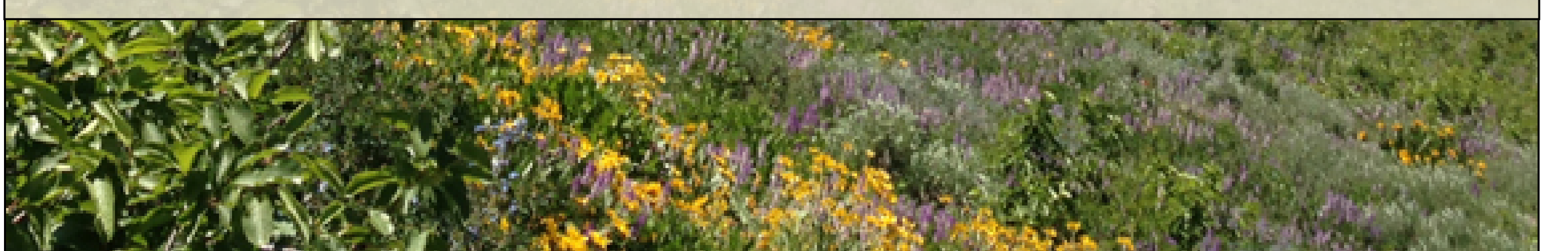
Fen Mapping for the Humboldt-Toiyabe National Forest

COLORADO NATURAL HERITAGE PROGRAM

September 2019



CNHP's mission is to preserve the natural diversity of life by contributing the essential scientific foundation that leads to lasting conservation of Colorado's biological wealth.

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Front Cover Photo:

Copper Basin in the Jarbidge Wilderness of Humboldt-Toiyabe National Forest

Fen Mapping for the Humboldt-Toiyabe National Forest

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EXECUTIVE SUMMARY

The Humboldt-Toiyabe National Forest covers 6.3 million acres spread across fourteen units in Nevada and California. Wetlands within the Humboldt-Toiyabe National Forest provide important ecological services to both the Forest and lands downstream. Organic soil wetlands known as fens are an irreplaceable resource that the U.S. Forest Service has determined should be managed for conservation and restoration. Fens are defined as groundwater-fed wetlands with organic soils that typically support sedges and low stature shrubs. In the arid west, organic soil formation can take thousands of years. Long-term maintenance of fens requires maintenance of both the hydrology and the plant communities that enable fen formation.

In 2012, the U.S. Forest Service released a new planning rule to guide all National Forests through the process of updating their Land Management Plans (also known as Forest Plans). A component of the new planning rule is that each National Forest must conduct an assessment of important biological resources within its boundaries. Through the biological assessment, biologists at the Humboldt-Toiyabe National Forest identified a need to better understand the distribution and extent of fen wetlands under their management. To this end, U.S. Forest Service contracted Colorado State University and the Colorado Natural Heritage Program (CNHP) to map all potential fens within the Humboldt-Toiyabe National Forest.

Potential fens in the Humboldt-Toiyabe National Forest were identified from digital aerial photography and topographic maps. Each potential fen polygon was hand-drawn in ArcGIS based on the best estimation of fen boundaries and attributed with a confidence value of 1 (low confidence), 3 (possible fen) or 5 (likely fen). The final map contained 2,436 potential fen locations (all confidence levels), covering 5,155 acres or less than 1% of the total land area. This total included 223 ***likely fens***, 661 ***possible fens***, and 1,522 ***low confidence fens.*** The average fen polygon was 2.11 acres, but individual fen polygons ranged from 66 acres to less than an acre.

Fen distribution was analyzed by elevation, bedrock geology, Land Type Association Subsection, and watershed. The majority of mapped potential fens occurred between 8,000 to 11,000 feet. This elevation range contained 65% of all potential fen locations and 83% of likely fen locations. Two watersheds in particular have higher numbers of likely fens: Robinson Creek contains 37 likely fens and the Cascade Creek – West Walker River watershed contains 28 likely fens.

This report and associated dataset provides the Humboldt-Toiyabe National Forest with a critical tool for conservation planning at both a local and Forest-wide scale. These data will be useful for the ongoing Humboldt-Toiyabe National Forest biological assessment required by the 2012 Forest Planning Rule, but can also be used for individual management actions, such as planning for timber sales, grazing allotments, and trail maintenance. Wherever possible, the Forest should avoid direct disturbance to the fens mapped through this project, and should also strive to protect the watersheds surrounding high concentrations of fens, thereby protecting their water sources.

ACKNOWLEDGMENTS

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Finally, we would like to thank Tracey Trujillo and Carmen Morales with Colorado State University for logistical support and grant administration.

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1.0 Introduction

The Humboldt-Toiyabe National Forest (Humboldt-Toiyabe National Forest) covers over 6 million acres in Nevada and California and spans a broad elevation range from 3,700 to 12,385 ft. Several types of wetlands occur within the Humboldt-Toiyabe National Forest. Snowfall in the mountains percolates through shallow mountain soils and creates wet meadows, riparian shrublands, and organic soil wetlands known as fens. These wetland habitats provide important ecological services to both Humboldt-Toiyabe National Forest and lands downstream (Mitsch & Gosselink 2007; Millennium Ecosystem Assessment 2005). Wetlands act as natural filters, helping to protect water quality by retaining sediments and removing excess nutrients. Wetlands help to regulate local and regional hydrology by stabilizing base flow, attenuating floods, and replenishing belowground aquifers. Wetlands also support habitat for numerous plant and animals species that depend on aquatic habitats for some portion of their life cycle (Redelfs 1980 as cited in McKinstry et al. 2004).

Organic soil wetlands known as fens are an irreplaceable resource. Fens are defined as groundwater-fed wetlands with organic soils that typically support sedges and low stature shrubs (Mitch & Gosselink 2007). The strict definition of an organic soil (peat) is one with 40 cm (16 in) or more of organic soil material in the upper 80 cm (31 in) of the soil profile (Soil Survey Staff 2014). Accumulation of organic material to this depth requires constant soil saturation and cold temperatures, which create anaerobic conditions that slow the decomposition of organic matter. By storing organic matter deep in their soils, fens act as a carbon sink. In the arid west, peat accumulation occurs very slowly; estimates are 20 cm (8 in) per 1,000 years in Colorado (Chimner 2000; Chimner and Cooper 2002). Long-term maintenance of fens requires maintenance of both the hydrology and the plant communities that enable fen formation.

In 2012, the U.S Forest Service released a new planning rule that will guide all National Forests through the process of updating their Land Management Plans (also known as Forest Plans).[1] A component of the new planning rule is that each National Forest must conduct an assessment of important biological resources within its boundaries. In advance of the biological assessment, biologists at the Humboldt-Toiyabe National Forest identified a need to better understand the distribution and extent of fen wetlands under their management. To this end, U.S. Forest Service contracted Colorado State University and the Colorado Natural Heritage Program (CNHP) to map all potential fens within the Humboldt-Toiyabe National Forest. This project builds upon CNHP's previous projects mapping fens on the White River National Forest (Malone et al. 2011), Rio Grande National Forest (Smith et al. 2016), Ashley National Forest (Smith & Lemly 2017a), Manti-La Sal National Forest (Smith & Lemly 2017b), Salmon-Challis National Forest (Smith et al. 2017), Bridger-Teton National Forest (Smith & Lemly 2018a) and Dixie National Forest (Smith & Lemly 2018b).

[1] For more information on the 2012 Forest Planning Rule, visit the following website: http://www.fs.usda.gov/main/planningrule/home.

2.0 Study Area

2.1 Geography

The fen mapping study area was the entire Humboldt-Toiyabe National Forest, which is administered as fourteen discontinuous units located in Nevada and California (Figure 1). It is the only National Forest in the state of Nevada and units of the Forest are located throughout the state. Humboldt-Toiyabe National Forest includes portions of thirteen counties in Nevada and six counties in California. The counties with the largest share of National Forest land are Nye, Elko, and White Pine Counties in Nevada and Mono County in California. The largest municipalities near the study area are Reno, Carson City, and Ely, Nevada. Elevation in the study area ranges from 3,733 ft. (1,139 m) to 12,385 ft. (3,775 m) and the mean elevation is 7,434 ft. (2,266 m). The Forest is located in close proximity Yosemite National Park, as well as Stanislaus, Inyo, Tahoe and Eldorado National Forests and the Lake Tahoe Basin Management Unit.

Humboldt-Toiyabe National Forest contains land in 12 different HUC6 basins (Figure 2). The largest amount of Forest land occurs in the Central Nevada Desert Basins (HUC6: 160600), in the center of Nevada. The Forest also contains land in these 11 additional HUC6 river basins: Lower Colorado–Lake Mead (HUC6: 150100); Great Salt Lake (HUC6:160203); Humboldt (HUC6: 160401); Black Rock Desert (HUC6: 160402); Truckee (HUC6: 160501); Carson (HUC6: 160502); Walker (HUC6: 160503); Upper Snake (HUC6: 170402); Middle Snake–Boise (HUC6: 170501); North Lahontan (HUC6: 180800); and Mono–Owens Lakes (HUC6: 180901). Most river basins in Nevada are closed basins, specifically those basins with HUC6 codes starting in 16. Streams and rivers in these basins drain onto terminus lakes or sinks rather than flowing into larger rivers that reach the ocean. The largest terminus lakes include Pyramid Lake in the Truckee Basin, Walker Lake in the Walker Basin, and the Humboldt and Carson sinks that form the edge of the Humboldt and Carson Basins. Under natural conditions, evaporation from the surface of these lakes is typically the only lake outflow.

The Forest covers several of the state's north-south trending mountain ranges. Nevada has more mountain ranges than any other state, with over 300 distinct ranges, each separated by open basins. Perhaps the most picturesque of Nevada's mountain ranges in the Ruby range in northeast Nevada, mostly within Elko County. This range is primarily within the Humboldt-Toiyabe National Forest.

2.2 Land Type Associations

The U.S. Forest Service has developed Land Type Associations for each National Forest to describe the major geomorphic landforms within the Forest (USDA 2019). The Land Type Association subsections referenced in this report were in draft form at the time of analysis (as of August 2, 2019) and have not yet been aggregated into LTA Groups. The final version of the LTA dataset may be different than what is described in this report.

There are 173 unique Land Type Associations in Humbolt-Toiyabe and 38 subsections. The most common Land Type Association subsection in the Humboldt-Toiyabe National Forest is the 341Gb

(14% of study area) (Figure 3). The next most common Land Type Association subsections are the M341Di (11%), M341Ag (11%) and M341Dj (9%).

2.3 Geology

Nevada's basin and range topography is driven by its underlying geology. Nearly every mountain range is bound on at least one side by faults. Over millions of years, activity along these faults has caused mountain ranges to rise and the basins to fill with thick erosional deposits. Most mountain ranges are dominated by volcanic or intrusive igneous bedrock, while the basins are characterized by unconsolidated deposits. During glacial periods, large portions of Nevada were covered by water, specifically in ancient Lake Bonneville and Lake Lahontan. Glaciers also carved dramatic U-shaped valleys in the highest mountain ranges.

Based on geologic mapping created by the U.S. Geologic Survey (1974), the most common geology in the fen mapping study area is igneous,volcanic, which covers 35% of the study area (Figure 4). The next most common geology is unconsolidated, undifferentiated (18% of study area). Igneous, intrusive and (11%) and sedimentary, undifferentiated (11%) are also common.

