NO	NO
MACON 12	6/10/08	PEMA	INV, WFL, AMP	YES	NO
MACON 02	6/10/08	PEMA	INV, WFL, AMP	YES	NO
MACON 30	6/10/08	PEMA	VEG	NO	NO
MACON 31	6/10/08	PEMA	NO: DRY	NO	NO
MACON 32	6/10/08	PEMA	NO: DRY	NO	NO
MACON 29	6/10/08	PEMA	NO: NOT A VERNAL POOL	NO	NO
MACON 28	6/10/08	PEMA/PEMC	NO: SPRING	YES	NO
TAPPER LAKE 1	6/11/08	PEMA/PUBF	NO: DRY	NO	YES
TAPPER LAKE 2	6/11/08	PEMC/PUBF	NO: DRY	NO	YES
TAPPER LAKE 3	6/11/08	PEMC	NO: DRY	NO	YES
SUGARLOAF 1	6/12/08	PSSU/PUSC	INV, AMP, VEG	YES	NO
SUGARLOAF 2	6/12/08	PSSU/PUSA	INV, VEG	YES	NO
SUGARLOAF 3	6/13/08	PSSA	VEG	NO	YES
SUGARLOAF 4	6/13/08	PSSU	VEG	NO	YES
SUGARLOAF 5	6/13/08	N/A	NO: NOT A VERNAL POOL	NO	NO
SUGARLOAF 6	6/13/08	PUSA	INV, VEG	YES	NO
SUGARLOAF 7	6/13/08	PSSU	VEG	NO	YES
CRATER RINGS SE 1	3/17/09	PUSC	INV, WFL[4]	YES	NO
CRATER RINGS SE 2	3/17/09	PUSC	NO: DRY	NO	NO
CRATER RINGS SE 3	3/17/09	PUSC	NO: DRY	NO	NO
CRATER RINGS SE 4	3/17/09	PUSC	INV	NO	NO
CRATER RINGS SE 5	3/17/09	PUSC	NO: DRY	NO	YES
LITTLE JOE BUTTE 1	3/17/09	N/A	NO: NOT A VERNAL POOL	NO	NO
HOLE IN ROCK 1	3/18/09	PUSA	INV	YES	NO
HOLE IN ROCK 2	3/18/09	PUSA	INV	NO	NO
HOLE IN ROCK 3	3/18/09	PUSA	NO: DRY	NO	NO
HOLE IN ROCK 4	3/18/09	PUSA	INV	YES	NO
GRASMERE 1	3/19/09	PEMA	NO: DRY	NO	NO
GRASMERE 2	3/19/09	PEMA/PUSCx	NO: DRY	NO	NO
HILL PASTURE 1	3/19/09	PUSA	NO: DRY	NO	YES
HILL PASTURE 2	3/19/09	PUSA	INV	YES	NO

SITE NAME	DATE	WETLAND CLASS*	SURVEYS**	VOUCHERS	SOIL SAMPLE
HILL PASTURE 3	3/19/09	PUSA	NO: DRY	NO	NO
HILL PASTURE 4	3/19/09	PUSA	NO: DRY	NO	NO
HILL PASTURE 5	3/19/09	PUSA	NO: DRY	NO	YES
TICESKA 4	4/8/09	PSSA	NO: DRY	NO	YES
TICESKA 5	4/8/09	PUSA	NO: DRY	NO	NO
TICESKA 6	4/8/09	PSSA	NO: DRY	NO	YES
TICESKA 7	4/8/09	PEMJ	NO: DRY	NO	NO
TICESKA 8	4/8/09	PSSA	NO: DRY	NO	NO
GRASMERE RESERVOIR 6	4/9/09	PEMC	INV, VEG	NO	NO
MACON 01	4/20/09	PEMA	INV, VEG	YES	NO
MACON 02	4/20/09	PEMA	INV, VEG	YES	NO
MACON 03	4/20/09	PEMA/PUSCx	INV, WFL, AMP	YES	NO
MACON 04	4/20/09	PEMA	INV, AMP	YES	NO
MACON INCIDENTAL 1	4/20/09	PEMA	INV	YES	NO
MACON INCIDENTAL 2	4/20/09	PEMA	INV	YES	NO
MACON 05	4/21/09	PEMA	INV	YES	NO
MACON 07	4/21/09	PEMA	INV	YES	NO
MACON 24	4/21/09	PEMA/PUSCx	INV, WFL, AMP	YES	NO
MACON 25	4/21/09	PEMA	INV	YES	NO
MACON 26	4/21/09	PEMA	INV	YES	NO
MACON 27	4/21/09	PEMA/PEMCx	INV, WFL	NO	NO
MACON INCIDENTAL 7A	4/21/09	PEMA	INV	YES	NO
MACON INCIDENTAL 7B	4/21/09	PEMA	INV	YES	NO
MACON INCIDENTAL 7C	4/21/09	PEMA	INV	YES	NO
MAMMOTH CAVE 1	5/27/09	PUSCx	INV	YES	NO
MAMMOTH CAVE 7	5/27/09	PEMA	NO: DRY	NO	YES
MAMMOTH CAVE 2	5/28/09	PUSA	INV, AMP	YES	NO
MAMMOTH CAVE 3	5/28/09	PEMA	NO: DRY	NO	NO
MAMMOTH CAVE 4	5/28/09	PEMA	INV, AMP	YES	NO
MAMMOTH CAVE 4B	5/28/09	PEMA	INV, AMP	YES	NO
MAMMOTH CAVE 4C	5/28/09	PEMA	NO: DRY	NO	YES
MAMMOTH CAVE 5	5/28/09	PEMA	NO: DRY	NO	NO
GRASMERE RESERVOIR 5	6/2/09	PEMA	VEG	NO	YES
CHINA HAT	6/2/09	PEMF	NO: NOT A VERNAL POOL	NO	NO
LITTLE BLUE TABLE 1	6/3/09	PEMA	INV, AMP, VEG	NO	NO
LITTLE BLUE TABLE 3	6/3/09	PEMA	INV, VEG	NO	NO
JACKASS BUTTE 1	6/23/09	PUSA	VEG	NO	NO
LITTLE JOE BUTTE 2	6/24/09	PUSA	VEG	NO	NO
LITTLE JOE BUTTE 3	6/24/09	PUSA	VEG	NO	NO
LITTLE JOE BUTTE 4	6/23/09	PUSA	VEG	NO	NO
SILVER CITY	6/24/09	N/A	NO: NOT A VERNAL POOL	NO	NO
OX LAKE 1	6/25/09	PUSA	VEG	NO	NO
OX LAKE 2	6/25/09	PUSA	VEG	NO	NO
WICKAHONEY POINT 1	7/2/09	PUSA	VEG	NO	NO
WICKAHONEY POINT 1	7/2/09	PUSA	VEG	NO	NO
GRASMERE 3	7/15/09	PUSA	VEG	NO	NO

[1] Dried copepods were collected from shallow depressions in this dry vernal pool
[2] Site was a cattle dugout; 1 larval Great Basin spadefoot was vouchered
[3] The waterfowl/shorebird survey at Macon Lake was conducted on 7/16/2009
[4] The waterfowl/shorebird survey at Crater Rings SE 1 was conducted on 7/15/2009
* Wetland classes are from NWI maps (Cowardin 1979): PEMA, PEMC = palustrine emergent temporarily flooded or seasonally flooded; PUSA, PUSC = palustrine unconsolidated shore temporarily flooded or seasonally flooded; PUBF = palustrine unconsolidated bottom semi-permanently flooded; PSSA, PSSU = palustrine scrub-shrub temporarily flooded or unknown; subscript x indicates a portion of the wetland feature has been excavated
** Survey Types are Invertebrate (INV); Waterfowl/Shorebirds (WFL); Amphibian (AMP), Vegetation (VEG)

Table 3. Sites where large branchiopod crustaceans were vouchered.

Site Name	DATE	Family	Genus	Species*	Count
LITTLE BLUE TABLE 2	5/5/2008	Branchinectidae	*Branchinecta*	*coloradensis*	4
GRASMERE RESERVOIR 3	5/9/2008	Branchinectidae	*Branchinecta*	*coloradensis*	12
GRASMERE RESERVOIR 4	5/9/2008	Branchinectidae	*Branchinecta*	*coloradensis*	1
CRATER RINGS 2	6/5/2008	Branchinectidae	*Branchinecta*	N/A	18
MACON 2	6/10/2008	Chirocephalidae	*Eubranchipus*	*serratus*	50
MACON 2	6/10/2008	Branchinectidae	*Branchinecta*	*coloradensis*	1
SUGARLOAF 6	6/12/2008	Triopsidae	*Lepidurus*	*cryptus*	2
SUGARLOAF 1	6/12/2008	Branchinectidae	*Branchinecta*	*coloradensis*	3
SUGARLOAF 2	6/12/2008	Branchinectidae	*Branchinecta*	N/A	18
CRATER RINGS SE 1	3/17/2009	Branchinectidae	*Branchinecta*	N/A	15
HOLE IN ROCK 1	3/18/2009	Branchinectidae	*Branchinecta*	N/A	6
HOLE IN ROCK 4	3/18/2009	Branchinectidae	*Branchinecta*	*mackini*	9
MACON 01	4/20/2009	Branchinectidae	*Branchinecta*	N/A	13
MACON 01	4/20/2009	Triopsidae	*Lepidurus*	N/A	4
MACON 02	4/20/2009	Branchinectidae	*Branchinecta*	N/A	1
MACON 02	4/20/2009	Chirocephalidae	*Eubranchipus*	N/A	5
MACON 02	4/20/2009	Triopsidae	*Lepidurus*	N/A	2
MACON 03	4/20/2009	Branchinectidae	*Branchinecta*	N/A	36
MACON 03	4/20/2009	Triopsidae	*Lepidurus*	N/A	4
MACON 04	4/20/2009	Branchinectidae	*Branchinecta*	*constricta*	40
MACON 04	4/20/2009	Branchinectidae	*Lepidurus*	N/A	3
MACON INCIDENTAL 1	4/20/2009	Branchinectidae	*Branchinecta*	*coloradensis*	6
MACON INCIDENTAL 2	4/20/2009	Chirocephalidae	*Eubranchipus*	*serratus*	10
MACON 25	4/21/2009	Branchinectidae	*Branchinecta*	N/A	30
MACON 25	4/21/2009	Triopsidae	*Lepidurus*	N/A	1
MACON 05	4/21/2009	Triopsidae	*Lepidurus*	N/A	1
MACON 05	4/21/2009	Branchinectidae	*Branchinecta*	N/A	14
MACON 07	4/21/2009	Branchinectidae	*Branchinecta*	*constricta*	16
MACON 07	4/21/2009	Triopsidae	*Lepidurus*	N/A	1
MACON 24	4/21/2009	Branchinectidae	*Branchinecta*	*coloradensis*	24
MACON 24	4/21/2009	Triopsidae	*Lepidurus*	N/A	1
MACON 26	4/21/2009	Triopsidae	*Lepidurus*	N/A	2
MACON 26	4/21/2009	Branchinectidae	*Branchinecta*	N/A	30
MACON 26	4/21/2009	Chirocephalidae	*Eubranchipus*	N/A	2
MACON 27	4/21/2009	Chirocephalidae	*Eubranchipus*	*serratus*	8
MACON INCIDENTAL 7A	4/21/2009	Branchinectidae	*Branchinecta*	*constricta*	18
MACON INCIDENTAL 7C	4/21/2009	Branchinectidae	*Branchinecta*	N/A	12
MAMMOTH CAVE 4	5/28/2009	Branchinectidae	*Branchinecta*	*coloradensis*	12

*Immature specimens lacked morphological characters necessary for species identification.

