Fen Mapping for the Payette National Forest

August 2022

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.

Colorado Natural Heritage Program
Warner College of Natural Resources
Colorado State University
1475 Campus Delivery
Fort Collins, CO 80523

Report Prepared for:

Payette National Forest
500 N. Mission St. Bld. # 2
McCall, ID 83638

Recommended Citation:
Smith, G. and J. Lemly. 2022. Fen Mapping for the Payette National Forest.
Colorado Natural Heritage Program, Colorado State University, Fort Collins, Colorado.

Front Cover Photo:

By Payette National Forest Botanist Kristin Williams
Photo title: 449_overview.jpg

Fen Mapping for the Payette National Forest

Gabrielle Smith and Joanna Lemly
Colorado Natural Heritage Program
Warner College of Natural Resources
Colorado State University
Fort Collins, Colorado 80523

August 2022

Page intentionally left blank.

EXECUTIVE SUMMARY

The Payette National Forest covers over 2.3 million acres spread across two units in western central Idaho. Wetlands within the Payette 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. To support this effort, U.S. Forest Service contracted Colorado State University and the Colorado Natural Heritage Program (CNHP) to map all potential fens within the Payette National Forest.

Potential fens in the Payette 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 3,709 potential fen locations (all confidence levels), covering 9,777 acres or less than 1% of the total land area. This total included 359 ***likely fens***, 734 ***possible fens***, and 2,616 ***low confidence fens.*** The average fen polygon was 2.64 acres, but individual fen polygons ranged from 100 acres to less than an acre.

Fen distribution was analyzed by elevation, geology, Ecological Subsection, and watershed. The majority of mapped likely fens occurred between 7,000 to 8,000 feet. This elevation range contained 56% of all potential fen locations and 66% of likely fen locations. Three watersheds in particular have higher numbers of likely fens: Upper Chamberlain Creek contains 28 likely fens, Box Creek – North Fork Payette River watersheds contains 16 likely fens, and Payette Lake contains 15 likely fens.

This report and associated dataset provide the Payette National Forest with a critical tool for conservation planning at both a local and Forest-wide scale. These data will be useful for the Payette 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, wilderness stewardship, and other management actions. 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

The authors at Colorado Natural Heritage Program (CNHP) would like to acknowledge the U.S. Forest Service for their financial support of this project. Special thanks to John Proctor and Tova Spector, Regional Botanists for U.S. Forest Service Region 4, and Jeff Bruggink , Regional Soils and BAER Program Manager for US Forest Service Region 4 for supporting this project. Thanks to Forest Botanist Kristin Williams who shared her rare plant observations as well as general knowledge of the Payette National Forest landscape.

We also thank colleagues at CNHP who have worked on previous projects mapping and surveying fen wetlands in the field, specifically Denise Culver, Laurie Gilligan, Peggy Lyon, Dee Malone, and Sarah Marshall. Special thanks David Cooper, Rod Chimner, and Brad Johnson, each of whom has shared with us their great knowledge of fens over the years.

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

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

1.0 INTRODUCTION

The Payette National Forest covers over 2.3 million acres in Idaho, and spans a very broad elevation range from 1,700 to 9,326 ft at the top of North Loon Mountain. Several types of wetlands occur within the Payette 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 higher-elevation headwaters 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. To support this effort, U.S. Forest Service contracted Colorado State University and the Colorado Natural Heritage Program (CNHP) to map all potential fens within the Payette 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), Dixie National Forest (Smith & Lemly 2018b), Humboldt-Toiyabe National Forest (Smith & Lemly 2019a), Fishlake National Forest (Smith and Lemly 2019b), Caribou-Targhee National Forest (Smith & Lemly 2020a), Sawtooth National Forest (Smith & Lemly 2020b) and Boise National Forest (Smith & Lemly 2021).

[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 Payette National Forest, which is administered as two discontinuous units located in west central Idaho (Figure 1). Payette National Forest is surrounded by several other National Forest units, including the Wallowa-Whitman National Forest to the west, Nez-Perce-Clearwater and Bitterroot National Forests to the north, Salmon-Challis National Forest to the east, and Boise National Forest to the south. The Oregon/Idaho state border run along the western edge of the Payette National Forest where is abuts the Wallowa-Whitman National Forest. Payette National Forest includes portions of four Idaho counties: Idaho, Valley, Adams, and Washington counties. The counties with the largest share of National Forest land are Idaho and Valley counties. The largest municipality near the study area is McCall, Idaho. Elevation in the study area ranges from 1,700 ft. (518 m) to 9,326 ft. (2,843 m) and the mean elevation is 6,188 ft. (1,886 m).

Payette National Forest spans three different HUC6 river basins (synonymous with 3rd-field HUs) (Figure 2). The majority of the Forest land occurs in the Salmon River Basin (HUC6:170602), with smaller amounts in the Middle Snake - Boise (HUC6:170501) and the Middle Snake - Powder (HUC6: 170502) basins. The eastern portion of the Forest is drained by the Salmon River as it flows northwest while the western portions are drained by the Snake River.

2.2 Ecological Subsections

The U.S. Forest Service has developed a National Hierarchy of Ecological Units (Cleland et. al. 1997). Ecological Subsections of the hierarchy were used for this project to help describe geologic and geomorphic correlations of fen locations. A Subsection is a unit of land with similar surficial geology, lithology, geomorphic process, soil groups, subregional climate, and potential natural communities. They are generally mapped at 1:250K to 1:3.5M scale and represent land areas of 10s to 1,000s of square miles. Subsection boundaries usually correspond with discrete changes in geomorphology.

There are 18 unique Ecological Subsections in Payette National Forest. The most common Ecological Subsection in the Payette National Forest is the Monumental Summit Mountains (18% of study area) (Figure 3). The next most common Subsections are the Fitsum Peak Glaciated Lands (18%), Chamberlain Basin (13%) and Salmon River Canyonlands (13%) (USFS 2017 Ecological Subregions).