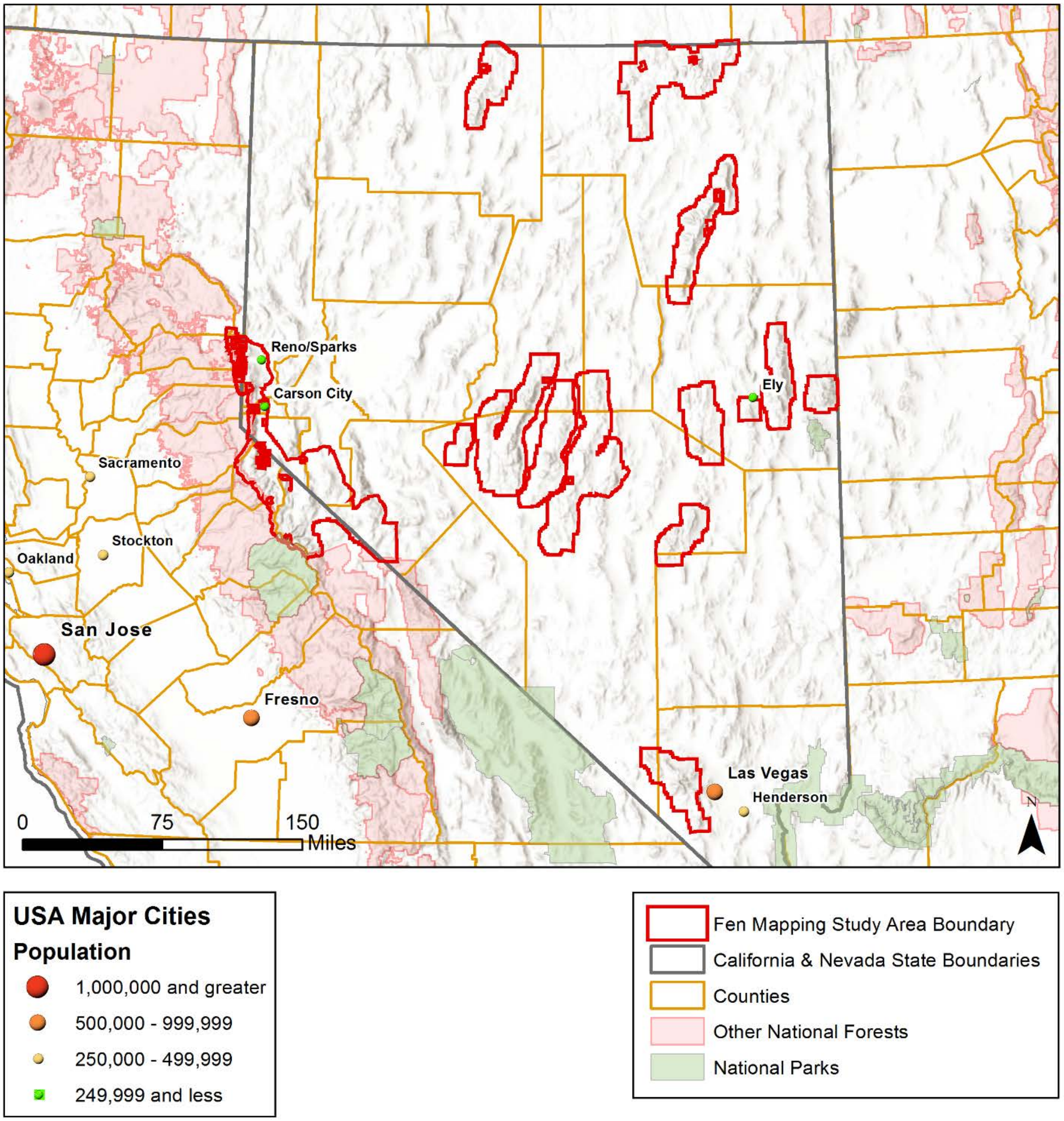

Figure 1. Location of the Humboldt-Toiyabe National Forest (fen mapping study area) within Nevada and California.

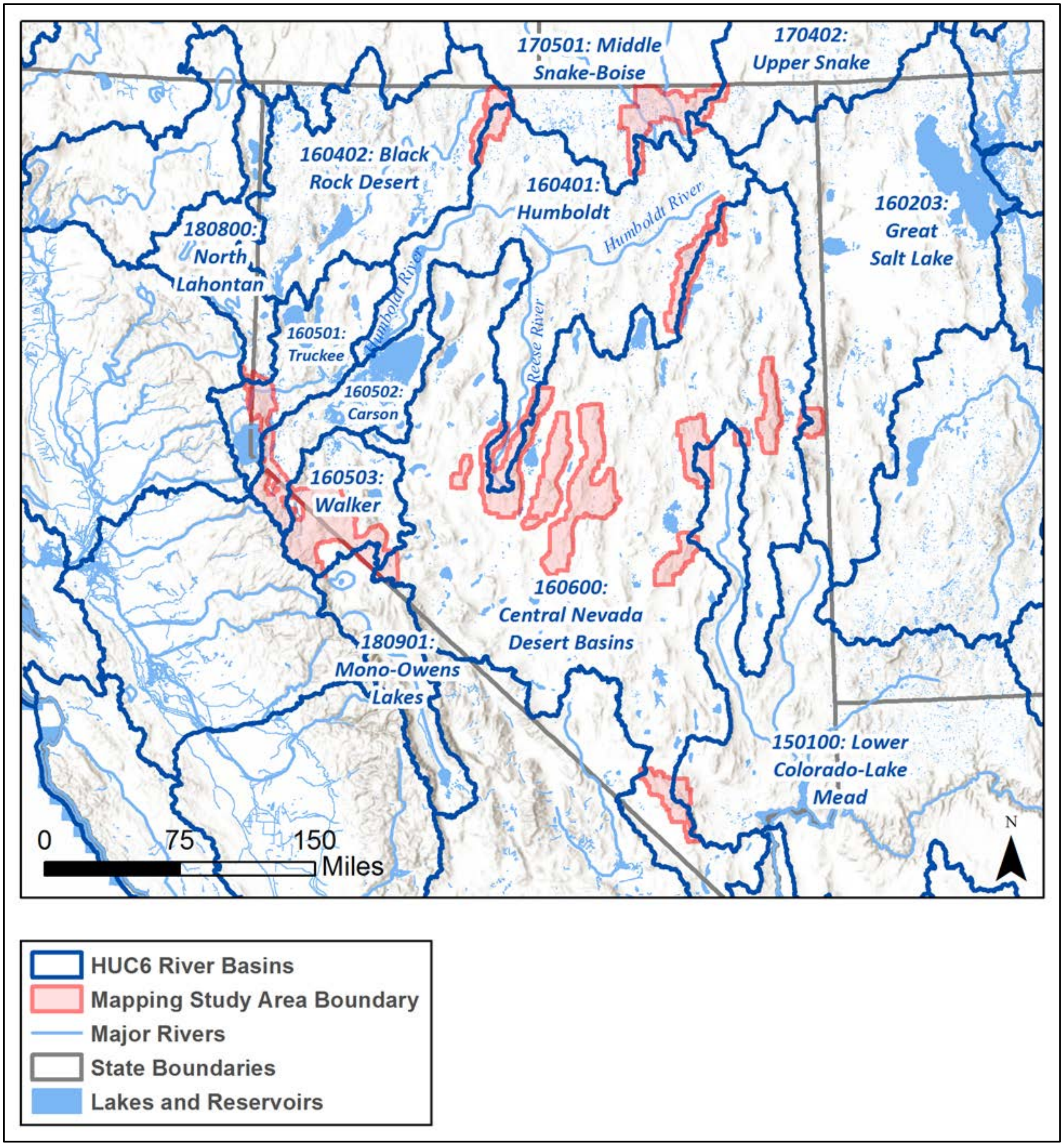

Figure 2. HUC6 river basins and major waterways in the fen mapping study area.

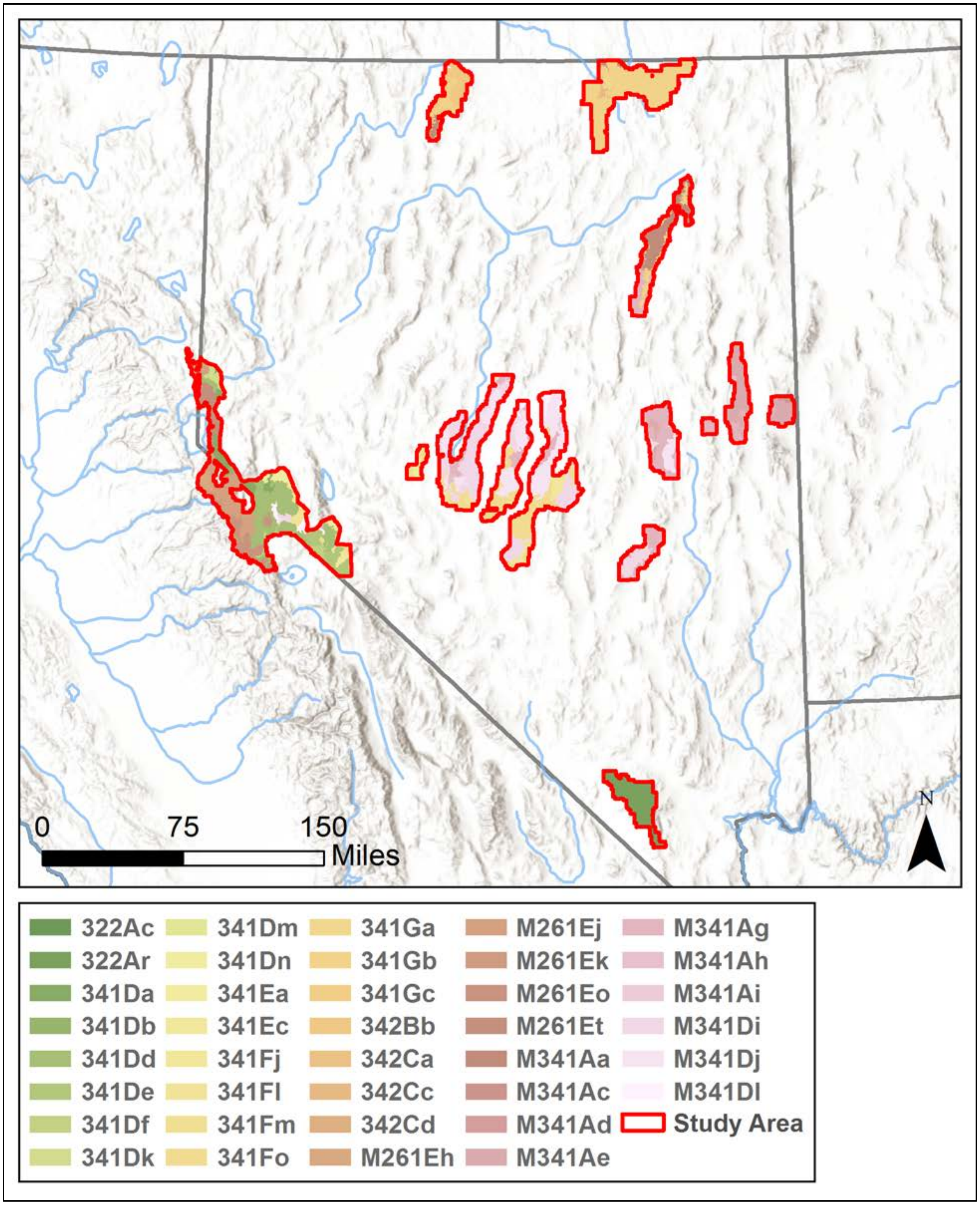

Figure 3. Land Type Association Subsections of the fen mapping study area.