Table 4. Waterfowl and shorebirds detected during 2008 - 2009 vernal pool and playa surveys.

Site Name	DATE	Species	Common name	#	Detection
TICESKA 2	5/7/2008	*Anas platyrhynchos*	Mallard	1	Incidental
TICESKA 2	5/7/2008	*Tringa semipalmata*	Willet	1	Incidental
TICESKA 3	5/7/2008	*Charadrius vociferus*	Killdeer	1	Incidental
GRASMERE RES. 3	5/9/2008	*Anas acuta*	Northern Pintail	1	Survey
GRASMERE RES. 3	5/9/2008	*Anas cyanoptera*	Cinnamon Teal	2	Survey
GRASMERE RES. 3	5/9/2008	*Anas platyrhynchos*	Mallard	5	Survey
GRASMERE RES. 3	5/9/2008	*Branta canadensis*	Canada Goose	1	Incidental
GRASMERE RES. 3	5/9/2008	*Charadrius vociferus*	Killdeer	1	Incidental
GRASMERE RES. 3	5/9/2008	*Himantopus mexicanus*	Black-Necked Stilt	9	Survey
GRASMERE RES. 3	5/9/2008	*Phalaropus tricolor*	Wilson's Phalarope	36	Survey
GRASMERE RES. 3	5/9/2008	*Plegadis chihi*	White-Faced Ibis	1	Survey
GRASMERE RES. 4	5/9/2008	*Anas acuta*	Northern Pintail	4	Incidental
GRASMERE RES. 4	5/9/2008	*Anas platyrhynchos*	Mallard	32	Incidental
GRASMERE RES. 4	5/9/2008	*Branta canadensis*	Canada Goose	1	Incidental
GRASMERE RES. 4	5/9/2008	*Himantopus mexicanus*	Black-Necked Stilt	4	Incidental
GRASMERE RES. 4	5/9/2008	*Numenius americanus*	Long-Billed Curlew	1	Incidental
MACON 12	6/10/2008	*Limosa fedoa*	Marbled Godwit	2	Survey
MACON 12	6/10/2008	*Phalaropus tricolor*	Wilson's Phalarope	2	Survey
MACON 12	6/10/2008	*Recurvirostra americana*	American Avocet	1	Survey
MACON 2	6/10/2008	*Charadrius vociferus*	Killdeer	1	Survey
MACON 2	6/10/2008	*Recurvirostra americana*	American Avocet	1	Survey
MACON 28	6/10/2008	*Numenius americanus*	Long-Billed Curlew	1	Incidental
MACON LAKE	6/10/2008	*Anas americana*	American Wigeon	3	Survey
MACON LAKE	6/10/2008	*Anas clypeata*	Northern Shoveler	7	Survey
MACON LAKE	6/10/2008	*Anas discors*	Blue-Winged Teal	4	Survey
MACON LAKE	6/10/2008	*Anas platyrhynchos*	Mallard	3	Survey
MACON LAKE	6/10/2008	*Charadrius vociferus*	Killdeer	2	Survey
MACON LAKE	6/10/2008	*Fulica americana*	American Coot	1	Survey
MACON LAKE	6/10/2008	*Limosa fedoa*	Marbled Godwit	5	Survey
MACON LAKE	6/10/2008	*Recurvirostra americana*	American Avocet	4	Survey
SUGARLOAF 1	6/12/2008	*Anas acuta*	Northern Pintail	2	Incidental
SUGARLOAF 2	6/12/2008	*Anas acuta*	Northern Pintail	2	Incidental
GRASMERE RES. 6	4/9/2009	*Anas platyrhynchos*	Mallard	2	Incidental
MACON 03	4/20/2009	*Anas acuta*	Northern Pintail	2	Survey
MACON 03	4/20/2009	*Anas clypeata*	Northern Shoveler	2	Survey
MACON 03	4/20/2009	*Anas platyrhynchos*	Mallard	2	Survey
MACON 03	4/20/2009	*Aythya affinis*	Lesser Scaup	2	Survey
MACON 03	4/20/2009	*Branta canadensis*	Canada Goose	2	Survey
MACON 03	4/20/2009	*Limosa fedoa*	Marbled Godwit	1	Survey
MACON 03	4/20/2009	*Numenius americanus*	Long-Billed Curlew	3	Survey
MACON 05	4/21/2009	*Limosa fedoa*	Marbled Godwit	2	Incidental
MACON 24	4/21/2009	*Anas acuta*	Northern Pintail	4	Survey
MACON 24	4/21/2009	*Anas cyanoptera*	Cinnamon Teal	2	Survey
MACON 24	4/21/2009	*Anas platyrhynchos*	Mallard	2	Survey

Site Name	DATE	Species	Common name	#	Detection
MACON 24	4/21/2009	*Branta canadensis*	Canada Goose	1	Survey
MACON 24	4/21/2009	*Numenius americanus*	Long-Billed Curlew	4	Survey
MACON 24	4/21/2009	*Recurvirostra americana*	American Avocet	10	Survey
MACON 26	4/21/2009	*Anas acuta*	Northern Pintail	1	Incidental
MACON 26	4/21/2009	*Anas platyrhynchos*	Mallard	1	Incidental
MACON 26	4/21/2009	*Charadrius vociferus*	Killdeer	1	Incidental
MACON 27	4/21/2009	*Anas americana*	American Wigeon	2	Survey
MACON 27	4/21/2009	*Anas clypeata*	Northern Shoveler	10	Survey
MACON 27	4/21/2009	*Anas cyanoptera*	Cinnamon Teal	10	Survey
MACON 27	4/21/2009	*Anas platyrhynchos*	Mallard	6	Survey
MACON 27	4/21/2009	*Aythya americana*	Redhead	6	Survey
MACON 27	4/21/2009	*Branta canadensis*	Canada Goose	5	Survey
MACON 27	4/21/2009	*Numenius americanus*	Long-Billed Curlew	1	Survey
MAMMOTH CAVE 4	5/28/2009	*Charadrius vociferus*	Killdeer	2	Incidental
MAMMOTH CAVE 4	5/28/2009	*Phalaropus tricolor*	Wilson's Phalarope	2	Incidental
MAMMOTH CAVE 4	5/28/2009	*Recurvirostra americana*	American Avocet	7	Incidental
LITTLE BLUE TABLE 1	6/3/2009	*Anas discors*	Blue-Winged Teal	1	Incidental
LITTLE BLUE TABLE 1	6/3/2009	*Charadrius vociferus*	Killdeer	1	Incidental
LITTLE BLUE TABLE 1	6/3/2009	*Tringa semipalmata*	Willet	4	Incidental
LITTLE BLUE TABLE 3	6/3/2009	*Tringa semipalmata*	Willet	1	Incidental
CRATER RINGS SE 1	7/15/2009	*Charadrius vociferus*	Killdeer	1	Survey
CRATER RINGS SE 1	7/15/2009	*Recurvirostra americana*	American Avocet	2	Survey
MACON LAKE	7/16/2009	*Anas clypeata*	Northern Shoveler	20	Survey
MACON LAKE	7/16/2009	*Anas discors*	Blue-Winged Teal	20	Survey
MACON LAKE	7/16/2009	*Anas platyrhynchos*	Mallard	2	Survey
MACON LAKE	7/16/2009	*Charadrius vociferus*	Killdeer	12	Survey
MACON LAKE	7/16/2009	*Tringa semipalmata*	Willet	4	Survey

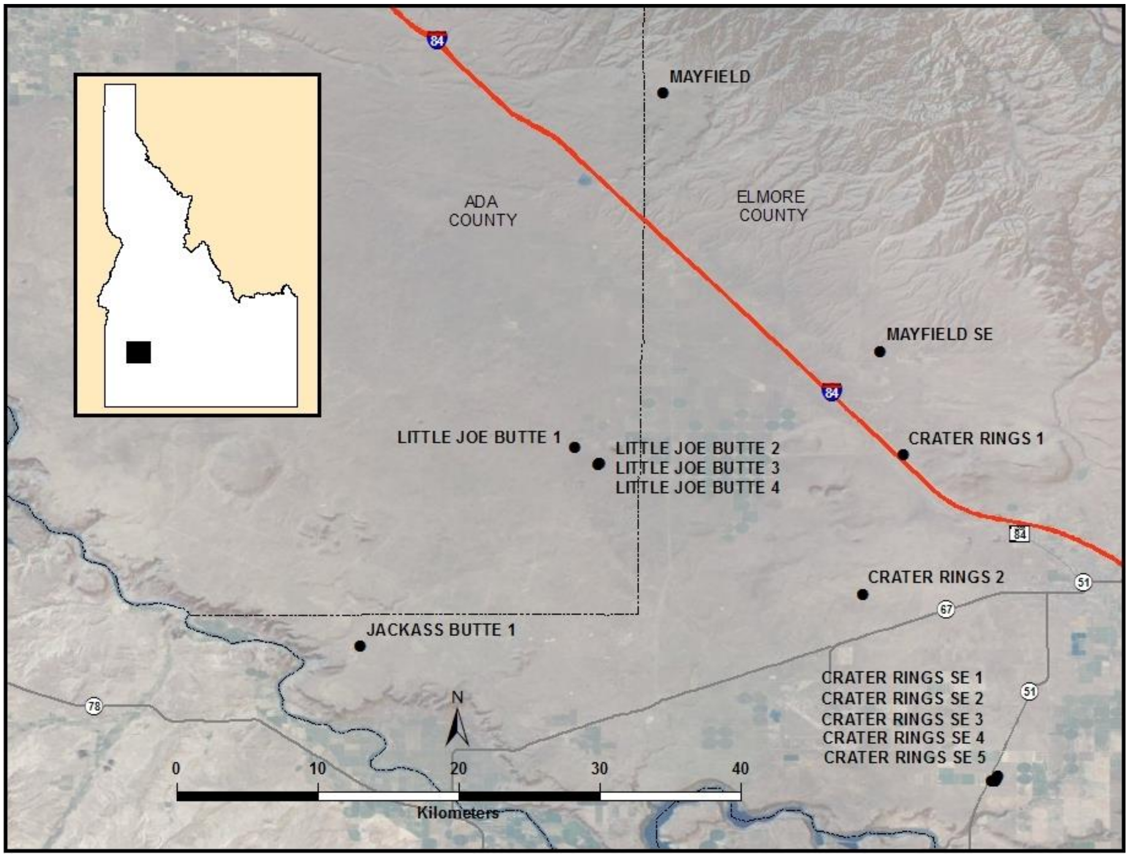
Table 5. Summary of observed disturbances in wetland and upland habitats at surveyed sites.