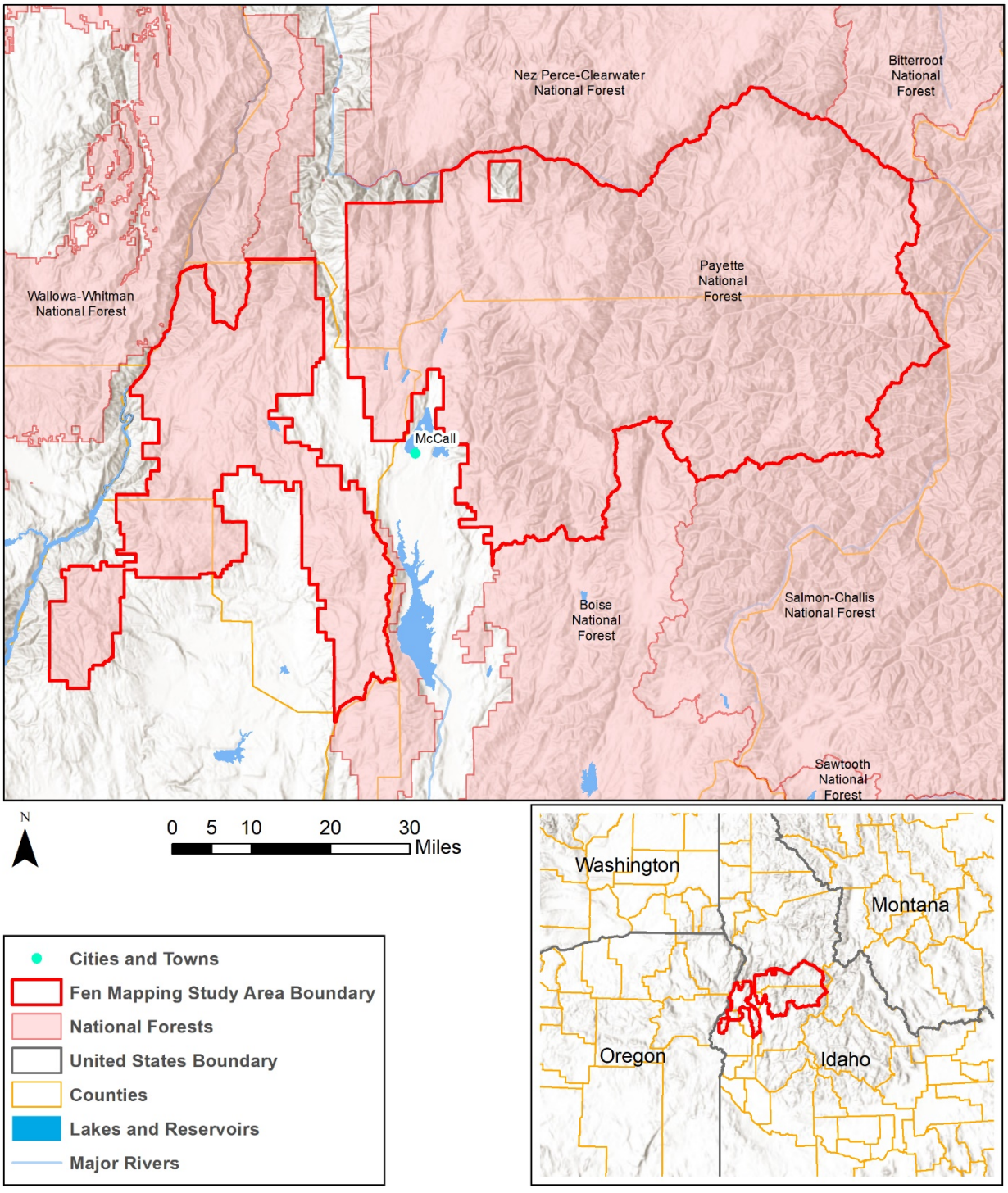

Figure 1. Location of the Payette National Forest (fen mapping study area).