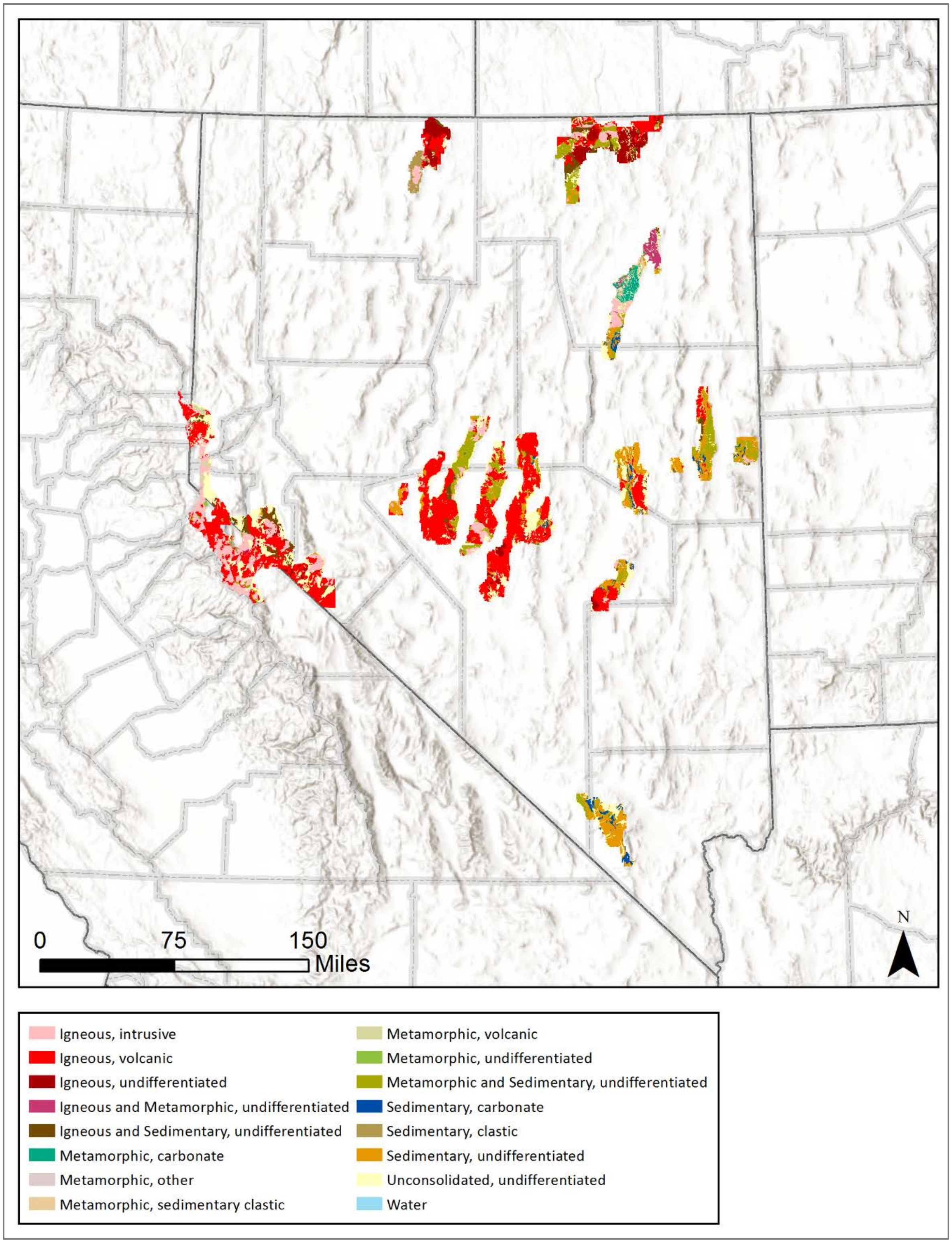

Figure 4. Geology within the fen mapping study area.

3.0 Fen Mapping Methods

Potential fens in the Humboldt-Toiyabe National Forest were identified by analyzing digital aerial photography and topographic maps. True color aerial photography taken by the National Agricultural Imagery Program (NAIP) in 2017 (Nevada) and 2018 (California) were used in conjunction with color-infrared imagery from 2010. High (but variable) resolution World Imagery from Environmental Systems Research Institute (ESRI) was also used. To focus the initial search, all wetland polygons mapped by the U.S. Fish and Wildlife Service's National Wetland Inventory (NWI) program in the 1970s and early 80s with a "B" (seasonally saturated) or "D" (continuously saturated) hydrologic regime were isolated from the full NWI dataset and examined.[2] Wetlands mapped as Palustrine Emergent Saturated (PEMB/D) and Palustrine Scrub-Shrub Saturated (PSSB/D) were specifically targeted, as they can be the best indication of fen formation, and every PEMB/D and PSSB/D polygon in the study area was checked. However, photo-interpreters were not limited to the original NWI polygons and also mapped any fens they observed outside of B/D regimes NWI polygons.

Potential fen polygons were hand-drawn in ArcGIS 10.4 based on the best estimation of fen boundaries. In most cases, this did not match the exact boundaries of the original NWI polygons because the resolution of current imagery is far higher than was available in the 1980s. The fen polygons were often a portion of the NWI polygon or were drawn with different, but overlapping boundaries. This will provide Humboldt-Toiyabe National Forest the most accurate and precise representation of fens in the Forest, as opposed to estimates based on the NWI polygons themselves. Each potential fen polygon was attributed with a confidence value of 1, 3 or 5 (Table 1). In addition to the confidence rating, any justifications of the rating or interesting observations were noted, including impoundments, beaver influence, floating mats and springs.

Table 1. Description of potential fen confidence levels.

Confidence	*Description*
5	***Likely fen.*** Strong photo signature of fen vegetation, fen hydrology, and good landscape position. All likely fens should contain peat of 40cm or more throughout the entire area of the mapped feature.
3	***Possible fen.*** Some fen indicators present (vegetation signature, topographic position, ponding or visibly saturated substrate), but not all indicators present. Some may be weak or missing. Possible fens may or may not have the required peat depth of 40cm, but may have patchy or thin peat throughout.
1	***Low confidence fen.*** At least one fen indicator present, but weak. Low confidence fens are consistently saturated areas that do not show peat signatures in the aerial photography, but may contain fen or peat.

[2] For more information about the National Wetland Inventory and the coding system, please visit: http://www.fws.gov/wetlands/

4.0 Results

4.1 Potential Fen Mapping Acreage

The final map of potential fens contained 2,436 potential fen locations (all confidence levels), covering 5,155 acres or 0.1% of the total land area (Table 2; Figures 5 and 6). This total included 223 likely ***fens*** (confidence level = 5), 661 ***possible fens***, and 1,552 ***low confidence fens.*** On average the likely and possible fens were larger in size than the low confidence fens (2.54 or 2.47 acres vs. 1.90 acres), resulting in 567 acres of likely fens, 1,636 acres of possible fens, and 2,952 acres of low confidence fens. The size of individual potential fens ranged from over 66 acres to 0.05 acres. The two largest mapped likely fens are shown in Figures 7 and 8.

Table 2. Potential fen counts and acreage, by confidence levels.

Confidence	*Count*	*Acres*	*Average size (acres)*
5 – Likely Fen	223	567	2.54
3 – Possible Fen	661	1,636	2.47
1 – Low Confidence Fen	1,552	2,952	1.90
TOTAL	**2,436**	**5,155**	2.11

Original NWI mapping for the Humboldt-Toiyabe National Forest contained 13,958 acres with a "B" (seasonally saturated) or a "D" (continuously saturated) hydrologic regime, including 5,380 acres of herbaceous wetlands (PEMB and PEMD) and 8,338 acres of shrub wetlands (PSSB and PSSD) (Table 3). These polygons were the starting point for potential fen mapping. NWI features mapped as saturated forest (PFOB) and beaver-influenced herbaceous semi permanently flooded (PEM1Fb) were also considered saturated and reviewed.

After examining each polygon with a saturated hydrologic regime and the landscape surrounding them, fen polygons were drawn covering 11% of those acres (1,495 acres), while the remaining 89% were determined to not be potential fens. Polygons mapped as saturated herbaceous in NWI made up a greater share of the potential fens (71% of the fen/NWI overlap) than polygons mapped as saturated shrubs (28%). Finally, 1,086 acres not mapped as saturated by NWI were mapped as potential fens.

The sections that follow (4.2 through 4.5) break down the fen mapping by elevation range, bedrock geology, Land Type Association, and HUC12 watershed. The last section summarizes observations made by the fen mappers during the mapping process, including potential floating mat fens.

Table 3. Acres mapped by NWI as saturated and the overlap with mapped potential fens.

NWI Code	Not Mapped as Fen	Mapped as Fen, by Confidence			Total Mapped as Fen	Grand Total by NWI Code
		1	3	5		
PEMB	4,243	703	261	56	1,020	5,263
PEMD	81	3	30	2	35	117
PEMFb	9	3	9	--	12	21
PSSB	5,841	296	108	14	415	6,259
PSSD	2,070	9	0	--	9	2,079
PFOB	218	1	1	--	2	220
Total Saturated NWI Acres	**12,463**	**1,014**	**409**	**72**	**1,495**	**13,958**
Other NWI Code	127,437	1,323	879	372	2,574	130,011
Total NWI Acres	**139,899**	**2,336**	**1,288**	**444**	**4,069**	**143,968**
Not Mapped by NWI	n/a	615	347	123	1,086	n/a
Grand Total	**139,899**	**2,952**	**1,635**	**567**	**5,155**	**145,054**