SITE NAME	TYPE	DATE	POOL DISTURBANCE	BUFFER DISTURBANCE	IMPACT SEVERITY	CONDITION SCORE
BUSTER BUTTE	VERNAL POOL	5/5/2008	LG, INV	LG, INV	LIGHT	0.06
LITTLE BLUE TABLE 2	VERNAL POOL	5/5/2008	LG, RD	LG, EX	HEAVY	0.44
TICESKA 1	VERNAL POOL	5/7/2008	LG, INV	LG, INV	LIGHT	0.06
TICESKA 2	VERNAL POOL	5/7/2008	LG, INV	LG, INV	LIGHT	0.06
TICESKA 3	VERNAL POOL	5/7/2008	INV	LG, INV	LIGHT	0.04
GRASMERE RESERVOIR 3	VERNAL POOL	5/9/2008	LG	LG	MODERATE	0.08
GRASMERE RESERVOIR 4	VERNAL POOL	5/9/2008	LG, PU	LG, PU	MODERATE	0.23
CRATER RINGS 2	PLAYA	6/5/2008	NONE	LG	LIGHT	0.01
MACON 12	VERNAL POOL	6/10/2008	LG, PU	LG, PU, RD	HEAVY	0.42
MACON 2	VERNAL POOL	6/10/2008	LG, PU	LG, PU	HEAVY	0.30
MACON 30	VERNAL POOL	6/10/2008	LG	LG, RD	LIGHT	0.15
MACON 31	VERNAL POOL	6/10/2008	LG	LG, RD	LIGHT	0.15
MACON 32	VERNAL POOL	6/10/2008	LG	LG	LIGHT	0.03
MACON LAKE	VERNAL POOL	6/10/2008	LG	LG, RD	LIGHT	0.15
TAPPER LAKE 1	VERNAL POOL	6/11/2008	LG, PU, EX, INV	LG, INV	HEAVY	0.48
TAPPER LAKE 2	VERNAL POOL	6/11/2008	LG, PU, RD, INV	LG, INV, RD	HEAVY	0.55
TAPPER LAKE 3	VERNAL POOL	6/11/2008	LG, PU, INV	LG, INV	HEAVY	0.36
SUGARLOAF 1	VERNAL POOL	6/12/2008	LG, PU, EX	LG	HEAVY	0.42
SUGARLOAF 2	VERNAL POOL	6/12/2008	LG	LG	LIGHT	0.03
SUGARLOAF 3	VERNAL POOL	6/13/2008	LG	LG	MODERATE	0.08
SUGARLOAF 4	VERNAL POOL	6/13/2008	LG	LG	LIGHT	0.03
SUGARLOAF 6	VERNAL POOL	6/13/2008	LG, PU	LG	MODERATE	0.16
SUGARLOAF 7	VERNAL POOL	6/13/2008	LG	LG	LIGHT	0.03
CRATER RINGS SE 1	PLAYA	3/17/2009	LG	LG	LIGHT	0.03
CRATER RINGS SE 2	PLAYA	3/17/2009	LG	LG	LIGHT	0.03
CRATER RINGS SE 3	PLAYA	3/17/2009	LG	LG	LIGHT	0.03
CRATER RINGS SE 4	PLAYA	3/17/2009	LG	LG	LIGHT	0.03
CRATER RINGS SE 5	PLAYA	3/17/2009	LG	LG	LIGHT	0.03
HOLE IN ROCK 1	PLAYA	3/18/2009	LG, RD, EX, INV	LG, INV, RD	HEAVY	0.65
HOLE IN ROCK 2	PLAYA	3/18/2009	LG, EX	LG	LIGHT	0.28
HOLE IN ROCK 3	PLAYA	3/18/2009	RD	RD	MODERATE	0.30
HOLE IN ROCK 4	PLAYA	3/18/2009	LG, EX	LG	LIGHT	0.23
GRASMERE 1	VERNAL POOL	3/19/2009	LG, PU, INV	LG, INV	HEAVY	0.28
GRASMERE 2	VERNAL POOL	3/19/2009	LG, PU, INV	LG, INV	HEAVY	0.28
HILL PASTURE 1	PLAYA	3/19/2009	LG	LG	LIGHT	0.03
HILL PASTURE 2	PLAYA	3/19/2009	LG	LG	LIGHT	0.03
HILL PASTURE 3	PLAYA	3/19/2009	NONE	LG	LIGHT	0.01
HILL PASTURE 4	PLAYA	3/19/2009	NONE	LG	LIGHT	0.01
HILL PASTURE 5	PLAYA	3/19/2009	NONE	LG	LIGHT	0.01
TICESKA 4	VERNAL POOL	4/8/2009	LG, PU, INV	LG, INV	HEAVY	0.28
TICESKA 5	VERNAL POOL	4/8/2009	LG, PU, INV	LG, INV	HEAVY	0.28
TICESKA 6	VERNAL POOL	4/8/2009	LG, PU, INV	LG, INV	HEAVY	0.28
TICESKA 7	VERNAL POOL	4/8/2009	LG, PU, INV	LG, INV	HEAVY	0.28
TICESKA 8	VERNAL POOL	4/8/2009	LG, PU, INV	LG, INV	HEAVY	0.28
GRASMERE RESERVOIR 6	VERNAL POOL	4/9/2009	LG, PU	LG, PU	HEAVY	0.30

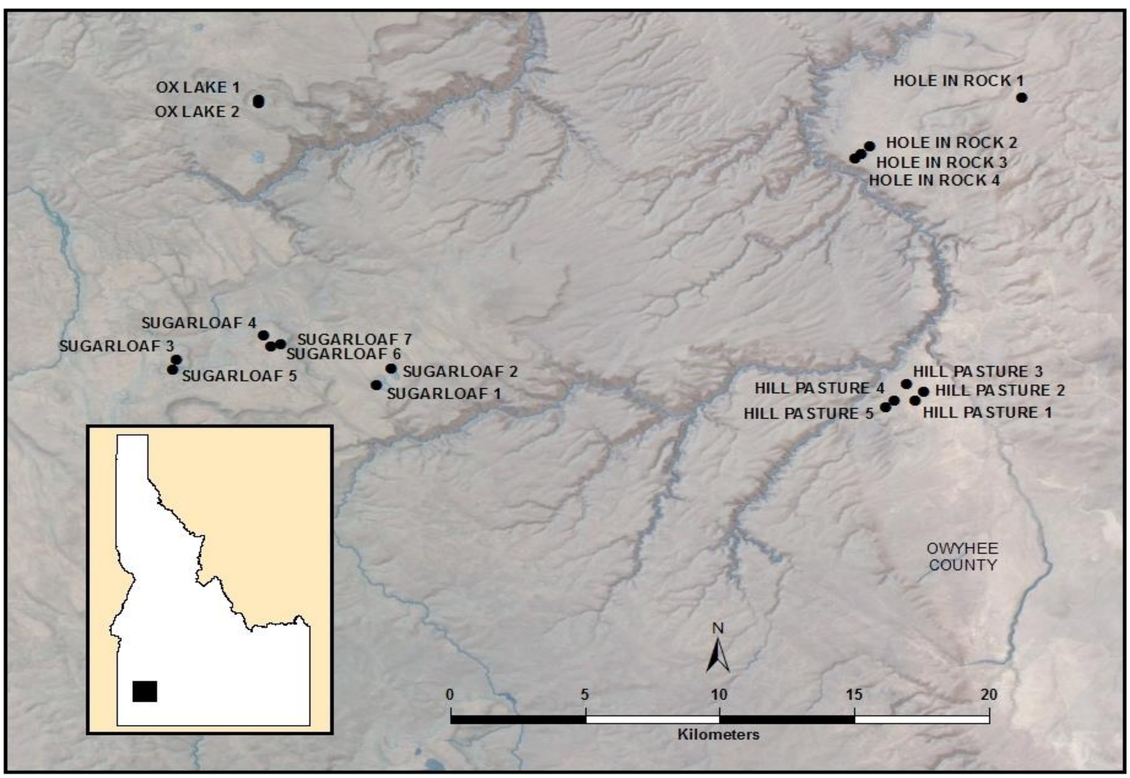
SITE NAME	TYPE	DATE	POOL DISTURBANCE	BUFFER DISTURBANCE	IMPACT SEVERITY	ECOLOGICAL CONDITION SCORE
MACON 01	VERNAL POOL	4/20/2009	LG, PU	LG, INV, PU	MODERATE	0.25
MACON 02	VERNAL POOL	4/20/2009	LG, PU	LG, PU	HEAVY	0.30
MACON 03	VERNAL POOL	4/20/2009	LG, PU, EX, RD, INV	LG, INV, PU, RD	HEAVY	0.83
MACON 04	VERNAL POOL	4/20/2009	LG	LG, RD	MODERATE	0.20
MACON INCIDENTAL 1	VERNAL POOL	4/20/2009	LG, PU	LG, PU	HEAVY	0.30
MACON INCIDENTAL 2	VERNAL POOL	4/20/2009	NONE	LG, RD	LIGHT	0.13
MACON 05	VERNAL POOL	4/21/2009	LG, PU	LG, RD	MODERATE	0.28
MACON 07	VERNAL POOL	4/21/2009	LG, PU	LG, PU	LIGHT	0.18
MACON 24	VERNAL POOL	4/21/2009	LG, PU	LG, INV, PU	HEAVY	0.28
MACON 25	VERNAL POOL	4/21/2009	LG	LG, INV	LIGHT	0.04
MACON 26	VERNAL POOL	4/21/2009	LG	LG, INV, PU	LIGHT	0.11
MACON 27	VERNAL POOL	4/21/2009	LG	LG, INV	LIGHT	0.04
MACON INCIDENTAL 7A	VERNAL POOL	4/21/2009	LG	LG	LIGHT	0.03
MACON INCIDENTAL 7B	VERNAL POOL	4/21/2009	LG	LG, RD	LIGHT	0.15
MACON INCIDENTAL 7C	VERNAL POOL	4/21/2009	LG	LG, RD	LIGHT	0.15
MAMMOTH CAVE 1	VERNAL POOL	5/27/2009	LG, INV, RD	LG, INV, RD	HEAVY	0.45
MAMMOTH CAVE 7	VERNAL POOL	5/27/2009	LG, INV	LG, INV, RD	HEAVY	0.30
MAMMOTH CAVE 2	VERNAL POOL	5/28/2009	LG, EX, INV	LG, INV, EX, RD	HEAVY	0.63
MAMMOTH CAVE 3	VERNAL POOL	5/28/2009	LG, INV	LG, INV	HEAVY	0.18
MAMMOTH CAVE 4	VERNAL POOL	5/28/2009	LG, EX, INV	LG, INV	HEAVY	0.38
MAMMOTH CAVE 4B	VERNAL POOL	5/28/2009	LG, INV	LG, INV	MODERATE	0.14
MAMMOTH CAVE 4C	VERNAL POOL	5/28/2009	LG, INV	LG, INV	LIGHT	0.06
MAMMOTH CAVE 5	VERNAL POOL	5/28/2009	LG, INV	LG, INV	HEAVY	0.18
GRASMERE RESERVOIR 5	VERNAL POOL	6/2/2009	LG	LG, INV	LIGHT	0.04
LITTLE BLUE TABLE 1	VERNAL POOL	6/3/2009	NONE	INV	LIGHT	0.01
LITTLE BLUE TABLE 3	VERNAL POOL	6/3/2009	LG	LG, INV	LIGHT	0.04
JACKASS BUTTE 1	VERNAL POOL	6/24/2009	LG, INV	LG, INV	MODERATE	0.14
LITTLE JOE BUTTE 2	VERNAL POOL	6/24/2009	INV	INV, RD	MODERATE	0.23
LITTLE JOE BUTTE 3	VERNAL POOL	6/24/2009	INV	INV, RD	MODERATE	0.23
LITTLE JOE BUTTE 4	VERNAL POOL	6/24/2009	INV	INV, RD	MODERATE	0.23
OX LAKE 1	VERNAL POOL	6/25/2009	LG, EX	LG	HEAVY	0.32
OX LAKE 2	VERNAL POOL	6/25/2009	LG, EX	LG	HEAVY	0.32
WICKAHONEY POINT 1	VERNAL POOL	7/2/2009	LG	LG	LIGHT	0.03
WICKAHONEY POINT 2	VERNAL POOL	7/2/2009	LG	LG	LIGHT	0.03
GRASMERE 3	VERNAL POOL	7/15/2009	INV, LG	LG, INV	LIGHT	0.06