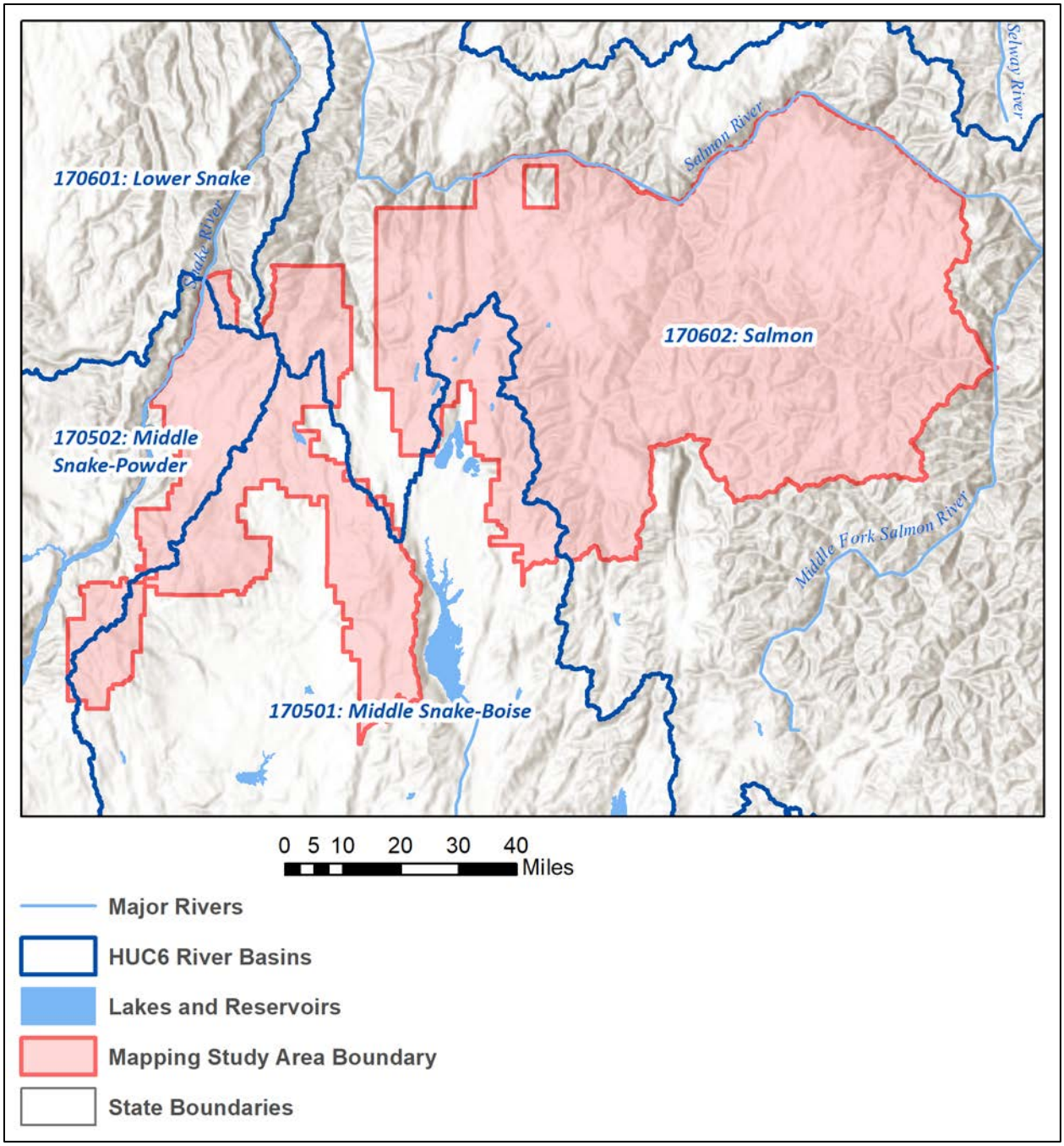

Figure 2. HUC6 river basins and major waterways in the fen mapping study area.

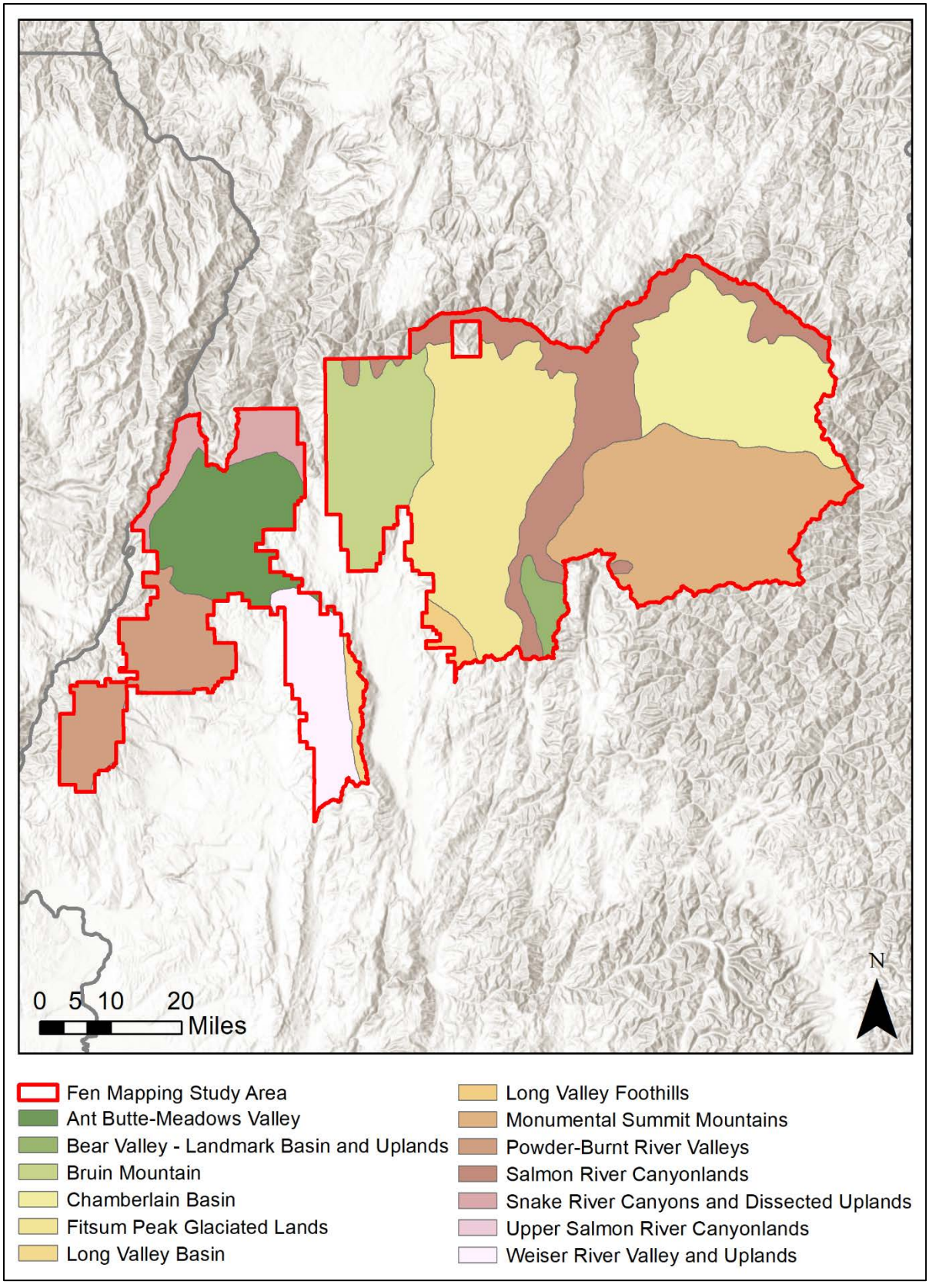

Figure 3. Ecological Subsections of the fen mapping study area.

2.3 Geology

Payette National Forests is comprised of the Atlanta lobe of the Idaho Batholith, a granitic and granodioritic formation that covers nearly 10,000 square miles of central Idaho and western Montana. Across the entire Forest, granodiorite is the most common bedrock geology unit (41% of the land area). Basalt (13%), granite (10%), rhyolite (8%), tholeiite (6%), and quartzite (5%) are also common. The central portion of the Forest is dominated by granodiorite and the eastern portion is a mix of granodiorite, granite, granitoid, rhyolite and quartzite. The western portion of the Forest is more geologically diverse with tholeiite, basalt, alluvium, quartz diorite, mafic metavolcanic and greenstone all present.