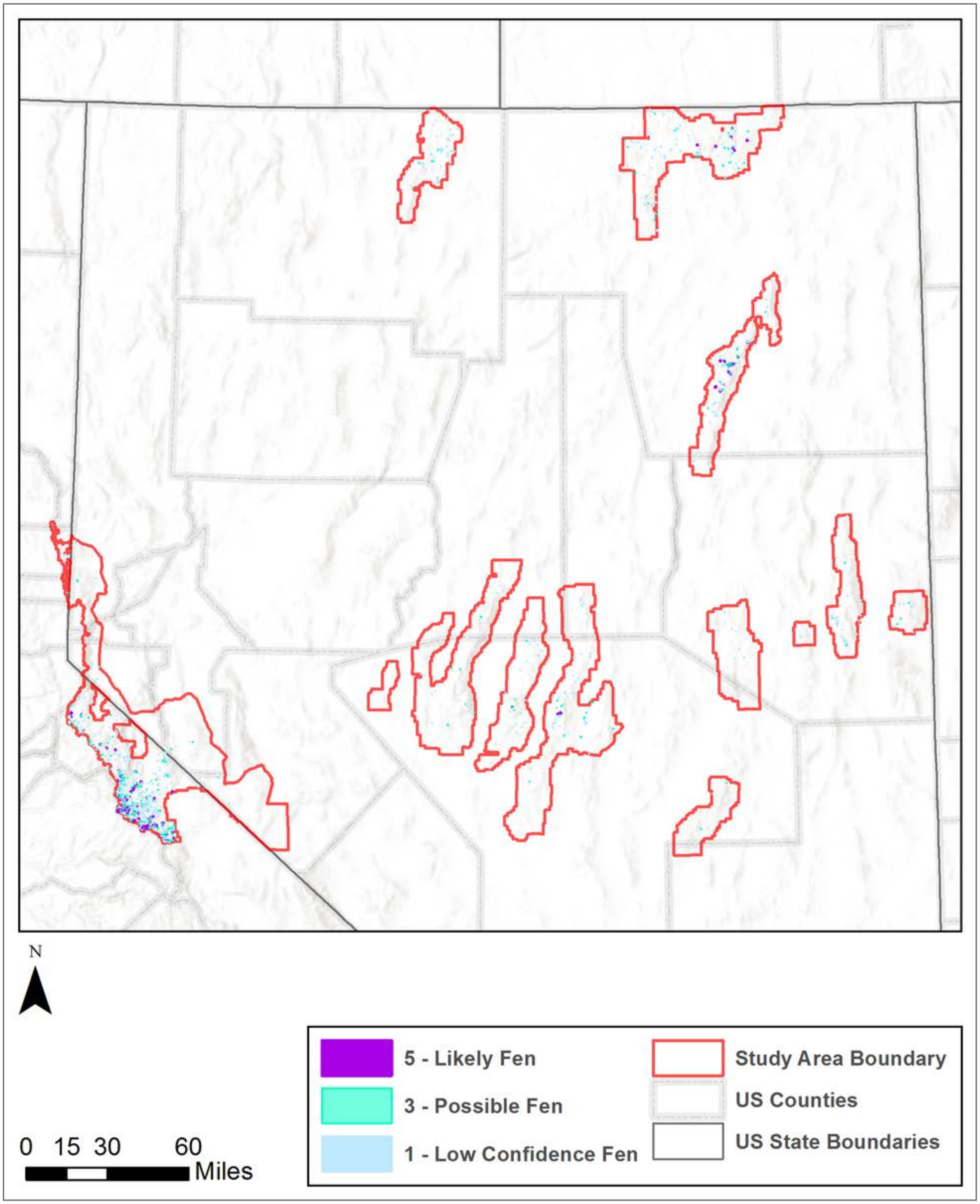

Figure 5. All potential fens within the fen mapping study area.

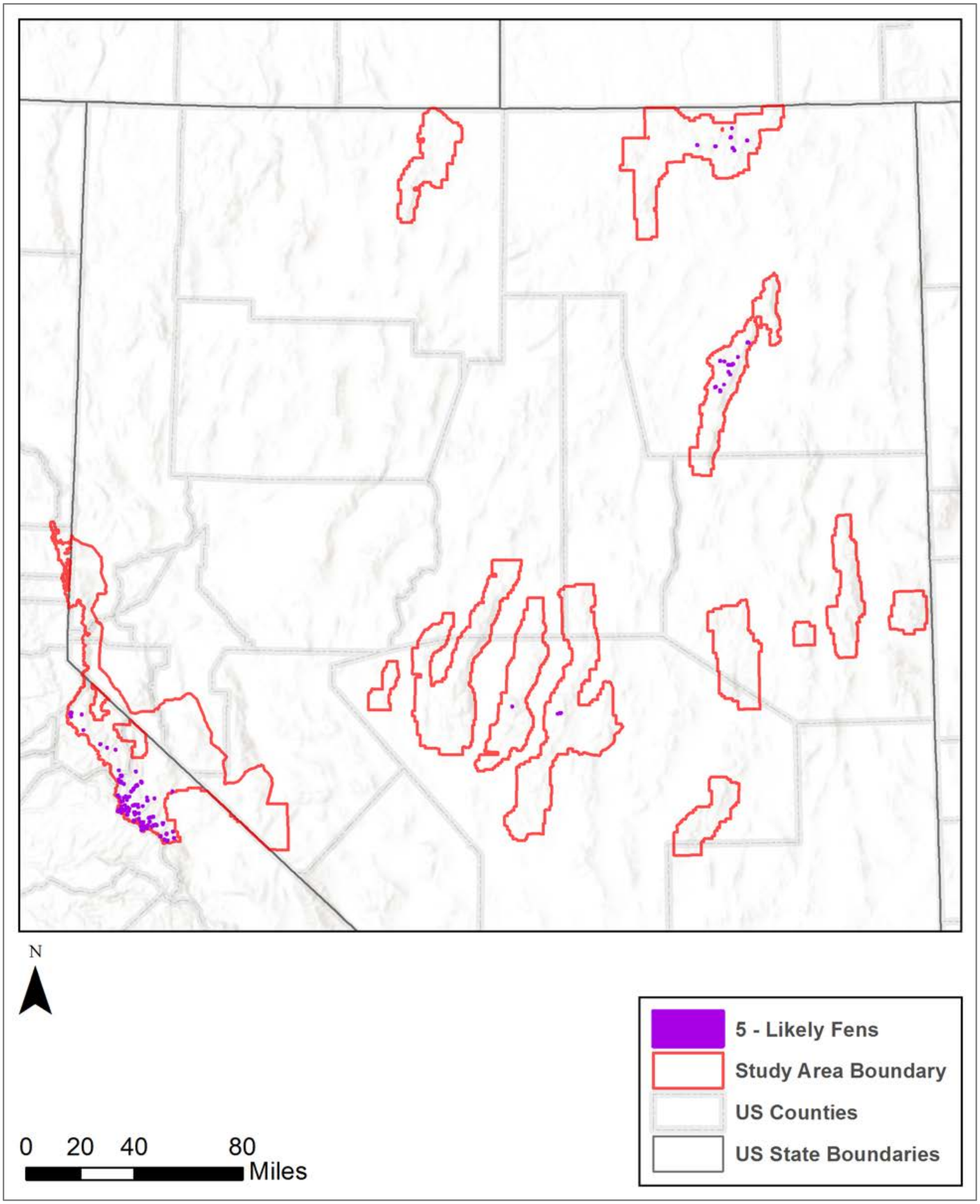

Figure 6. Likely fens (confidence rating = 5) within the fen mapping study area.

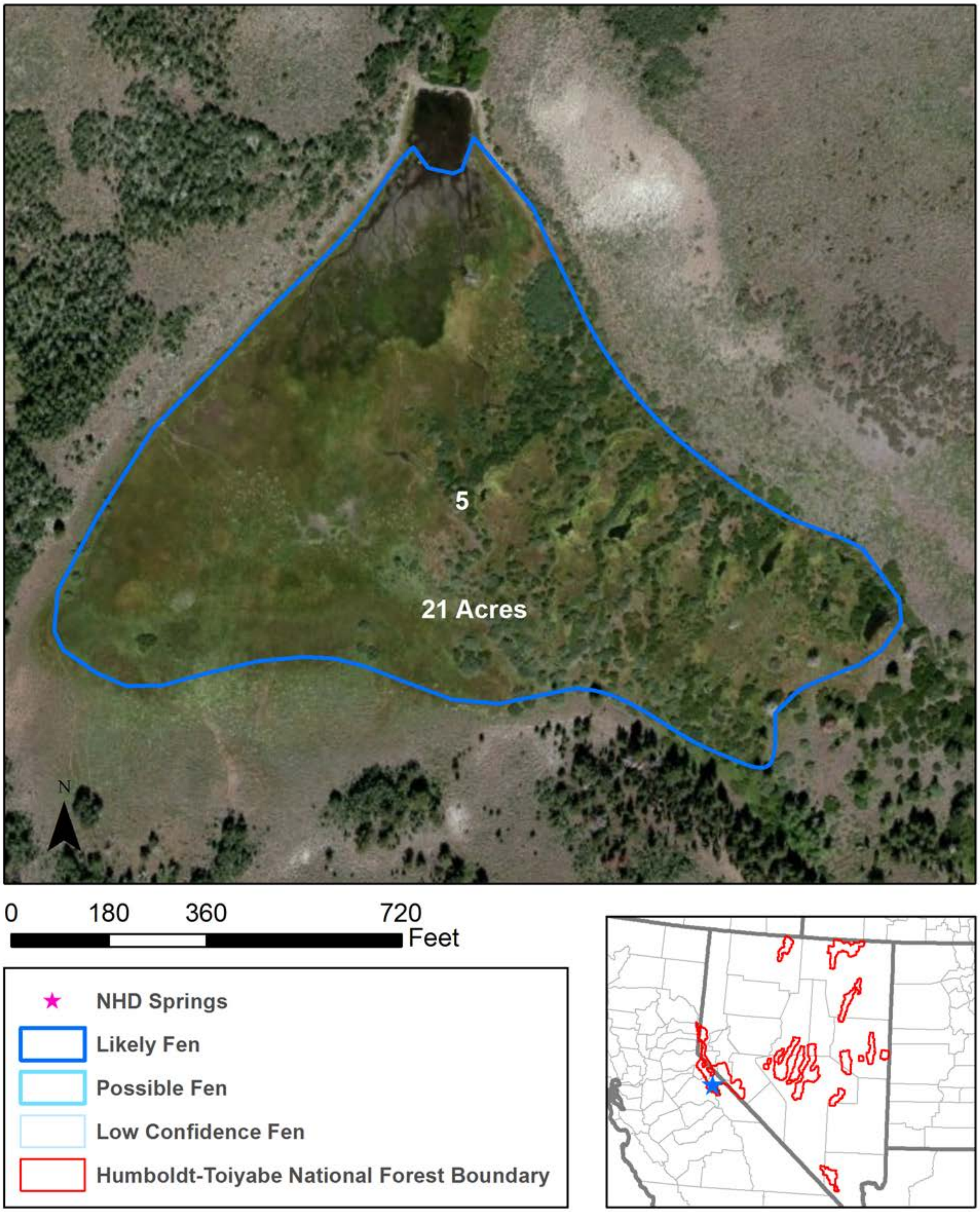

Figure 7. Largest mapped likely fen, 21 acres within one polygon. This fen is located in the Mud Springs Canyon, in Mono County, California.