*Disturbance classifications: LG = livestock grazing; PU = pugging/trampling; EX = excavated reservoir; INV = invasive species (plants); RD = roadway; OHV = off-highway vehicle use; NONE = no visible disturbance

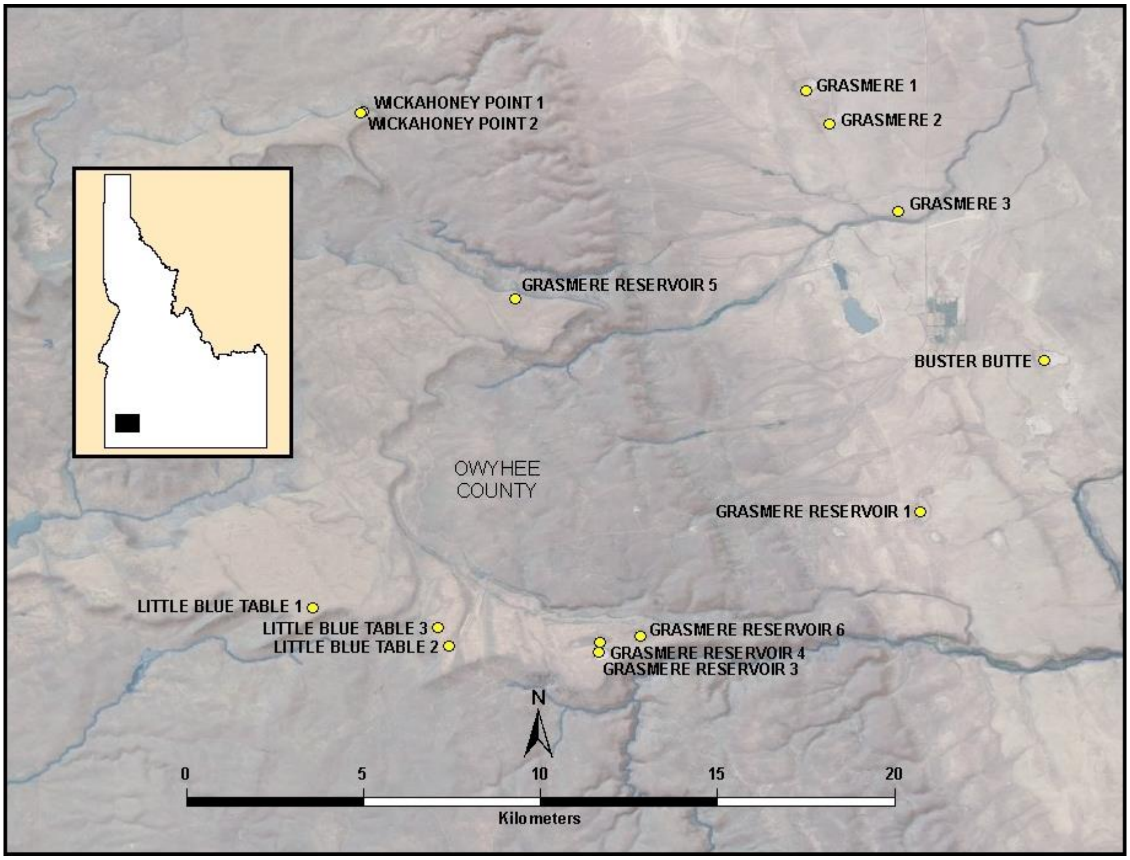
Appendix 1. Locations and site names of vernal pools and playas surveyed during 2008 - 2009.