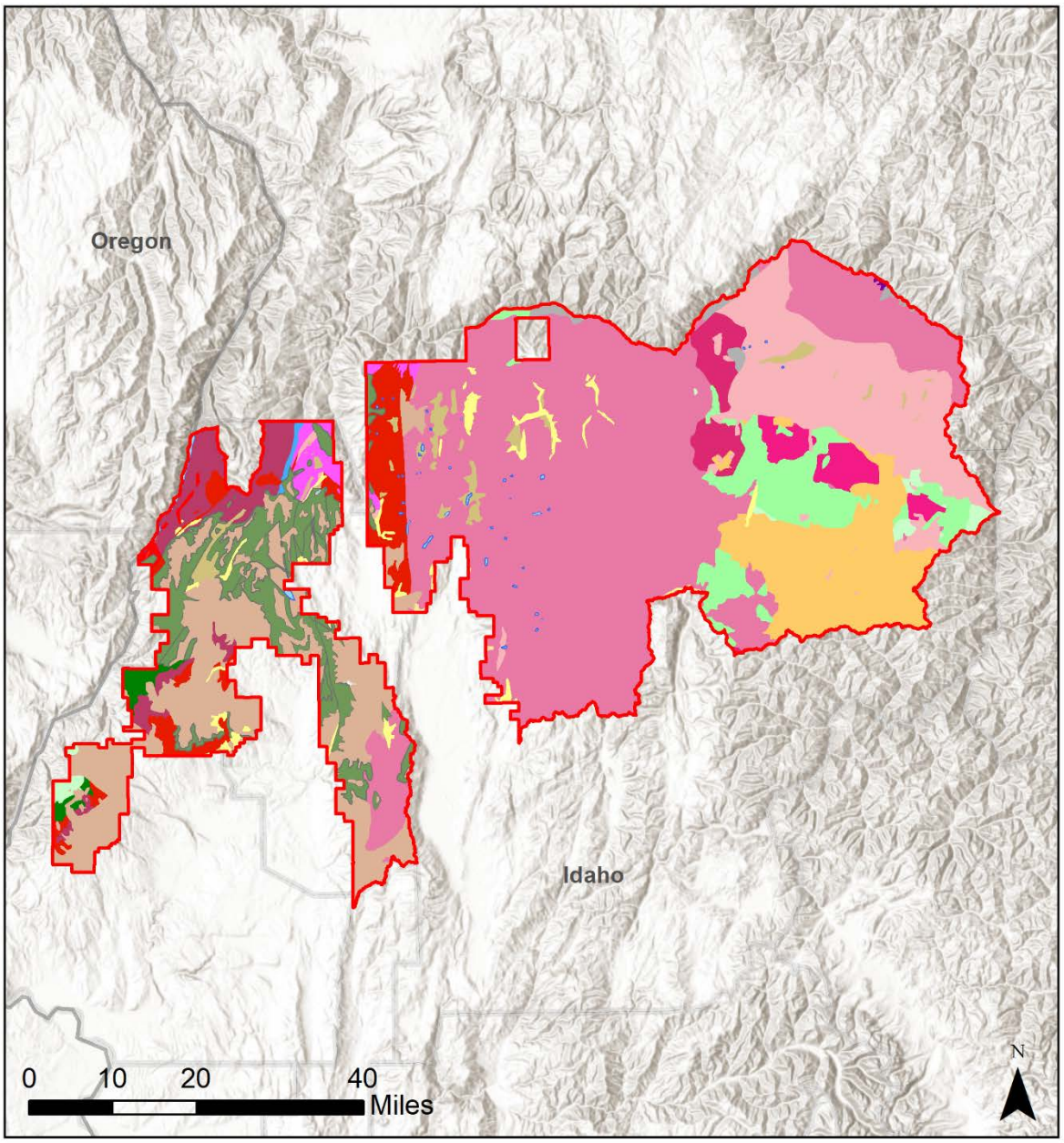

Figure 4. Geology within the fen mapping study area (USGS 2004).

3.0 Fen Mapping Methods

Potential fens in the Payette 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 2004, 2009, 2011, 2013, and 2019 were used in conjunction with color-infrared imagery from 2011, 2013, and 2019. High (but variable) resolution World Imagery from Environmental Systems Research Institute (ESRI) was also used. To focus the initial search, where possible, 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) hydrologic regime were isolated from the full NWI dataset and examined.[2] Wetlands mapped as Palustrine Emergent Saturated (PEMB) and Palustrine Scrub-Shrub Saturated (PSSB) were specifically targeted, as they can be the best indication of fen formation, and every PEMB and PSSB 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 regime NWI polygons.

Potential fen polygons were hand-drawn in ArcGIS 10.6 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 Payette 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 beaver influence, floating mats, springs or human stressors.

Each fen location for the purposes of this report is a single potential fen polygon. Potential fen polygons of different confidence levels may be adjacent or nested within each other and together represent a larger fen complex.

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 3,709 potential fen locations (all confidence levels), covering 9,777 acres or 0.4% of the total land area (Table 2; Figures 5 and 6). This total included 359 ***likely fens*** (confidence level = 5), 734 ***possible fens***, and 2,616 ***low confidence fens.***

On average the likely fens were similar in size to the possible and low confidence fens (2.95 acres vs. 3.27 or 2.42 acres), resulting in 1,061 acres of likely fens, 2,698 acres of possible fens, and 6,318 acres of low confidence fens. The size of individual potential fens ranged from over 100 acres to 0.1 acres. The largest mapped likely fen at 17 acres is located between the Sam's Throne and Lava Butte peaks in Idaho County, Idaho (Figure 7). The second and third largest fens (both mapped at 13 acres) occur near each other east of Boulder Lake in Valley County, Idaho (Figures 8 and 9).

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

Confidence	*Count*	*Acres*	*Average size (acres)*
5 – Likely Fen	359	1,061	2.95
3 – Possible Fen	734	2,698	3.27
1 – Low Confidence Fen	2,616	6,318	2.42
TOTAL	**3,709**	**9,777**	**2.64**

The sections that follow (4.2 through 4.5) break down the fen mapping by elevation range, geology, EcoMap Subsection and HUC12 (synonymous with 6th-field HU's) watershed. The last section summarizes observations made by the fen mappers during the mapping process, including potential floating mat fens.