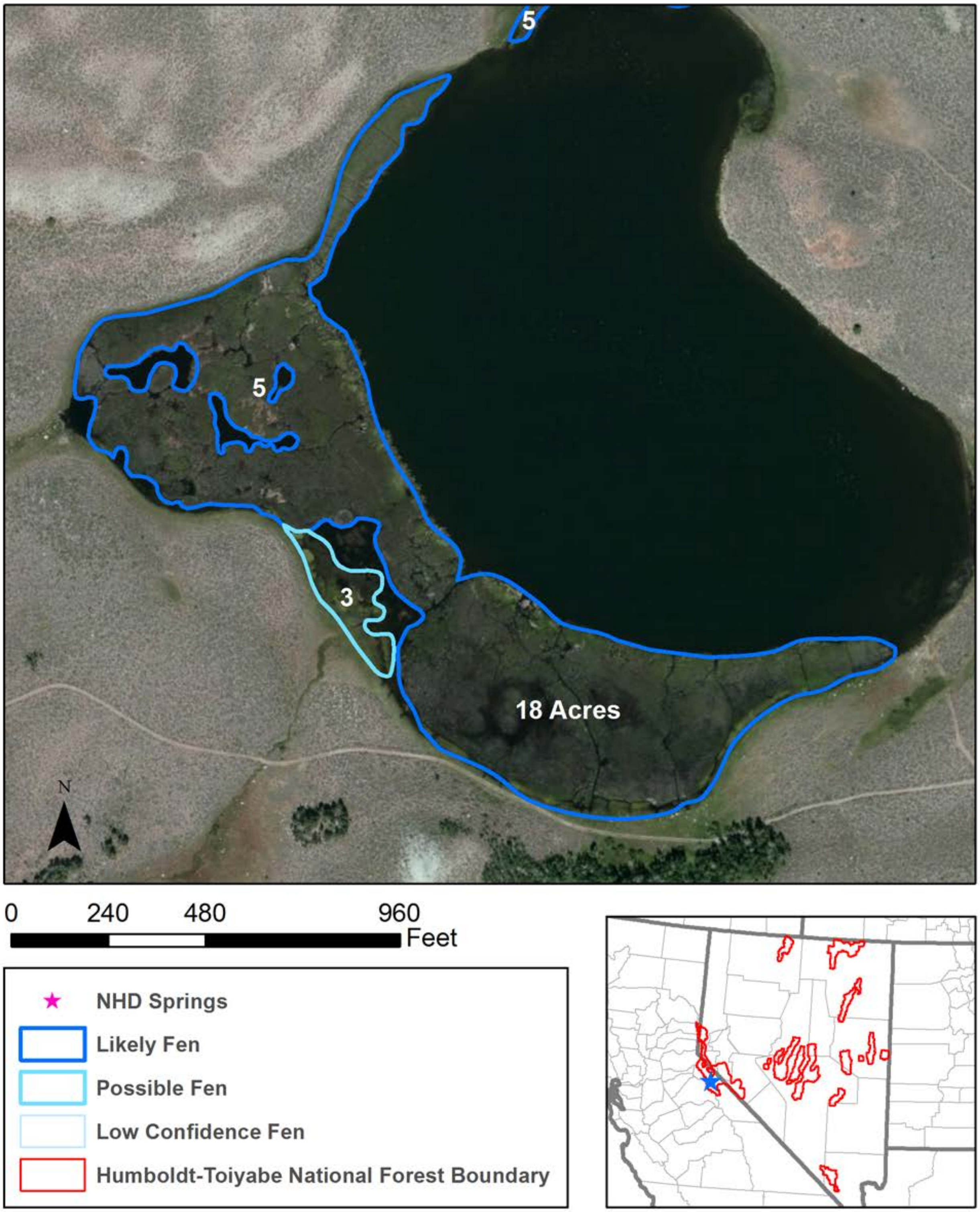

Figure 8. Second largest mapped likely fen, 18 acres within one polygon. This fen is located along the southwest bank of Kirman Lake, in Mono County, California.

4.2 Mapped Potential Fens by Elevation

Elevation is an important factor in the location of fens. Fen formation occurs where there is sufficient groundwater discharge to maintain permanent saturations. This is most often at higher elevations, closer to the zone of where slow melting snowpack can percolate into subsurface groundwater. Springs are also an important water source for fens in more arid regions and can occur across a wider elevation range.

Of all potential fens, 760 polygons (1,366 acres) were mapped between 9,000 and 10,000 feet, which represents 31% of potential fen locations and 26% of potential fen acres (Table 4; Figure 9). Of the 223 total likely fens mapped, 121 polygons (54%) and 266 acres (47%) were located between 9,000 and 10,000 feet (Table 5; Figures 10 and 11). This is the zone of maximum fen formation for the Humboldt-Toiyabe National Forest.

The elevation bands of 8,000 to 9,000 feet and 10,000 to 11,000 feet also contain many potential and likely fens. Between 8,000 to 9,000 feet, there were 579 mapped potential fens (1,191 acres), which represent 24% of potential fen locations and 23% of potential fen acres. In addition, there were 33 likely fens (99 acres), which represent 15% of likely fen locations and 17% of likely fen acres. Between 10,000 to 11,000 feet, there were 237 mapped potential fens (359 acres), which represent 10% of potential fen locations and 7% of potential fen acres, and 32 likely fens (94 acres), which represent 14% of likely fen locations and 17% of likely fen acres.

These three elevation bands combined (8,000 to 11,000 feet) contain 65% of potential fen locations (57% of acres) and 83% of likely fen locations (81% of acres).

Table 4. Potential and likely fens by elevation within the fen mapping study area.

Elevation Range (ft)	*# of All Potential Fens*	*All Potential Fen Acres*	*# of Likely Fens*	*Likely Fen Acres*
< 7,000	411	1,235	6	19
> 7,000 – 8,000	436	994	30	87
> 8,000 – 9,000	579	1,191	33	99
> 9,000 – 10,000	760	1,366	121	266
> 10,000 – 11,000	237	359	32	94
> 11,000	13	10	1	3
Total	**2,436**	**5,155**	**223**	**567**

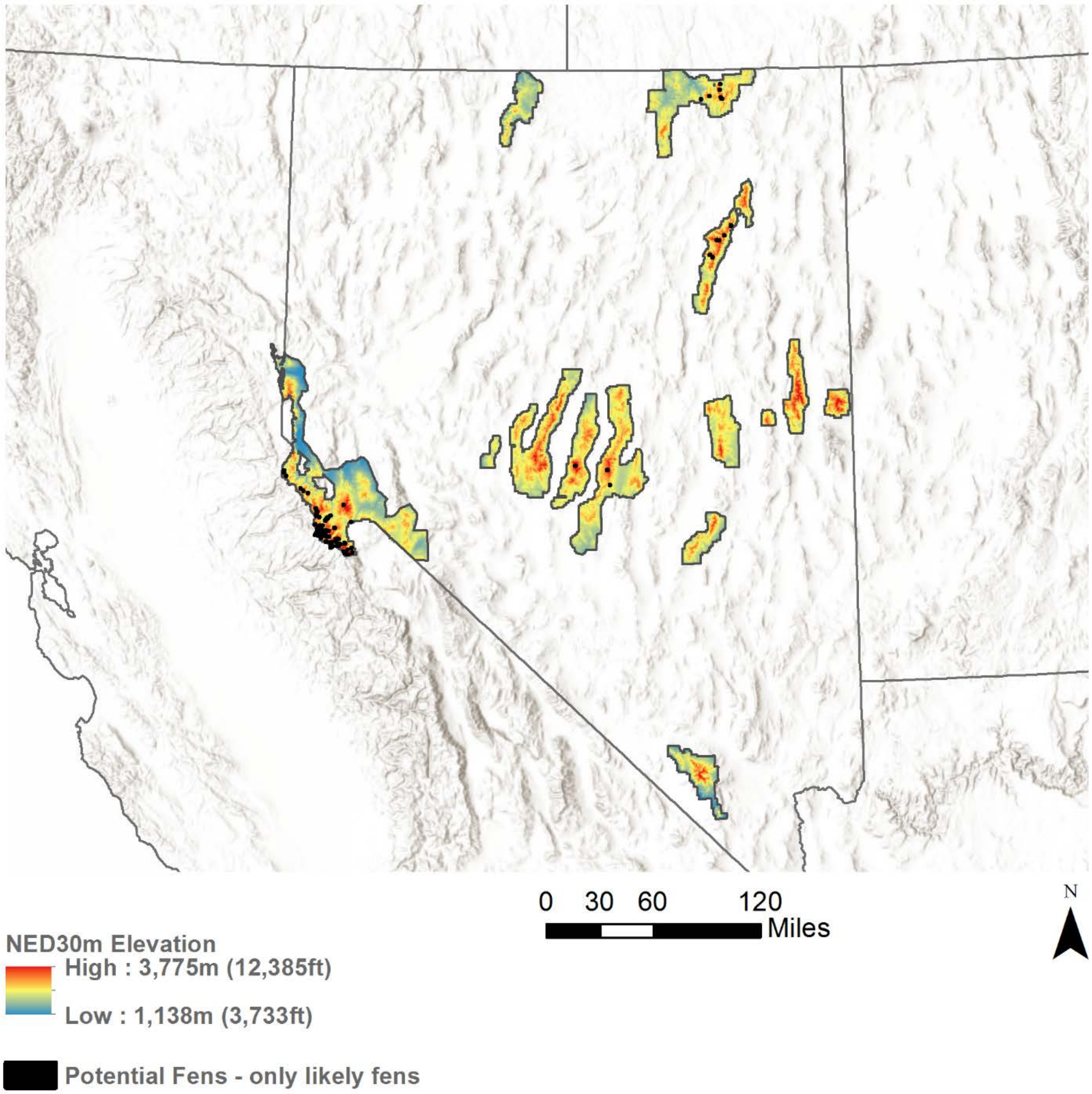

Figure 9. Likely fens (confidence rating = 5) and elevation within the fen mapping study area.

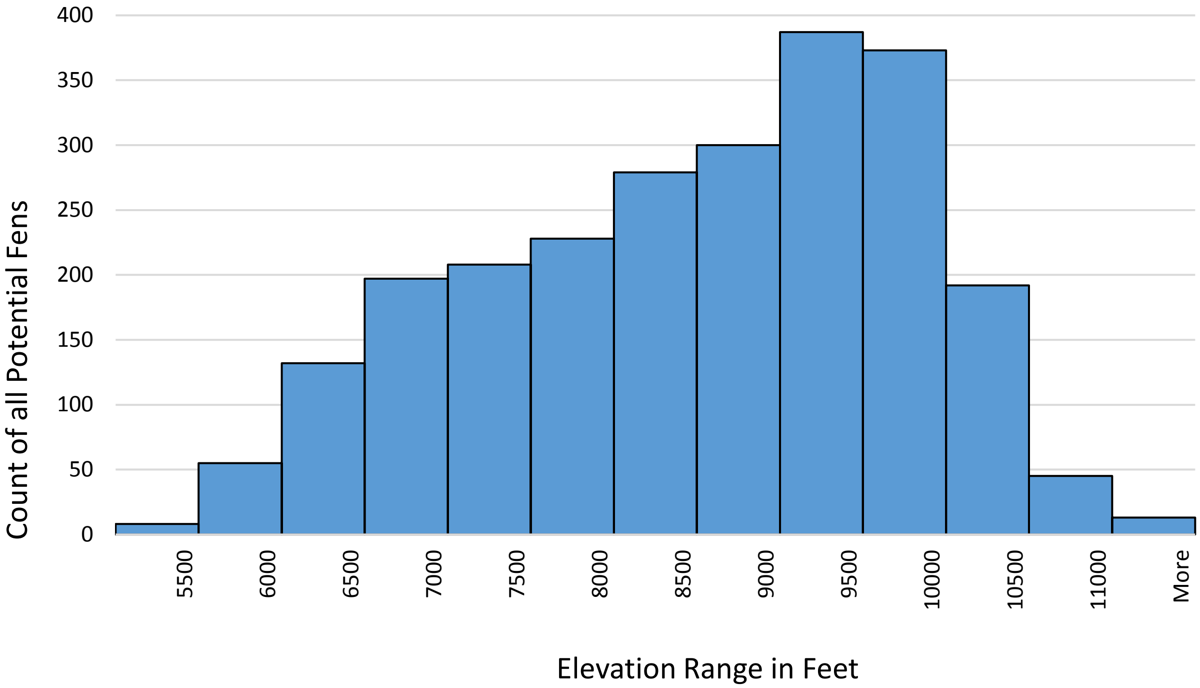

Figure 10. Histogram of all potential fens by elevation within the fen mapping study area.