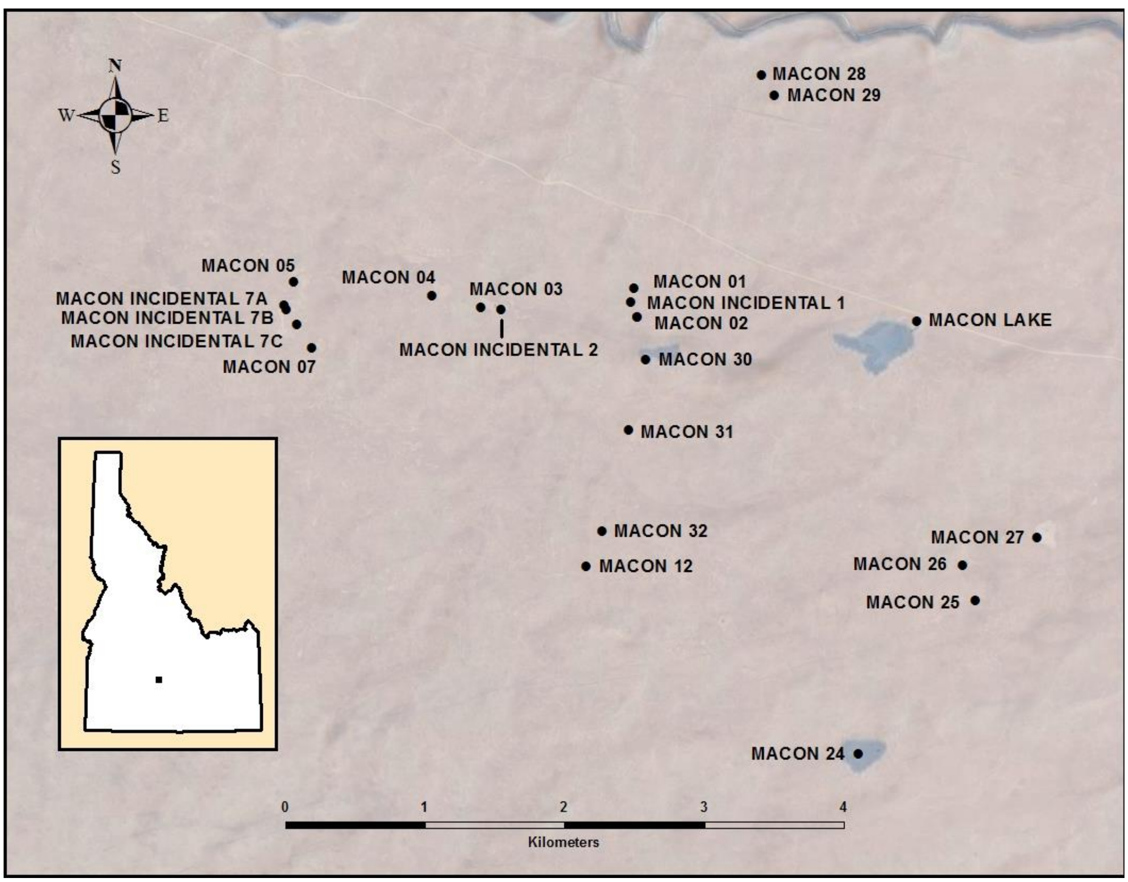
Mountain Home Sites



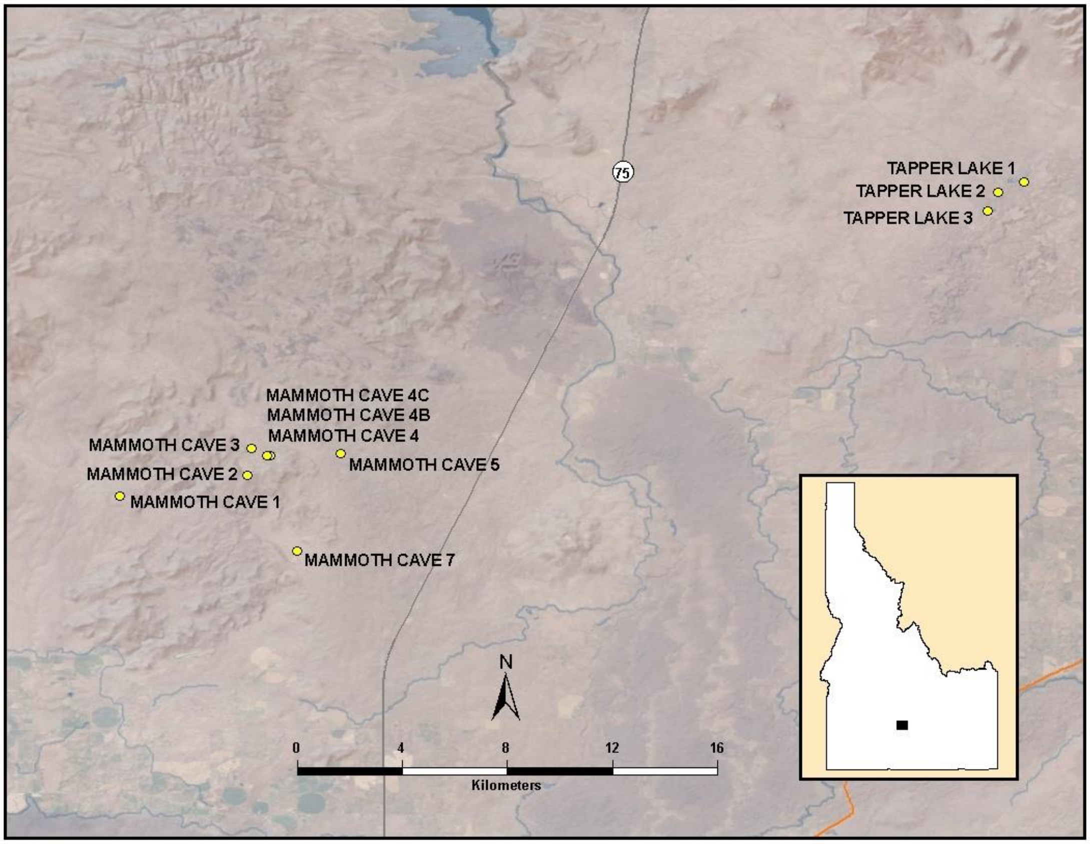
Owyhee Sites



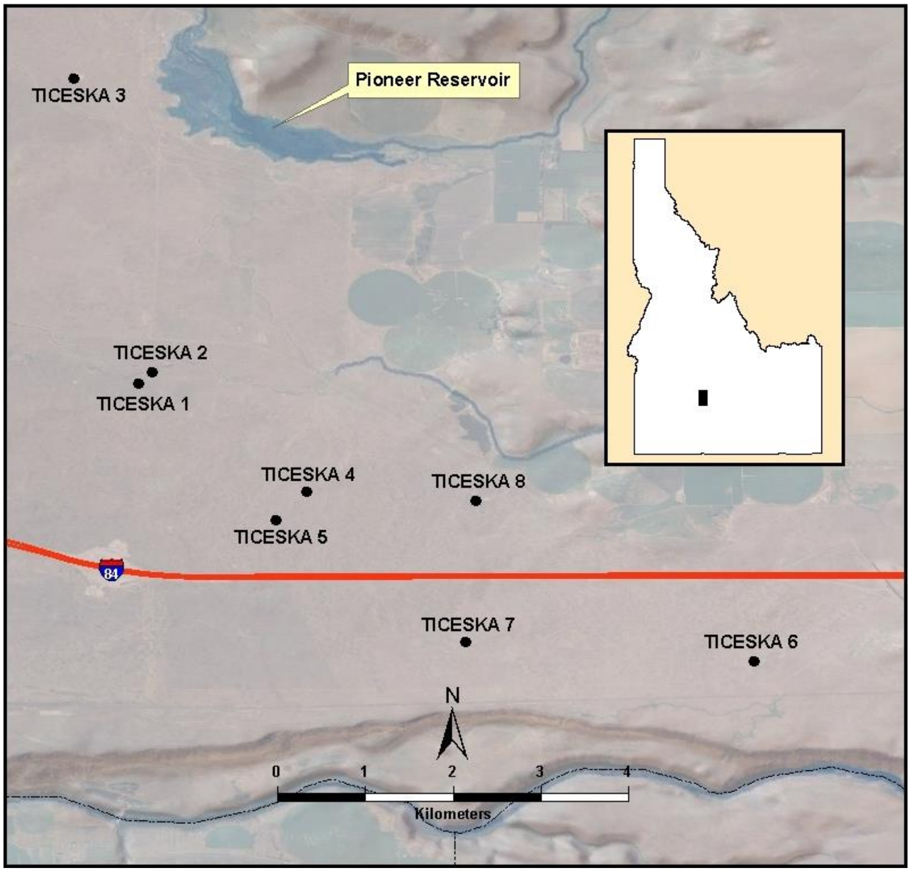
Grasmere Sites



Macon Flats Sites



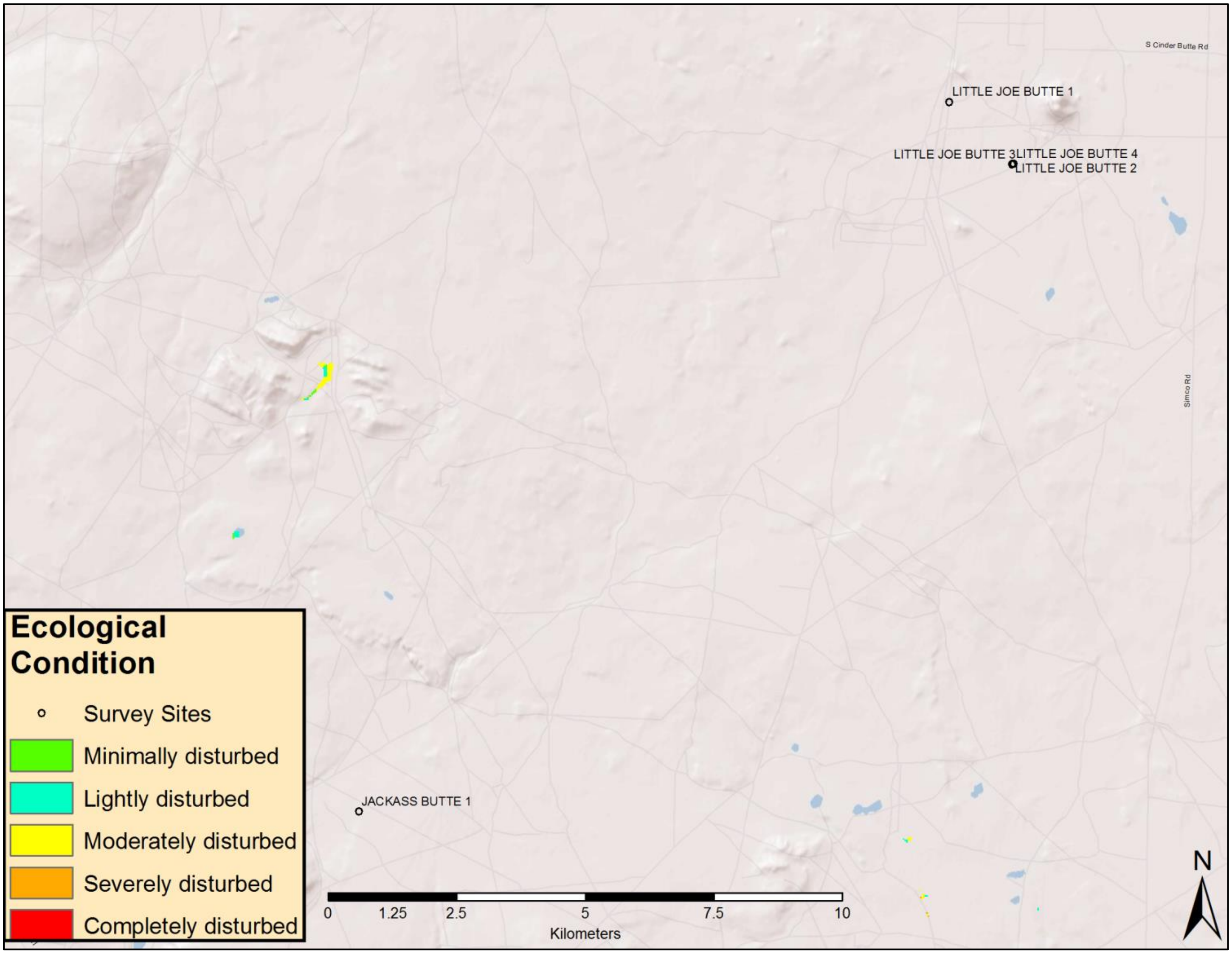
Mammoth Cave – Tapper Lake Sites

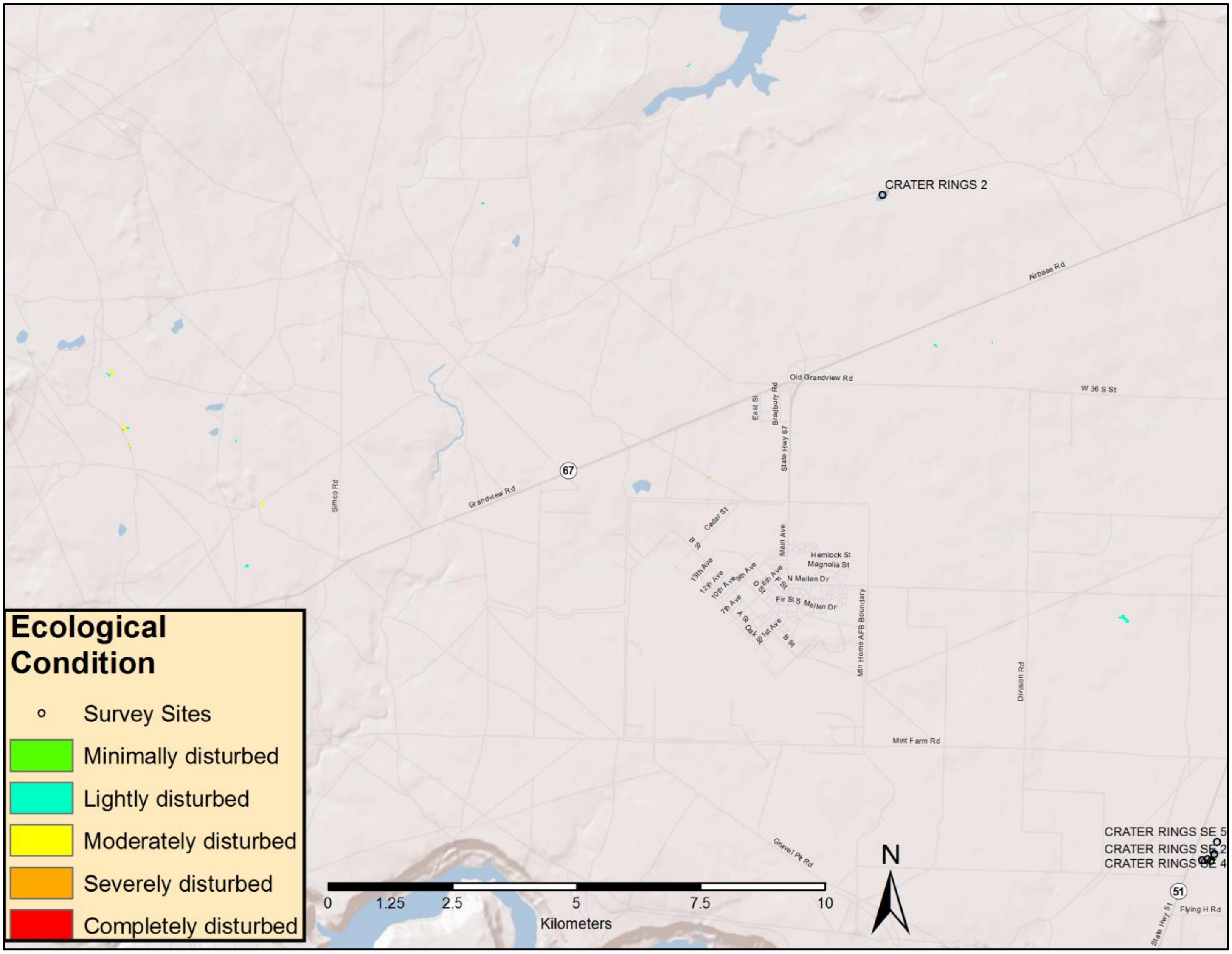


Ticeska Sites

Appendix 2. Landscape-scale Level 1 predicted condition at vernal pool and playa sites surveyed in 2008 - 2009 and Owyhee River Canyonlands.