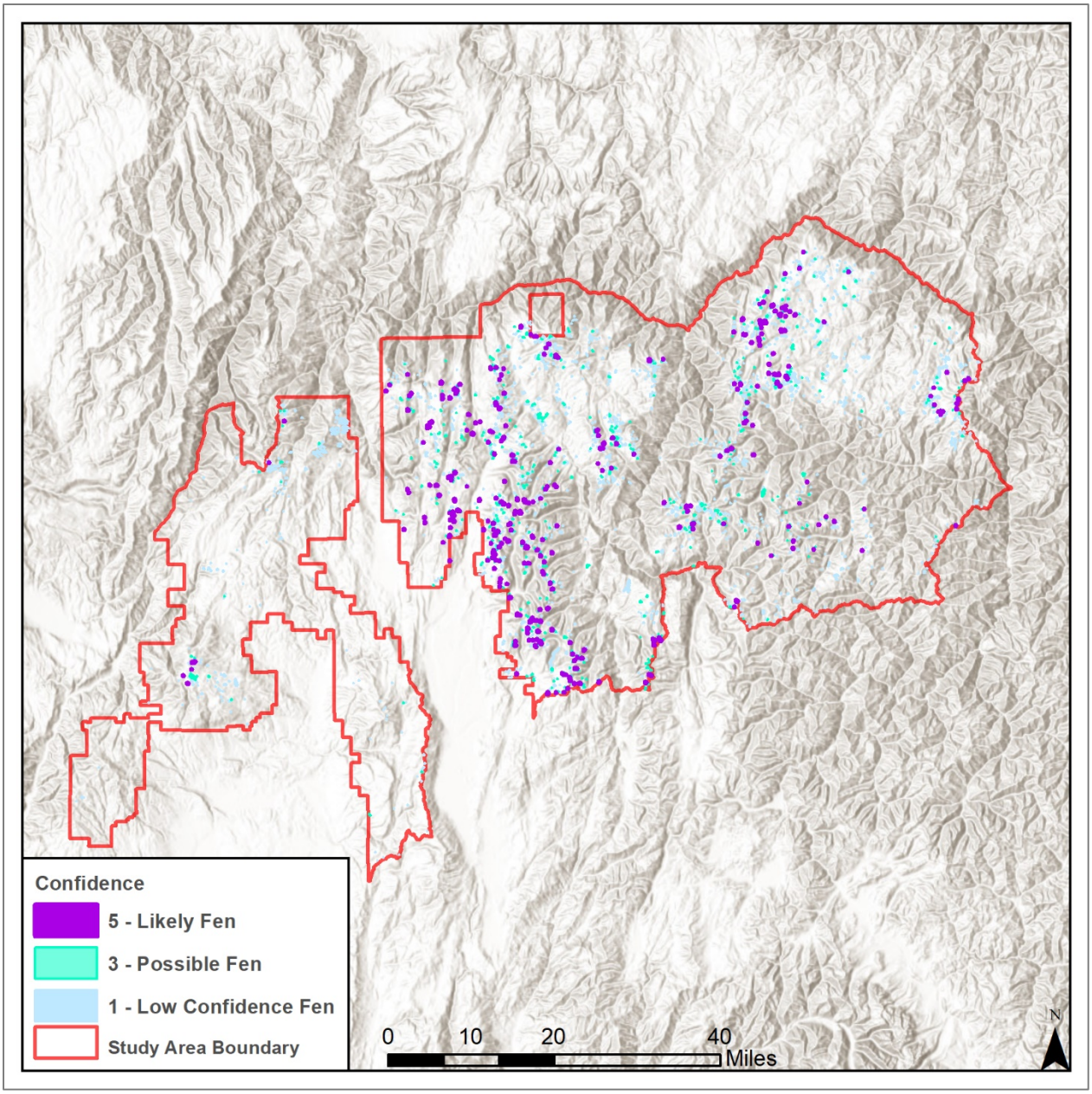

Figure 5. All potential fens within the fen mapping study area.