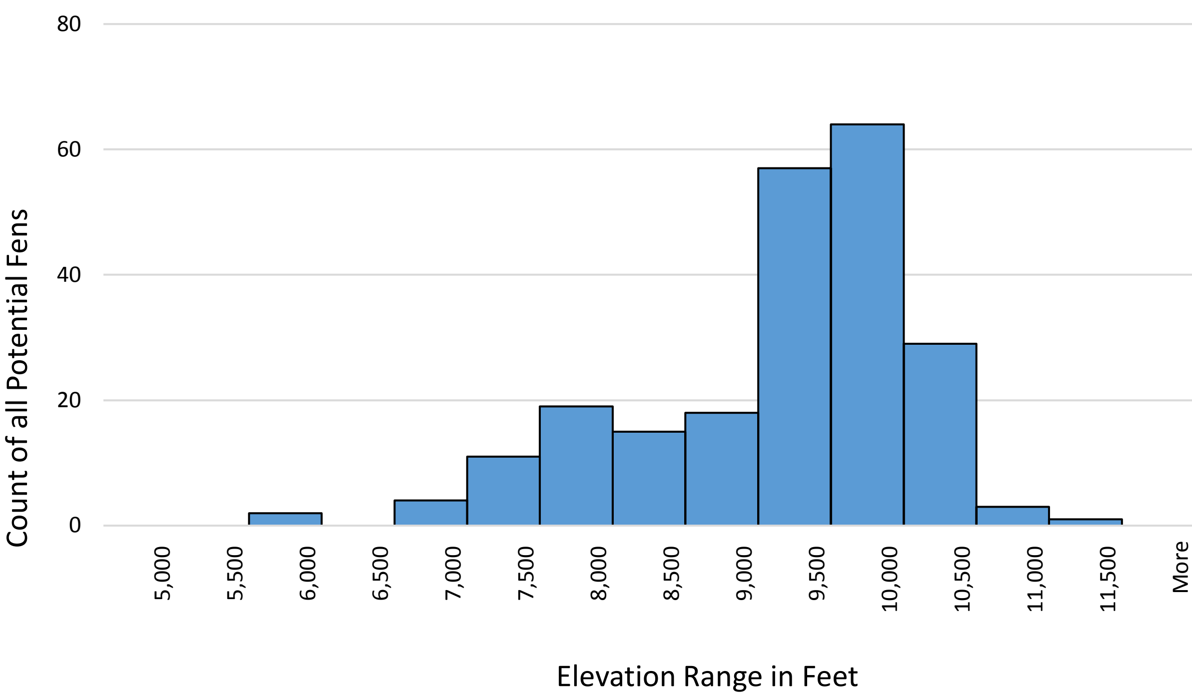

Figure 11. Histogram of the most likely fens by elevation within the fen mapping study area.

4.3 Mapped Potential Fens by Geology

The most common geologic substrate under potential fens in Humboldt-Toiyabe National Forest was igneous, volcanic, which underlies 840 mapped potential fens (1,490 acres). The most common geologic substrate under likely fens was igneous, intrusive, which underlies 107 mapped likely fens (271 acres) (Table 5). While igneous, intrusive is the bedrock geology underlying only 11% of the Forest, 31% of all potential fens and 48% of likely fens occurred in these areas. The next most common substrate containing potential or likely fens was unconsolidated, undifferentiated, which underlies 18% of the Humboldt-Toiyabe National Forest , 17% of all potential fens (407 locations), and 12% of likely fens (27 locations).

Table 5. Potential and likely fens by geologic substrate within the fen mapping study area

Geology	*Acres of Geologic Substrate Within HTNF*[1]	*# of All Potential Fens*	*All Potential Fen Acres*	*# of Likely Fens*	*Likely Fen Acres*
Unconsolidated, undifferentiated	1,179,221	407	1544	27	92
Igneous, intrusive	721,005	752	1535	107	271
Igneous, volcanic	2,325,829	840	1490	58	153
Metamorphic and Sedimentary, undifferentiated	639,098	113	145	5	13
Igneous, undifferentiated	390,625	99	133	5	3
Metamorphic, carbonate	75,962	59	87	17	29
Sedimentary, undifferentiated	714,197	77	84	1	0
Igneous and Sedimentary, undifferentiated	256,371	39	48		
Metamorphic, sedimentary clastic	59,185	10	28	1	0
Metamorphic, other	2,198	7	16		
Igneous and Metamorphic, undifferentiated	79,159	3	15		
Sedimentary, clastic	108,573	18	14		
Metamorphic, undifferentiated	9,153	3	7	1	5
Sedimentary, carbonate	111,875	7	6		
Metamorphic, volcanic	28,168	1	3		
Water	2,505	1	1	1	1
		2,436	**5,155**	**223**	**567**

[1] Acres of geologic substrate shown are only for those substrates where fens were mapped. The total acreage is not shown because it does not equal the total acreage of the Humboldt-Toiyabe National Forest.

4.4 Mapped Potential Fens by Land Type Association

Land Type Associations (LTA) combine location, geology, and dominant vegetation and are defined by each Forest. The LTA subsection M261Eo only covers 2% of the Humboldt-Toiyabe National Forest but this LTA contains 30% of potential fens (733) and 47% likely fen locations (105) in Humboldt-Toiyabe National Forest. LTA subsection M261Eo contains LTA numbers 45, 47, and 56 which have annual precipitation values of 14, 32 and 37 inches respectively. These LTAs get more precipitation than the Forest does on average, which may be a factor that causes this subsection to contain many potential fens. The M341Aa subsection covers only 4% of the Forest yet it contains 128 mapped potential fens (274 acres) and 29 likely fens (68 acres) (Table 6).

Table 6. Potential and likely fens by Land Type Association within the fen mapping study area.

Land Type Association Subsection Name	*Acres within Humboldt-Toiyabe National Forest[1]*	*# of All Potential Fens*	*All Potential Fen Acres*	*# of Likely Fens*	*Likely Fen Acres*
M261Eo	150,691	733	1,393	105	264
341Gb	873,383	281	309	17	16
341Dd	459,436	261	752	22	104
M261Ej	290,423	190	576	19	58
M341Dj	570,168	180	184	6	14
M261Ek	43,277	159	272	19	23
M341Aa	268,285	128	274	29	68
M341Ag	664,423	100	143	0	0
342Bb	178,612	82	89	0	0
M341Ae	347,327	79	69	0	0
M341Di	716,169	47	41	0	0
M261Eh	47,172	46	247	6	20
341Fo	509,966	28	91	0	0
341Fj	126,534	16	118	0	0
341Da	125,491	16	174	0	0
342Ca	13,501	15	70	0	0
M341Dl	216,930	12	106	0	0
342Cc	24,088	12	15	0	0
341Df	37,082	11	11	0	0
341Ga	25,245	9	25	0	0
M261Et	120,578	7	107	0	0
341Gc	12,221	6	4	0	0
M341Ah	47,900	3	1	0	0
341Ea	54,902	3	0	0	0
341Fl	115,851	3	2	0	0

341Dk	40,971	3	72	0	0
341Db	24,866	3	1	0	0
341De	149,671	2	6	0	0
M341Ad	10,591	1	1	0	0
322Ar	311,867	0	0	0	0
M341Ai	18,837	0	0	0	0
322Ac	10,184	0	0	0	0
341Dm	514	0	0	0	0
341Dn	50,919	0	0	0	0
341Ec	28,499	0	0	0	0
341Fm	1,924	0	0	0	0
342Cd	63	0	0	0	0
M341Ac	16,070	0	0	0	0
		884	**2,281**	**62**	**193**

[1] Acres of Land Type Associations shown are only for those ecoregions where fens were mapped. The total acreage is not shown because it does not equal the total acreage of the Humboldt-Toiyabe National Forest.

4.5 Mapped Potential Fens by Watershed

An analysis of likely fens in HUC12 watersheds revealed interesting patterns. Four watersheds in particular had significant numbers of likely fens (Figure 12). Robinson Creek (HUC12: 160503010108) had 37 likely fens, which covered 0.34% of the landscape in this watershed. Cascade Creek-West Walker River (HUC12: 160503020102) had 28 likely fens, covering 0.26% of the landscape. West Fork Walker River (HUC12: 160503020101) had 24 likely fens, representing 0.49% of the landscape. Wolf Creek-West Walker River (HUC12: 160503020105) had 15 likely fens representing 0.48% of the basin. Of the top ten watersheds ranked by fen density, nine are within the California section of the Walker Basin and the tenth is in the neighboring Carson Basin. This area south of Lake Tahoe on the edge of the Sierra Nevada contains by far the highest concentration of fens in the Forest.

See Appendix A for the full HUC12 watershed and likely fens table.