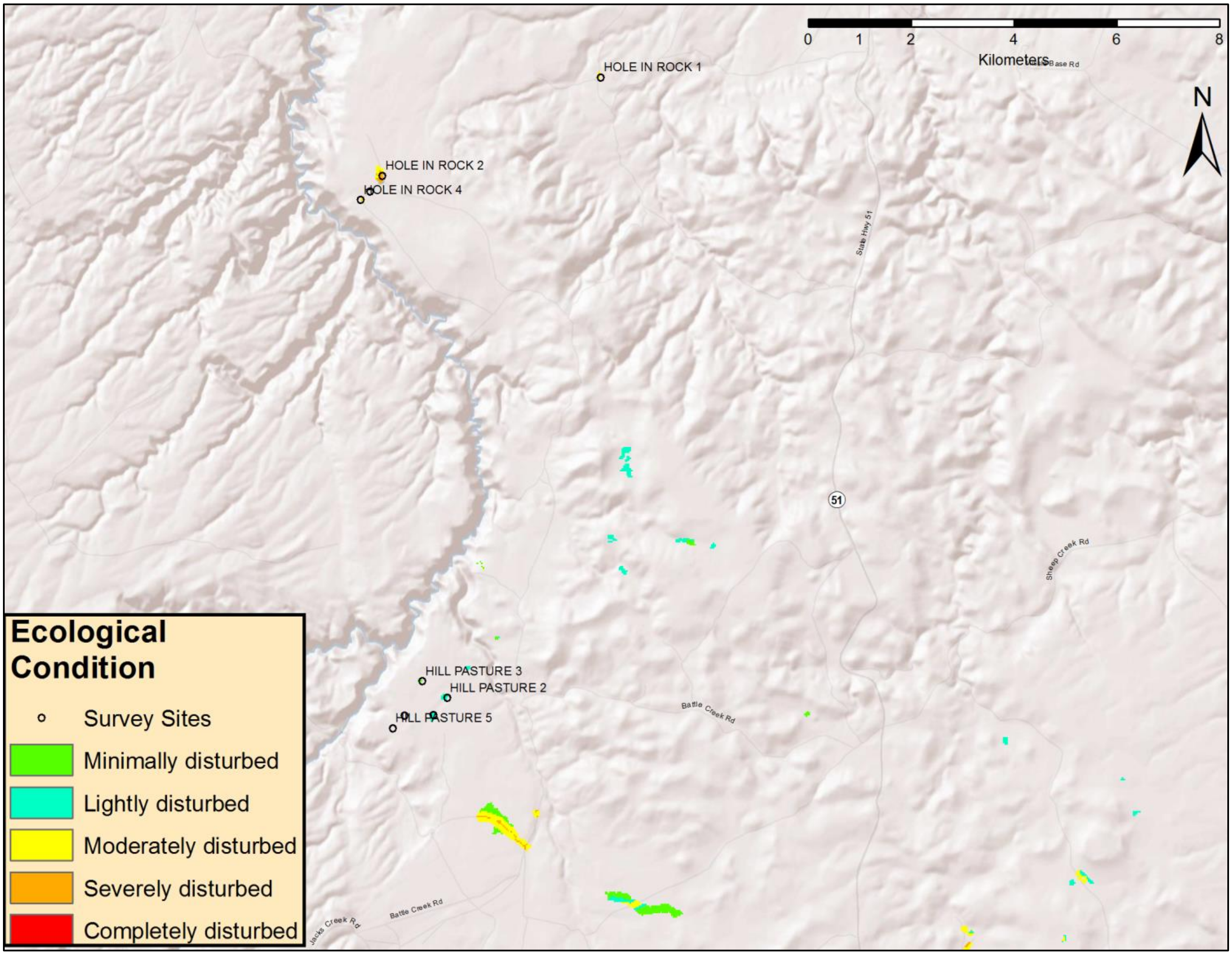
Mountain Home Sites

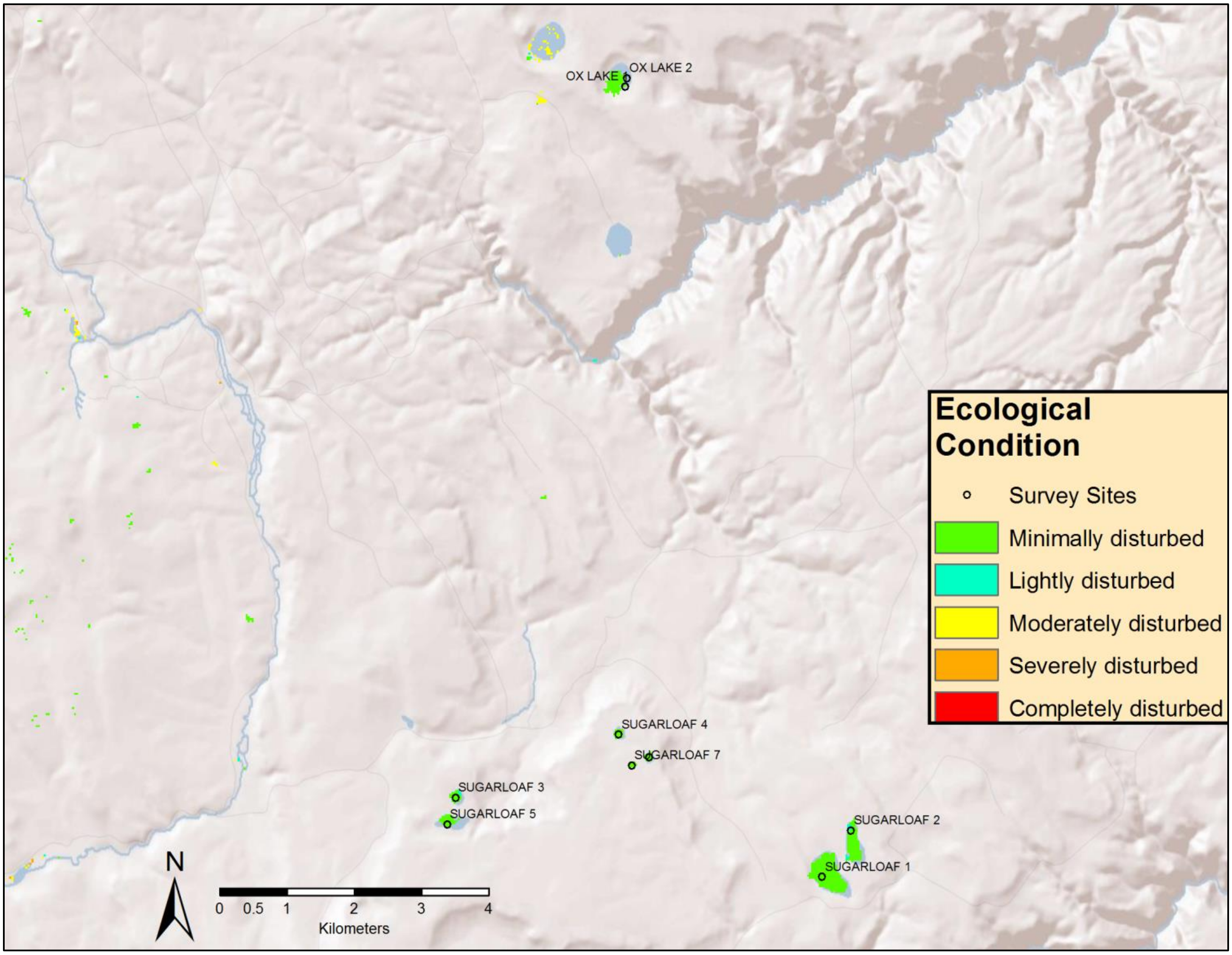


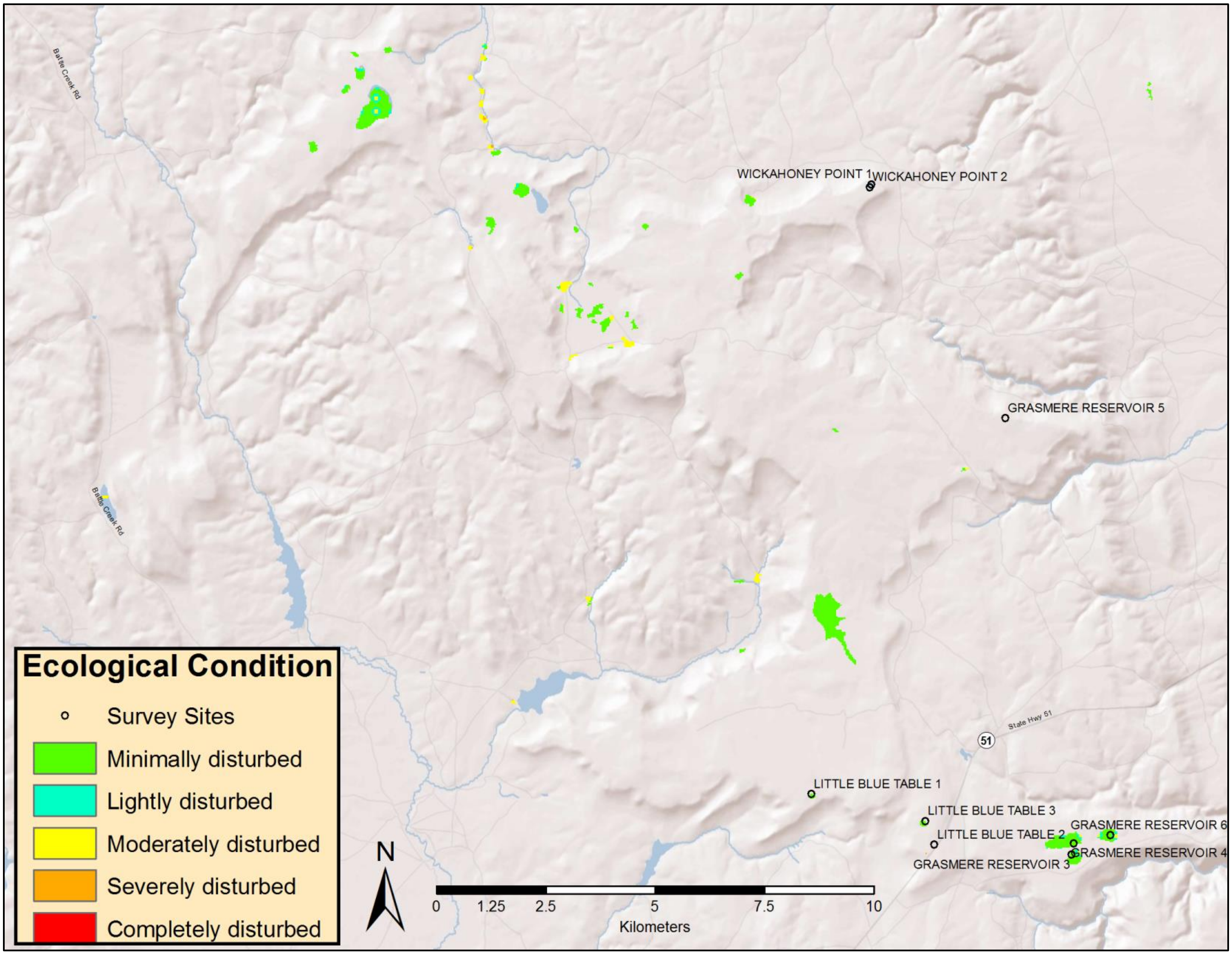


CRATER RINGS 2
Airbase Rd
Old Grandview Rd
W 36 S St
East St
Bradbury Rd
State Hwy 67
67
Grandview Rd
Simco Rd
Cedar St
Main Ave
Hemlock St
Magnolia St
N Mellen Dr
S Mellen Dr
Fir St
Mtn Home AFB Boundary
Division Rd
Mint Farm Rd
Gravel Pit Rd
CRATER RINGS SE 5
CRATER RINGS SE 2
CRATER RINGS SE 4
51
State Hwy 51
Flying H Rd
N
0
1.25
2.5
5
7.5
10
Kilometers
Ecological Condition
Survey Sites
Minimally disturbed
Lightly disturbed
Moderately disturbed
Severely disturbed
Completely disturbed