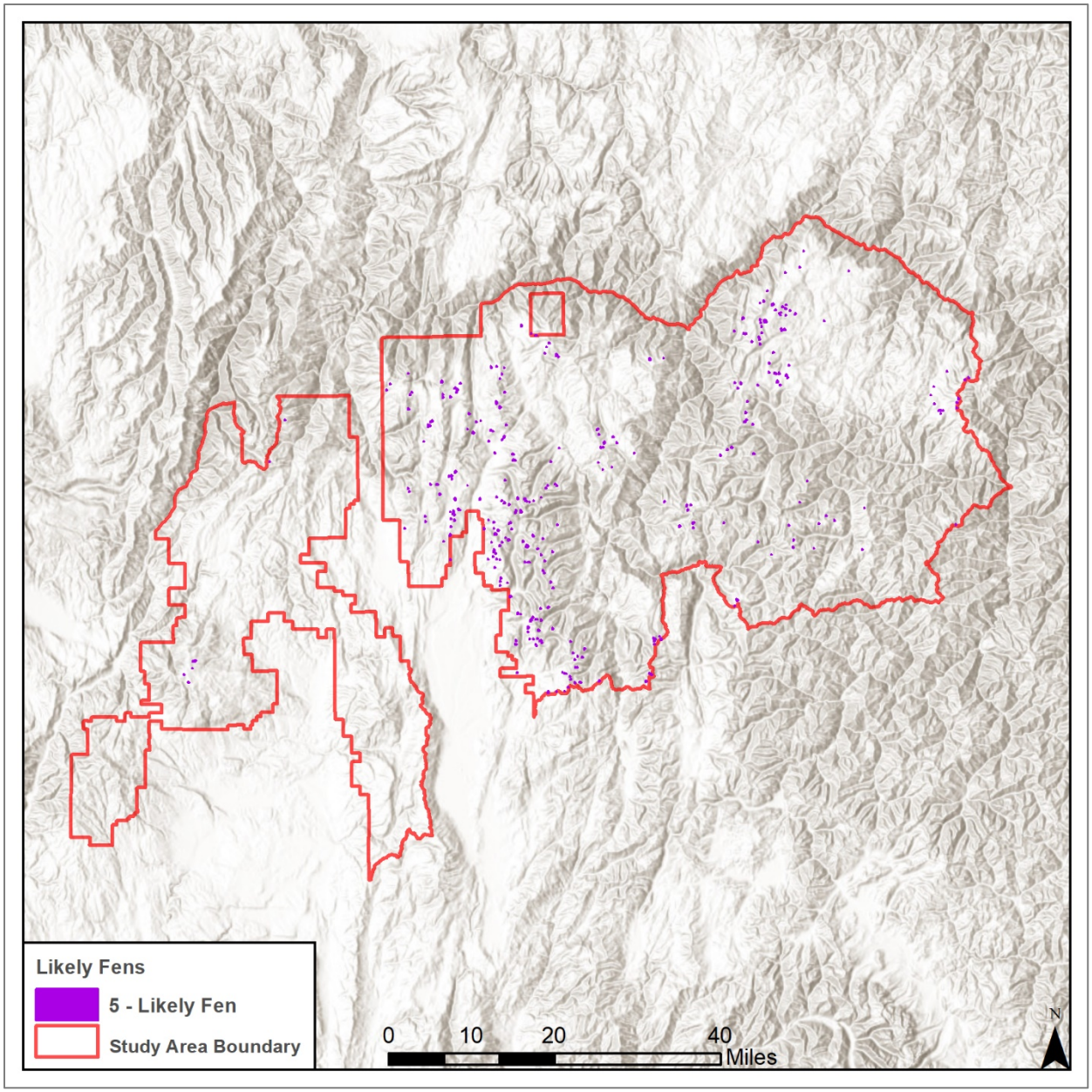

Figure 6. Likely fens (confidence rating = 5) within the fen mapping study area.

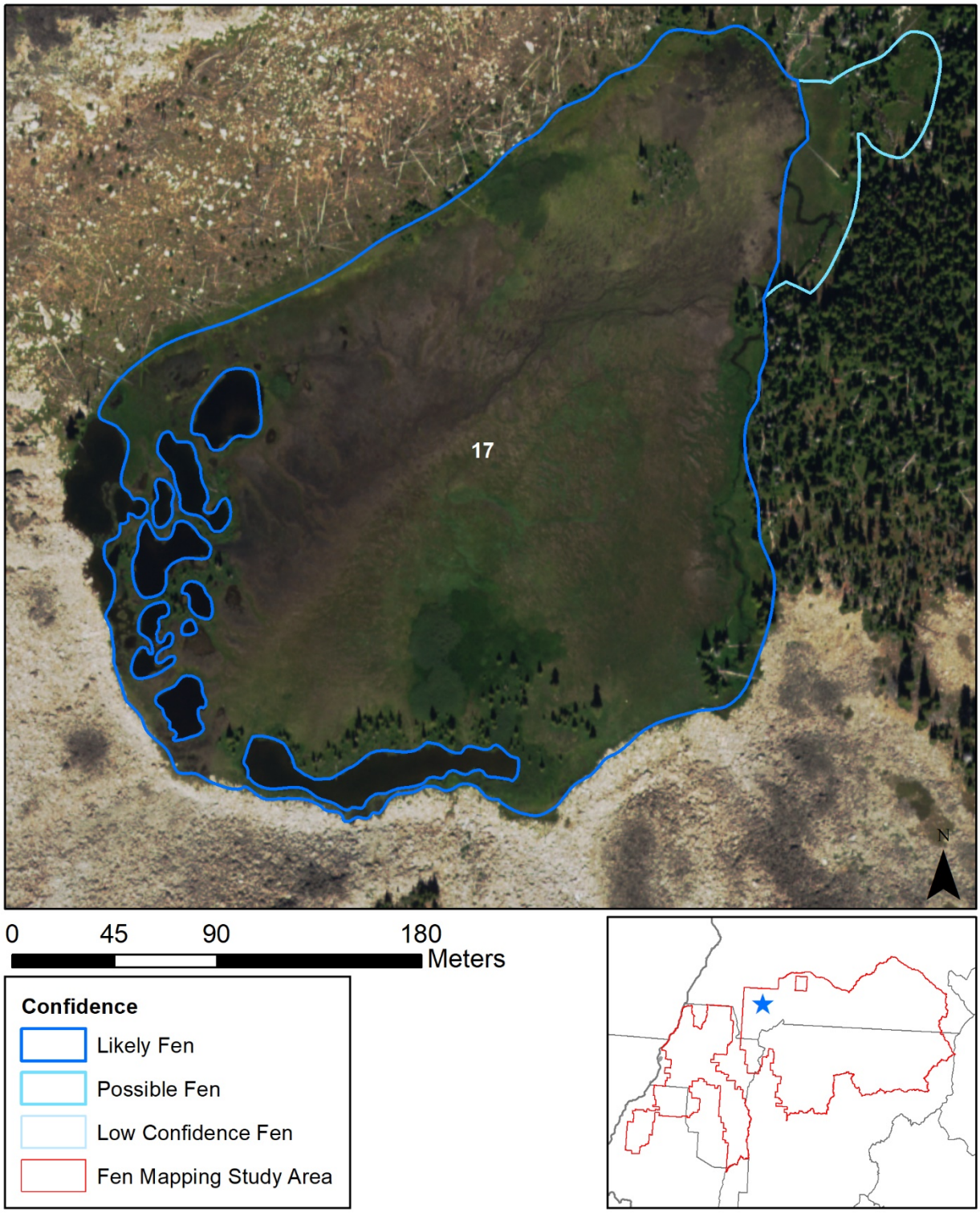

Figure 7. Largest mapped likely fen, 17 acres within one polygon, located in Idaho county between the Sam's Throne and Lava Butte peaks.