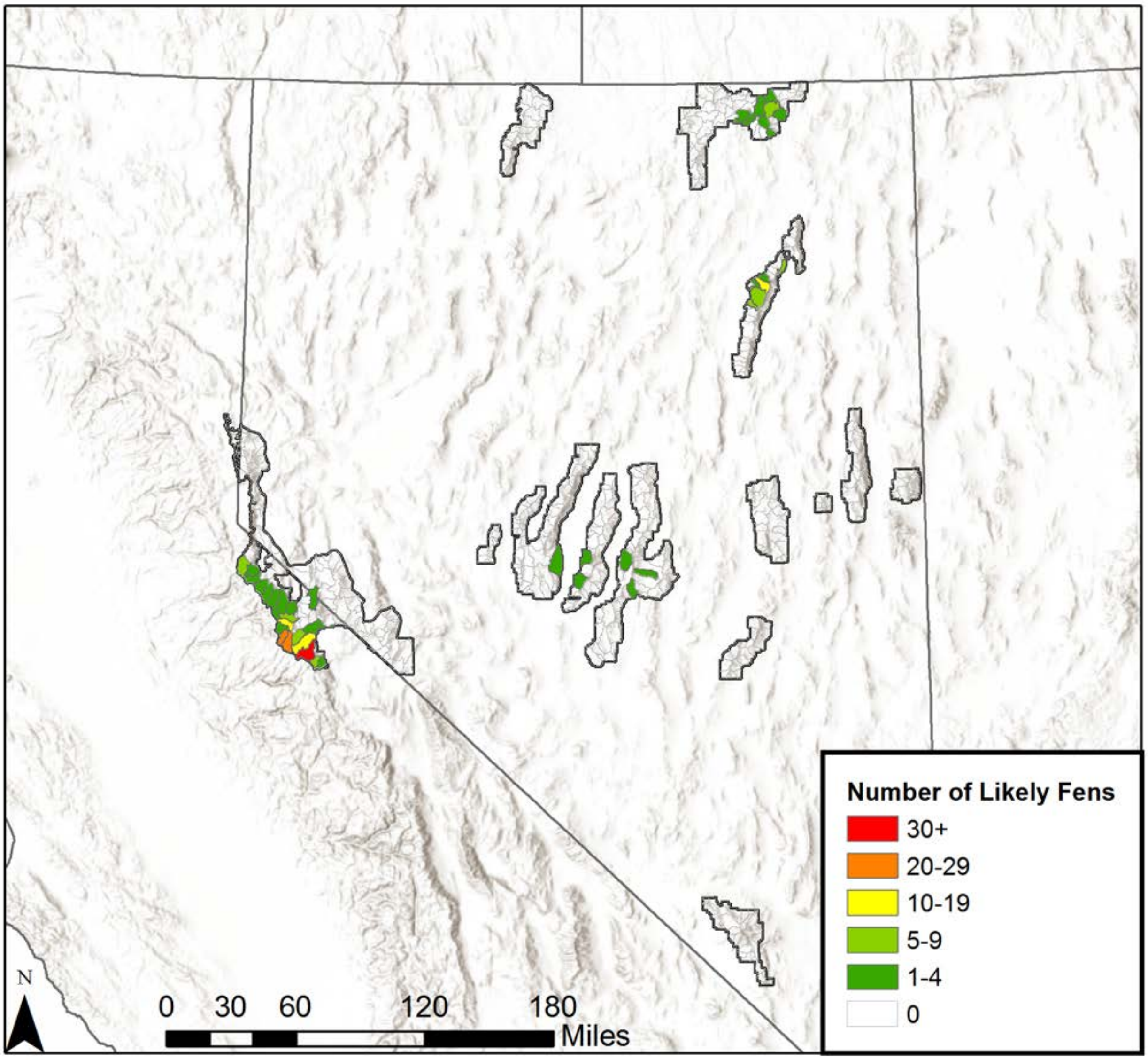

Figure 12. Likely fens by HUC12 watershed within the fen mapping study area.

4.6 Mapped Potential Fens with Distinctive Characteristics

Several characteristics related to fens were noted by photo-interpreters when observed throughout the fen mapping process (Table 7), though this was not an original objective of the project and was not consistently applied.

Of particular interest was identifying markers for potential floating mat fens, a rare type of fen that may occur in Humboldt-Toiyabe National Forest (Kate Dwire, *personal communications*). Twenty-one potential fens (31 acres) and ten likely fens (25 acres) were identified as potential floating mat fens. See Figure 13 for a large possible fen that shows floating mat characteristics in Deep Canyon, NV and Figure 14 for a likely fen with floating mat potential located in Copper Basin, NV.

Springs and fens are both important components of groundwater-dependent ecosystems (GDEs) and are of particular interest to the U.S. Forest Service (USDA 2012). Springs were noted when observed on either the topographic map or aerial imagery. However, this was not a comprehensive investigation of springs or even springs within fens. Five hundred and twenty-four potential fens and twelve likely fens were observed in proximity to springs. The largest spring influenced likely fen (7 acres) is shown in Figure 15.

Beaver influence is a potentially confounding variable in fen mapping because longstanding beaver complexes can cause persistent saturation that looks very similar to fen vegetation signatures. Beavers also build dams in fens, so areas influenced by beavers cannot be excluded from the mapping. Forty-one potential fens (200 acres) and one likely fen (<1 acre) showed some evidence of beaver influence.

Table 7. Potential and likely fens with distinctive characteristics within the fen mapping study area.

Observation	*# of Potential Fens*	*Potential Fen Acres*	*# of Likely Fens*	*Likely Fen Acres*
Spring	524	772	12	34
Possible Floating Mat	21	31	10	25
Beaver Influence	41	200	1	<1
Total	**586**	**1,003**	**23**	**59**

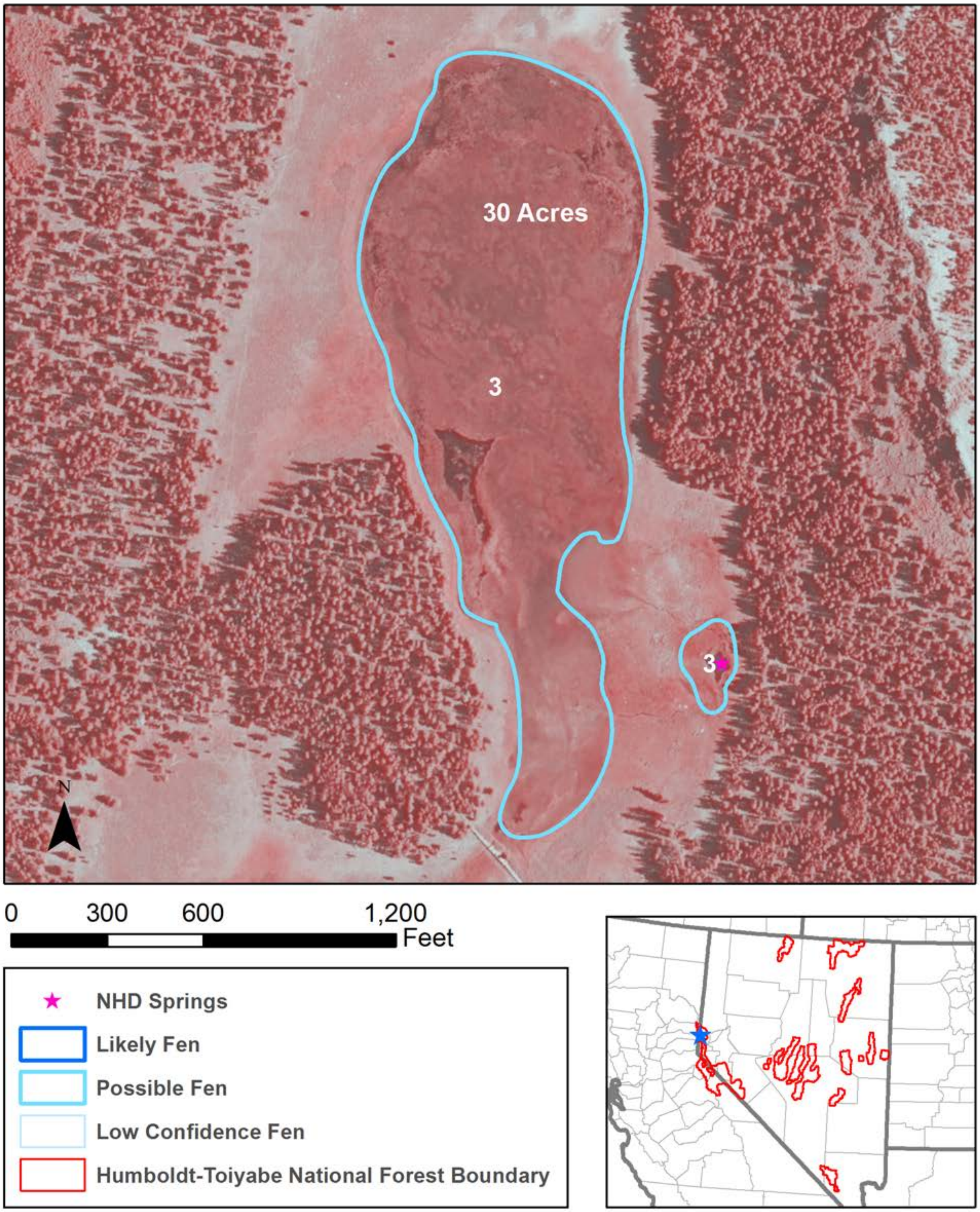

Figure 13. Possible floating mat fen located in the Big Meadows area of Deep Canyon, in Washoe County, Nevada.

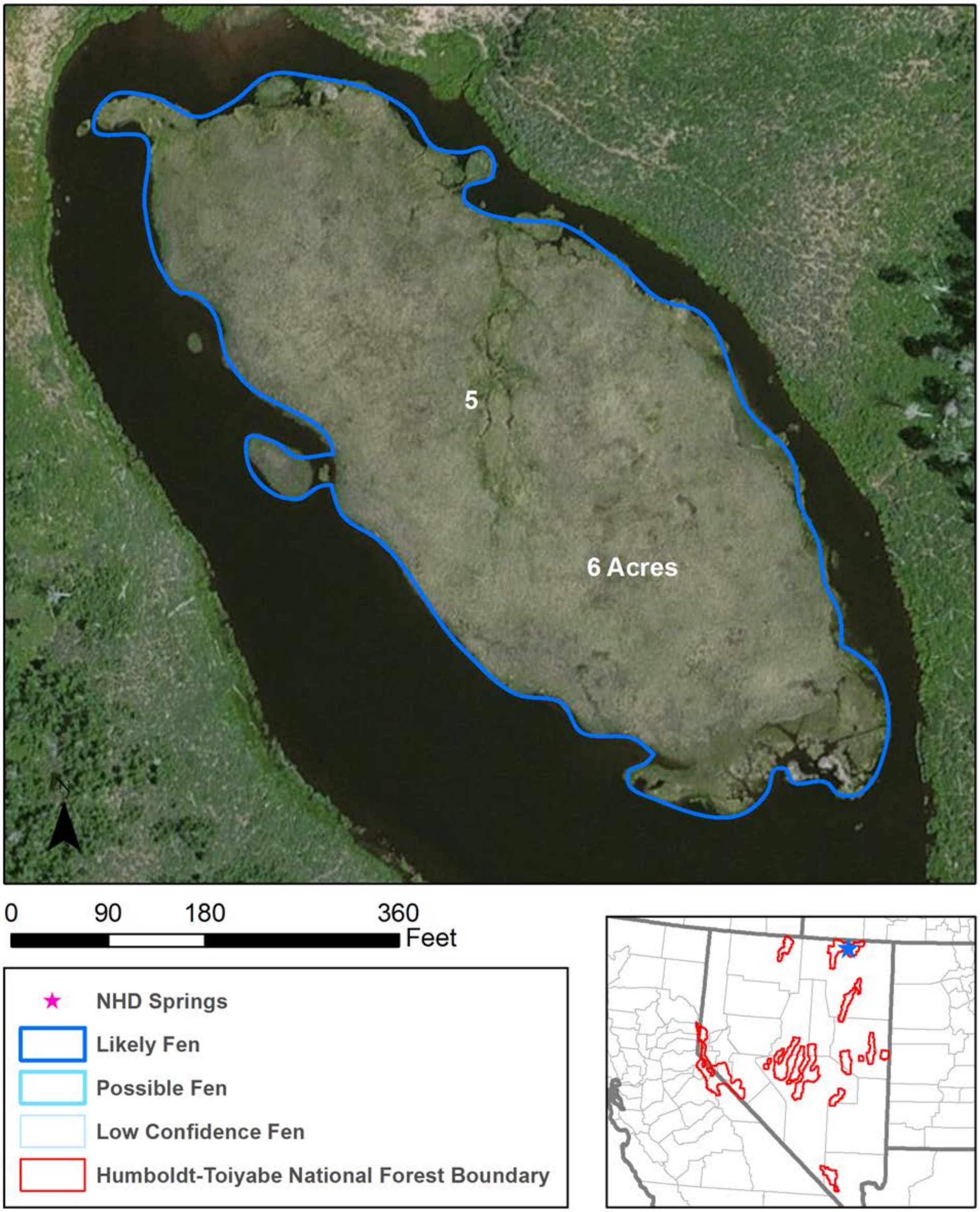

Figure 14: Likely floating mat fen located in the Copper Basin, in Elko County, Nevada. This site is also pictured on the front cover of this report.