Owyhee Sites

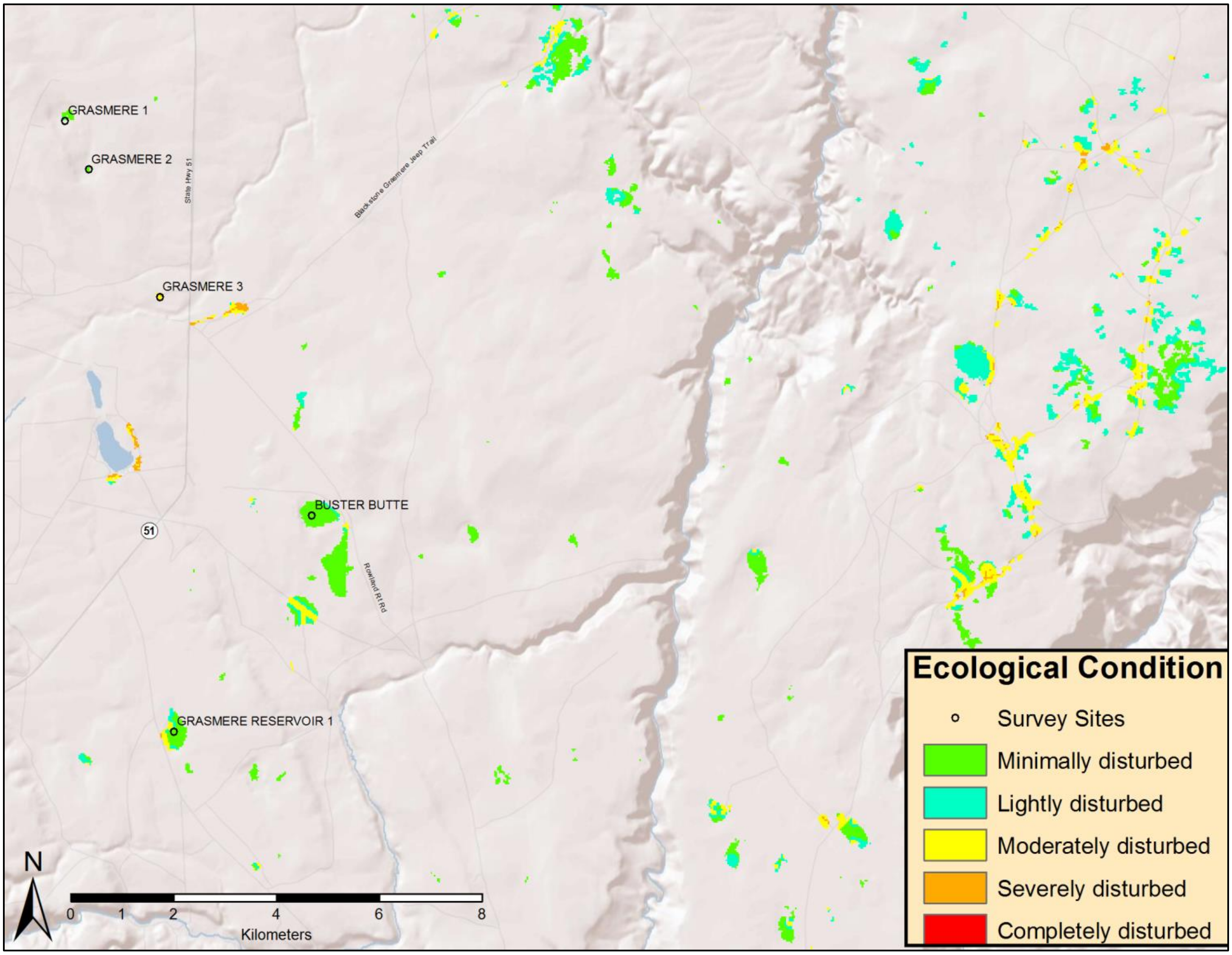



OX LAKE
OX LAKE 2
Ecological Condition
Survey Sites
Minimally disturbed
Lightly disturbed
Moderately disturbed
Severely disturbed
Completely disturbed
SUGARLOAF 4
SUGARLOAF 7
SUGARLOAF 3
SUGARLOAF 5
SUGARLOAF 2
SUGARLOAF 1
N
0 0.5 1 2 3 4
Kilometers

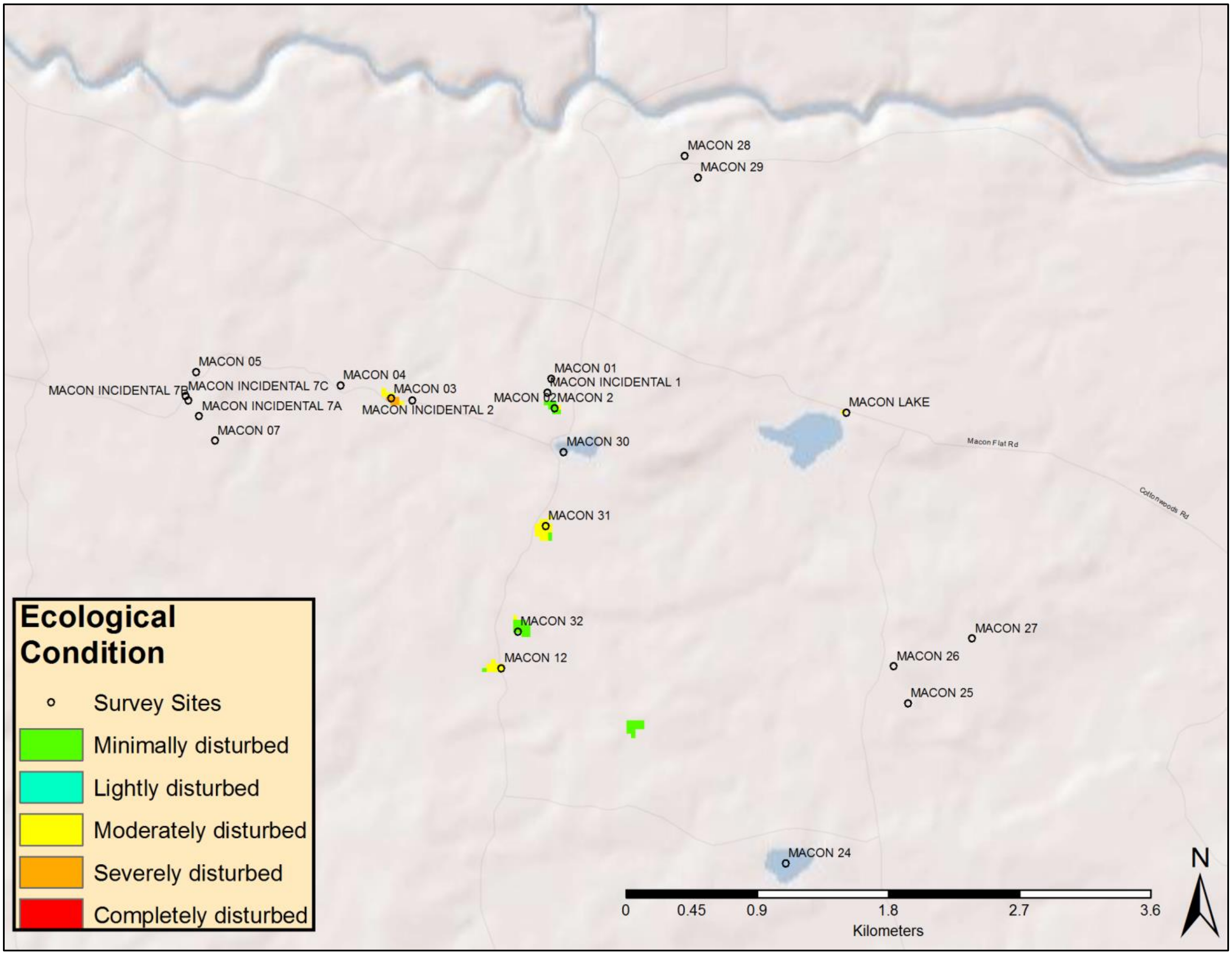


Ecological Condition
Survey Sites
Minimally disturbed
Lightly disturbed
Moderately disturbed
Severely disturbed
Completely disturbed
N
0
1.25
2.5
5
7.5
10
Kilometers
WICKAHONEY POINT 1
WICKAHONEY POINT 2
GRASMERE RESERVOIR 5
LITTLE BLUE TABLE 1
LITTLE BLUE TABLE 3
LITTLE BLUE TABLE 2
GRASMERE RESERVOIR 3
GRASMERE RESERVOIR 6
GRASMERE RESERVOIR 4
51
State Hwy 51
Battle Creek Rd