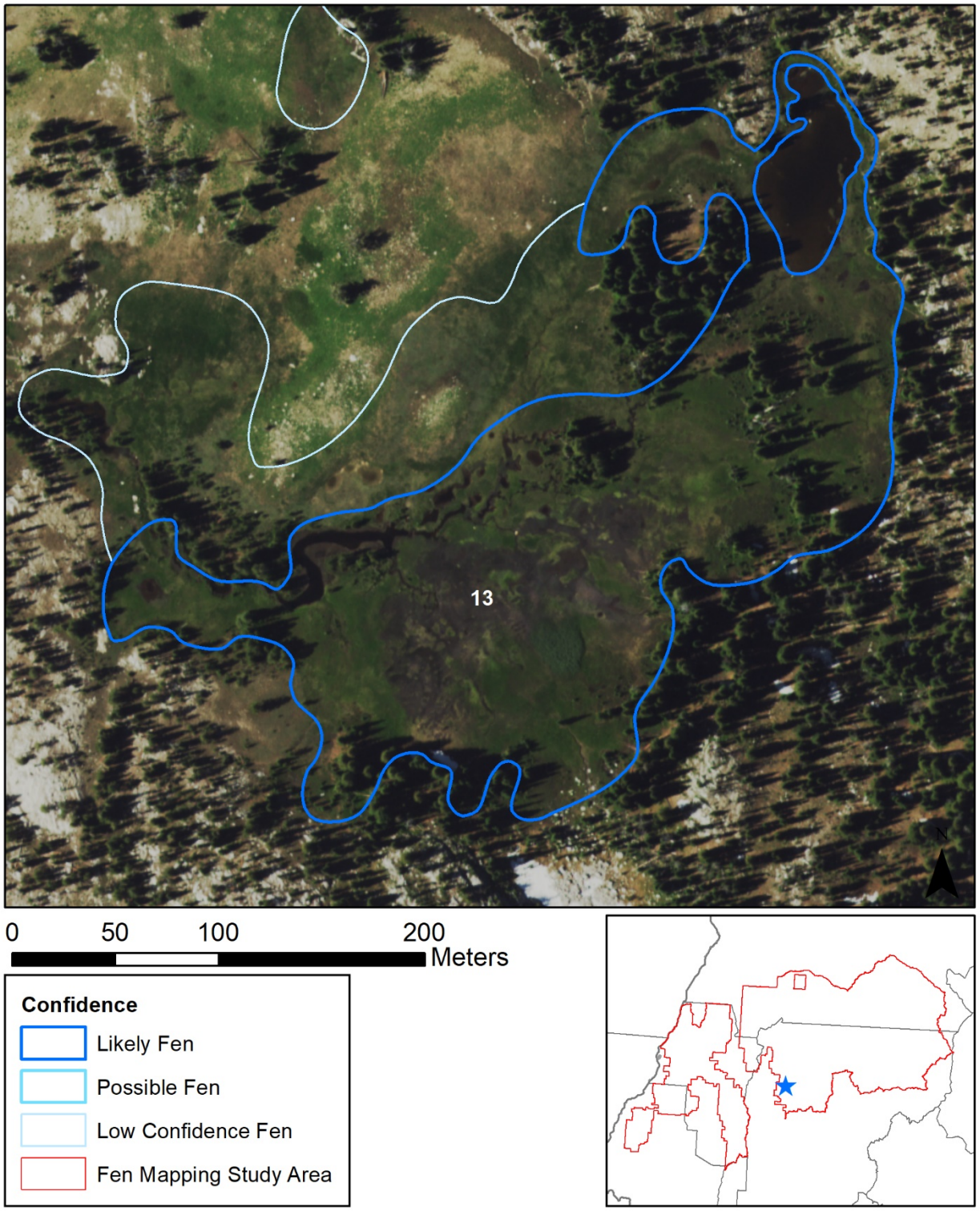

Figure 8. Second largest likely fen at 13 acres, located in Valley County, Idaho east of Boulder Lake along Boulder Creek.

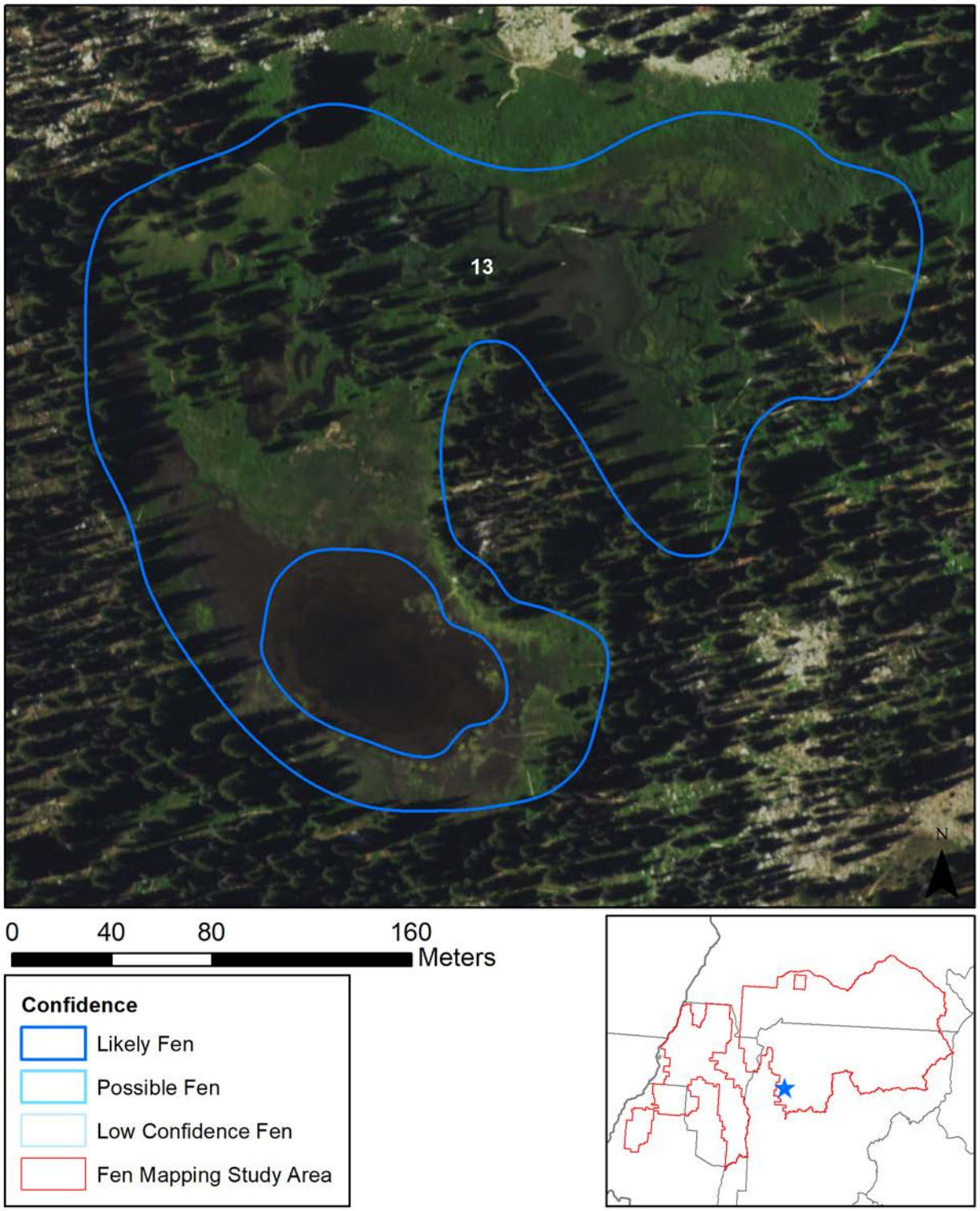

Figure 9: The third largest likely fen located downstream of Rapid Lake in Valley County, Idaho.