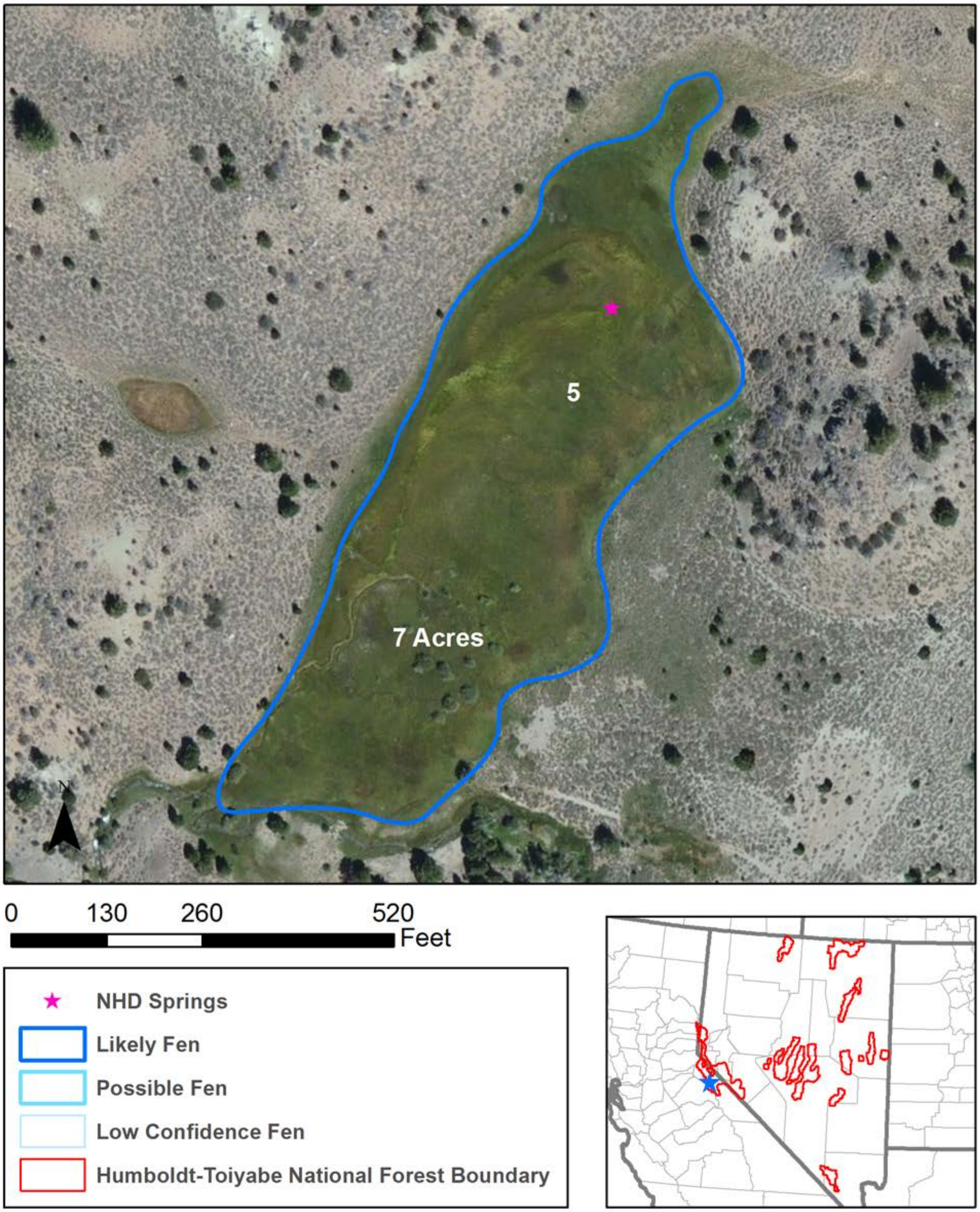

Figure 15: Largest spring influenced likely fen located north of Poore Lake in the Wolf Creek – West Walker River basin.

5.0 Discussion

The Humboldt-Toiyabe National Forest contains a relatively small number of potential fen wetlands, covering up to 5,155 acres across its jurisdiction. Some of the landforms in Humboldt-Toiyabe National Forest are not conducive to fen formation, particularly the hot dry canyons of the Spring Mountain National Recreation Area and other lower elevation regions of the Forest. However, some areas of Humboldt-Toiyabe National Forest do have a lot of fens, particularly the Robinson Creek and Cascade Creek-West Walker River watersheds in California.

These fen wetlands are an irreplaceable resource for the Forest and the citizens of Nevada and California. Fens throughout the West support numerous rare plant species that are often disjunct from their main populations (Cooper 1996; Cooper et al. 2002; Johnson & Stiengraeber 2003; Lemly et al. 2007). Along with habitat for rare plant species, fens also play a pivotal role in regional hydrologic processes. By slowly releasing groundwater, they help maintain stream flows throughout the growing season. With a predicted warmer future climate, in which snow pack may be less and spring melt may occur sooner, maintaining groundwater storage high in the mountains is imperative. Intact fens also sequester carbon in their deep organic soils, however, disturbing fen hydrology can lead to rapid decomposition of peat and associated carbon emissions (Chimner 2000).

In total, 2,437 potential fens were mapped throughout the Humboldt-Toiyabe National Forest, of which 223 were most likely to be fens. The number and acreage of mapped potential fens is less than for saturated polygons mapped by the National Wetland Inventory. While NWI polygons were an excellent starting point for identifying fens, this project showed that delineating new polygons specifically for fens produced a more accurate and precise accounting of fen number and acreage. Analysis of the potential fen data showed clear patterns in fen distribution within the Humboldt-Toiyabe National Forest. There was a strong elevation gradient with 83% of likely fen locations falling between 8,000 and 11,000 feet. High snowfall and slow snowmelt at these elevations allows for ample groundwater discharge for fen wetlands. There were also clear hotspots for fens in the Humboldt-Toiyabe National Forest, particularly the LTA subsection M261Eo which contains 47% of likely fen locations. These areas should be actively conserved.

To date, there have been no significant studies of fens in Nevada or in the Humboldt-Toiyabe National Forest. However, fens have been studied in the Sierra Nevada of California (Weixelman & Cooper 2009; Wolf & Cooper 2014). Similar to other research on mountain fens, these studies have found that fens of the Sierra Nevada are critically important to regional biodiversity. Patterns in species distribution are related to altitude, latitude, water chemistry, bedrock geology, and landform. Of particular note, several fens were identified on the neighboring Inyo National Forest in watersheds dominated by carbonate bedrock, particularly marble. These sites contained many rare calcium-loving plant species such as *Kobresia myosuroides, Trichophorum pumilum,* and *Carex scirpoidea*. Fens of this type may also exist in the Humboldt-Toiyabe National Forest in local geology contains high carbonate bedrock. In addition, floating mats formed in basin fens also contain rare plant species such as *Carex limosa, Carex lasiocarpa, Menyanthes trifoliata, and Dulichium arundinacea*. The floating mats of Humboldt-Toiyabe should be inventoried for these species.

Previous studies of wetland condition in other high elevation forests have found that high elevation wetlands were generally in excellent to good condition (Lemly 2012), however past and present grazing is a known source of stress on Sierra Nevada fens (Wolf & Cooper 2014). Human stressors were observed in some fen wetlands while mapping fens on the Humboldt-Toiyabe National Forest, such as impoundments, and those observations were captured in the "Notes" field of the GIS dataset accompanying this report. However most potential fens in Humboldt-Toiyabe National Forest showed little sign of human disturbance, particularly at higher elevations.

This report and associated dataset provide the Humboldt-Toiyabe National Forest with a critical tool for conservation planning at both a local and Forest-wide scale. These data will be useful for the ongoing Humboldt-Toiyabe National Forest biological assessment required by the 2012 Forest Planning Rule, but can also be used to establish buffers around fens for individual management actions, such as timber sales, grazing allotments, and trail maintenance. Wherever possible, the Forest should avoid direct disturbance to the fens mapped through this project, and should also strive to protect the watersheds surrounding high concentrations of fens, thereby protecting their water sources.

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APPENDIX A: LIKELY FENS BY HUC12 WATERSHED, SORTED BY FEN DENSITY

HUC 12 Code	HUC 12 Name	Watershed Acres	Likely Fen Count	Likely Fen Acres	Fen Density (Fen Acres/ Watershed Acres)
160503020101	West Fork Walker River	12,785	24	63	0.49%
160503020105	Wolf Creek-West Walker River	13,615	15	65	0.48%
160503010108	Robinson Creek	30,880	37	106	0.34%
160503020102	Cascade Creek-West Walker River	20,669	28	54	0.26%
160503020108	Silver Creek-West Walker River	14,198	9	32	0.22%
160503020103	Upper Little Walker River	19,116	5	30	0.15%
160503010101	Green Creek	13,021	8	20	0.15%
160503010109	Buckeye Creek	35,718	13	35	0.10%
160503010103	Virginia Creek	23,008	4	16	0.07%
160502010301	Upper West Fork Carson River	24,186	5	16	0.07%
160401010607	Thomas Creek-Lamoille Creek	32,421	10	19	0.06%
160600071102	Robinson Creek-Franklin River	36,964	5	20	0.06%
160401030902	Rattlesnake Creek-South Fork Humboldt River	30,735	5	15	0.05%
170501020201	Copper Creek-Bruneau River	22,792	2	6	0.03%
160503020104	Leavitt Creek-West Walker River	13,037	4	3	0.02%
160600050204	Mosquito Creek	32,510	3	8	0.02%
160502010103	Wolf Creek	19,033	2	4	0.02%
160502010102	Bryant Creek-East Fork Carson River	31,615	3	7	0.02%
160401030901	Stoddard Creek-South Fork Humboldt River	35,009	7	8	0.02%
160502010107	Hot Springs Creek	18,276	1	4	0.02%
170501020303	Upper East Fork Jarbidge River	25,464	5	5	0.02%
160401010605	Talbot Creek	17,599	1	3	0.02%
160502010101	Silver King Creek	27,781	1	4	0.02%
160503010107	Lower Swauger Creek	22,653	1	3	0.01%
160503020304	Upper Desert Creek	22,360	3	2	0.01%

160401030701	Spring Creek	29,854	1	3	0.01%
160600110102	Hidden Creek-Willow Creek	24,090	1	2	0.01%
160503010110	Bridgeport Reservoir-East Walker River	24,899	1	1	0.01%
160502010106	Pleasant Valley Creek	16,190	4	1	0.01%
160600120205	Upper Fish Lake	20,334	1	1	0.01%
160401010401	Headwaters Marys River	16,882	2	1	0.01%
160503020203	Mill Creek	18,932	2	1	0.01%
170501020202	Cottonwood Creek-Bruneau River	17,974	3	1	0.01%
160401010403	Headwaters T Creek	14,589	1	1	<0.01%
170402130104	Cottonwood Creek	32,971	1	1	<0.01%
170501020301	West Fork Pine Creek-Jarbidge River	25,902	2	1	<0.01%
160502010104	Silver Creek	19,671	1	1	<0.01%
160600040903	Barker Creek-Jett Creek	163,273	1	3	<0.01%
170501020304	Lower East Fork Jarbidge River	28,990	1	0	<0.01%