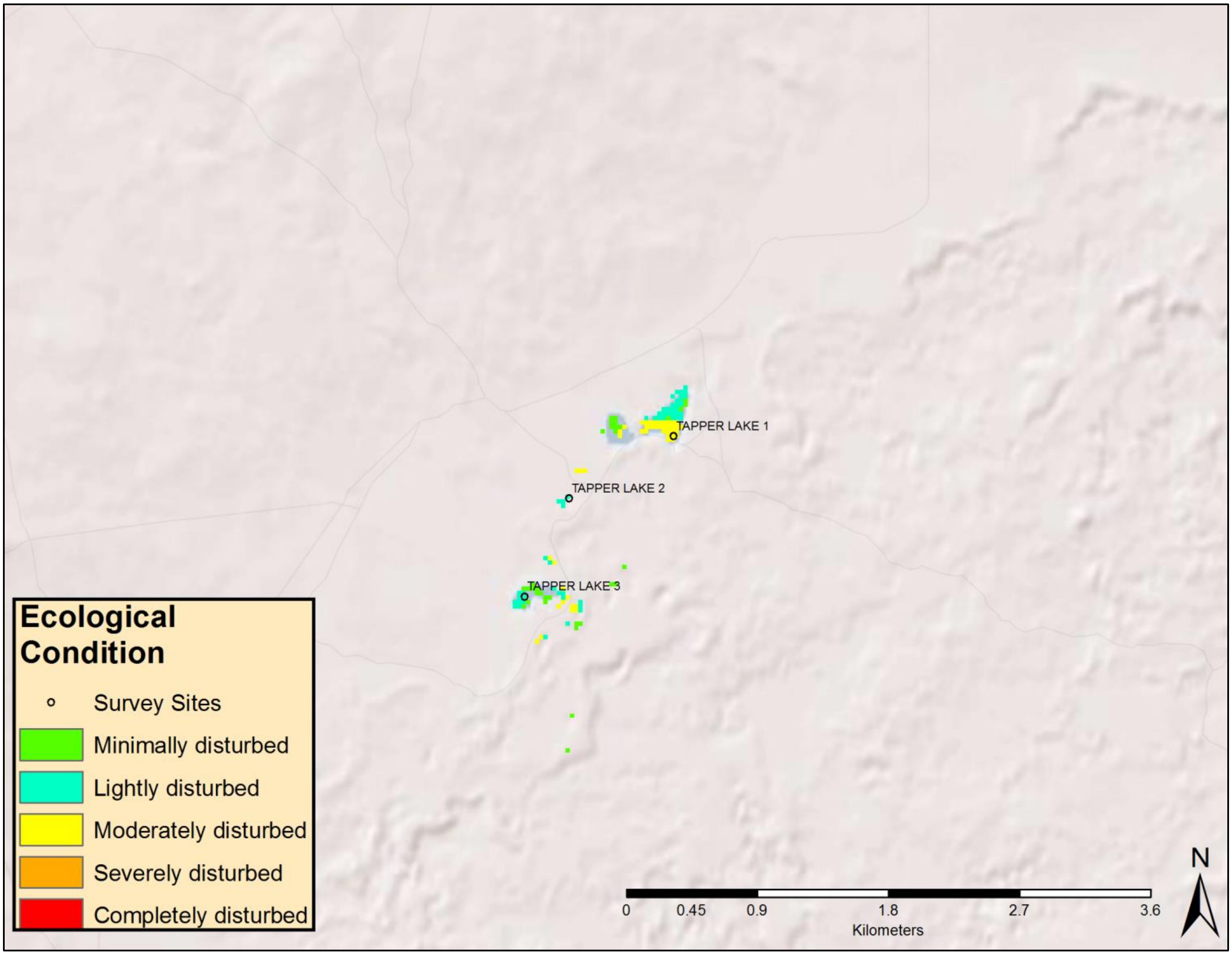
Grasmere Sites

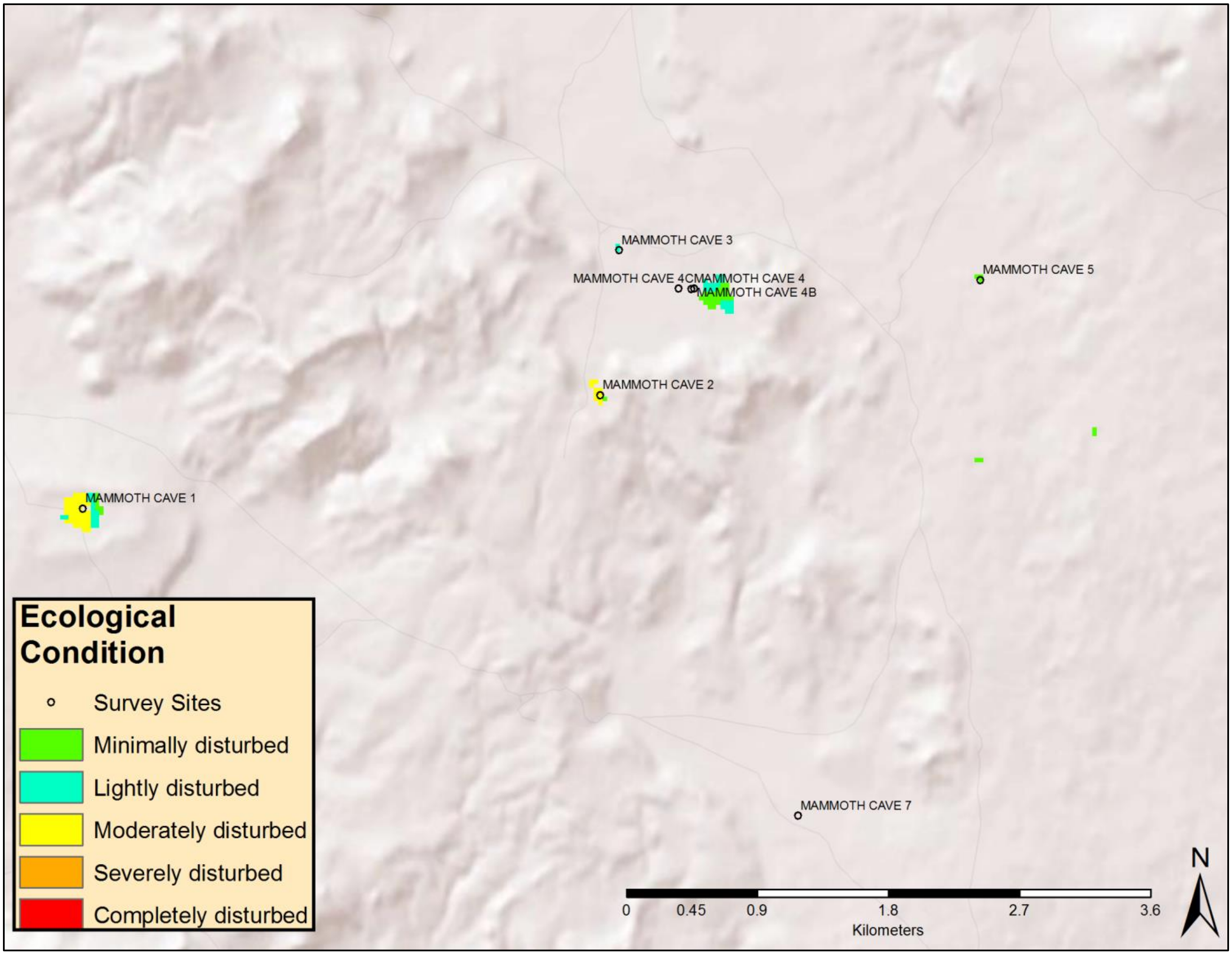


Macon Flat Sites



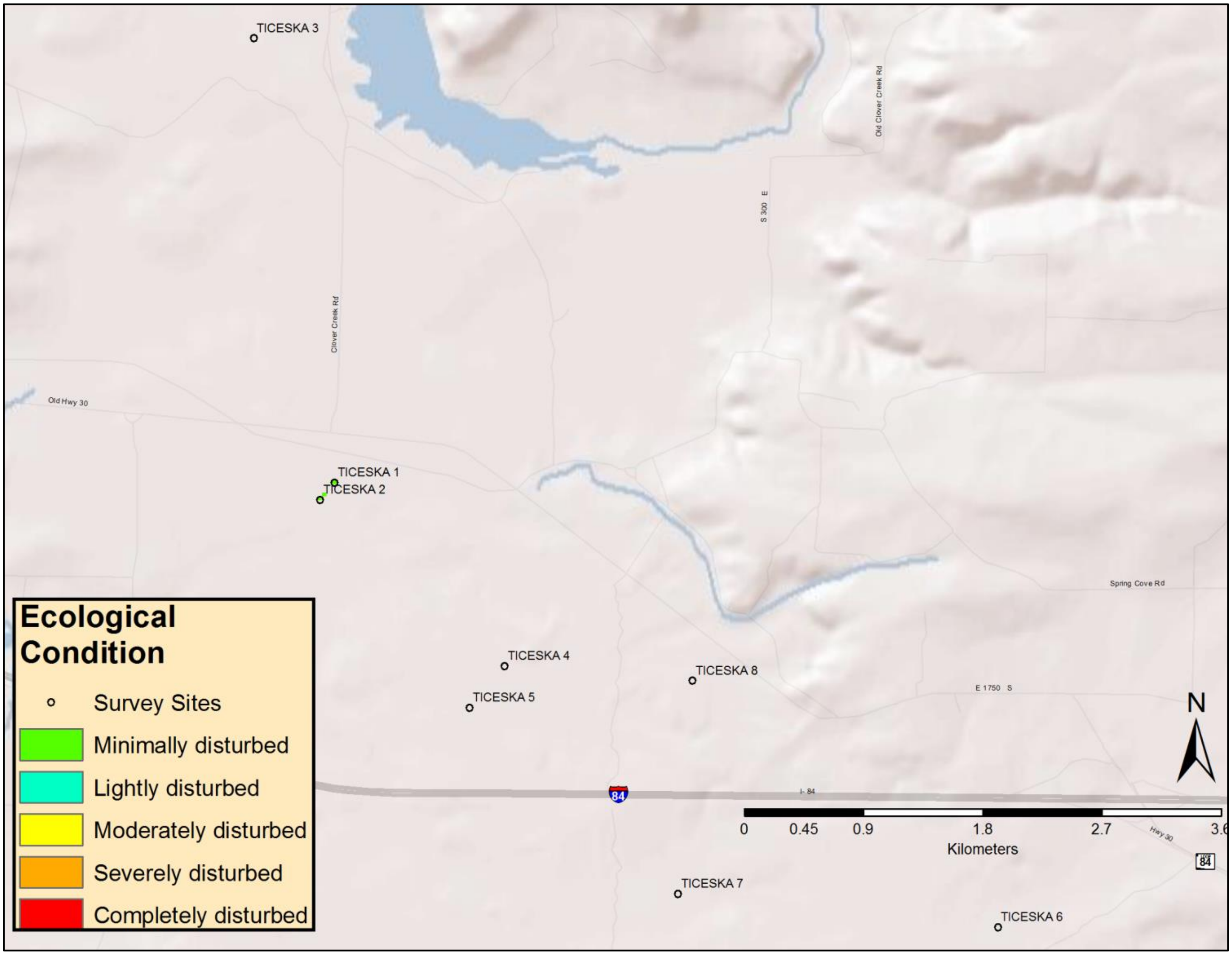
Mammoth Cave – Tapper Lake Sites





MAMMOTH CAVE 3
MAMMOTH CAVE 4C
MAMMOTH CAVE 4
MAMMOTH CAVE 4B
MAMMOTH CAVE 5
MAMMOTH CAVE 2
MAMMOTH CAVE 1
MAMMOTH CAVE 7
Ecological Condition
Survey Sites
Minimally disturbed
Lightly disturbed
Moderately disturbed
Severely disturbed
Completely disturbed
0
0.45
0.9
1.8
2.7
3.6
Kilometers
N

Ticeska Sites



Owyhee River Canyonlands