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 saturation. This is most often at higher elevations, 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, 916 polygons (4,833 acres) were mapped between 7,000 and 8,000 feet, which represents 56% of potential fen locations and 49% of potential fen acres (Table 3; Figure 10). Of the 359 total likely fens mapped, 238 polygons (66%) and 739 acres (70%) were located between 7,000 and 8,000 feet (Table 3; Figures 11 through 14). This is one zone of maximum fen formation for the Payette National Forest.

In addition, the elevation band of 6,000 to 7,000 feet also contains many potential and likely fens. Between 6,000 to 7,000 feet, there were 821 mapped potential fens (2,876 acres), which represent 22% of potential fen locations and 29% of potential fen acres. In addition, there were 71 likely fens (218 acres), which represent 20% of likely fen locations and 21% of likely fen acres. The elevation band of 8,000 to 9,000 feet contains 36 likely fens (53 acres) which represent 10% of likely fen locations and 5% of likely fen acres.

Table 3. 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*
< 4,000	9	9	-	-
> 4,000 – 5,000	54	58	-	-
> 5,000 – 6,000	295	1,448	14	51
> 6,000 – 7,000	821	2,876	71	218
> 7,000 – 8,000	2,082	4,833	238	739
>8,000	448	553	36	53
Total	**3,709**	**9,777**	**359**	**1,061**

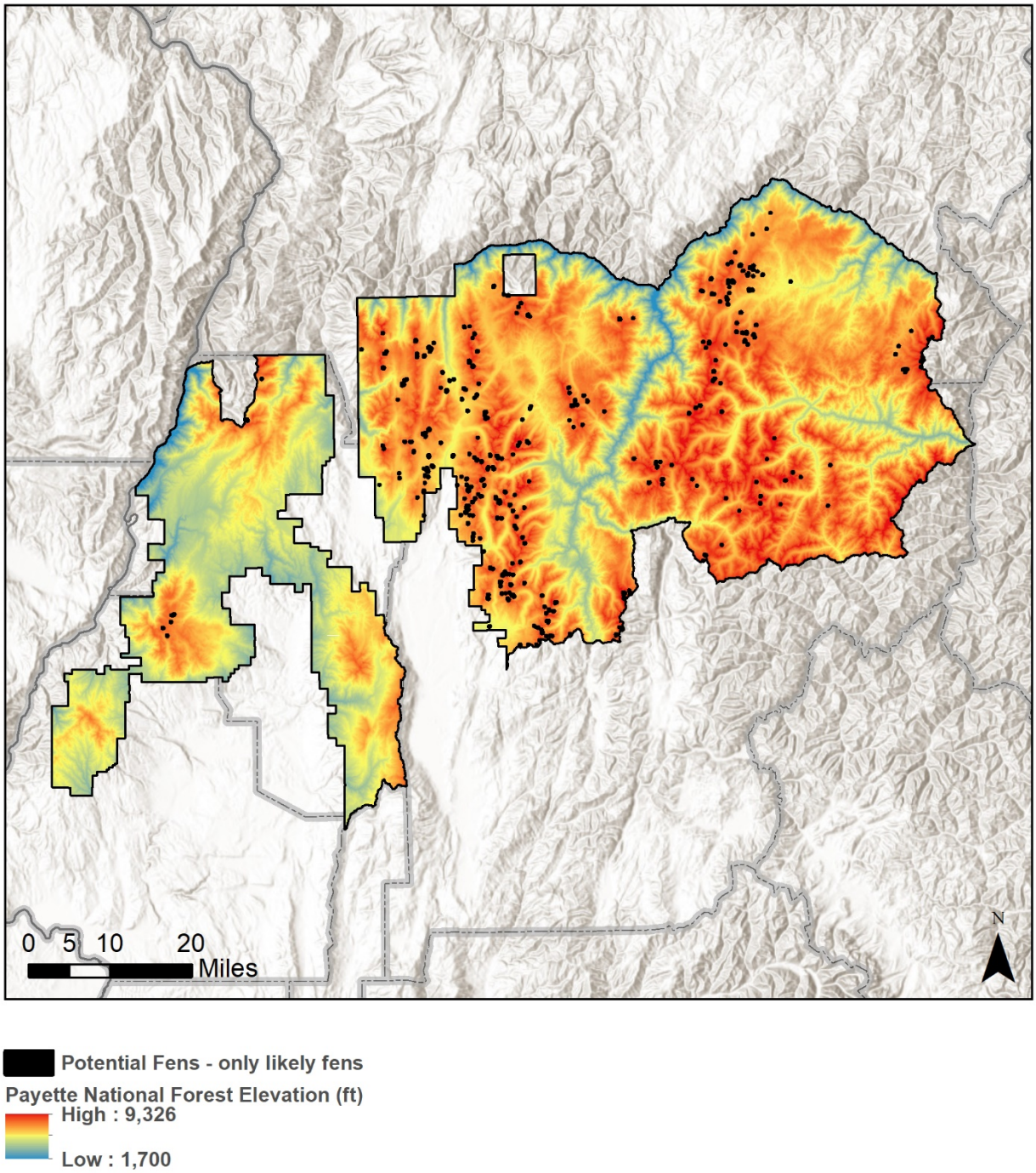

Figure 10: Likely fens (confidence rating = 5) and elevation within the fen mapping study area.

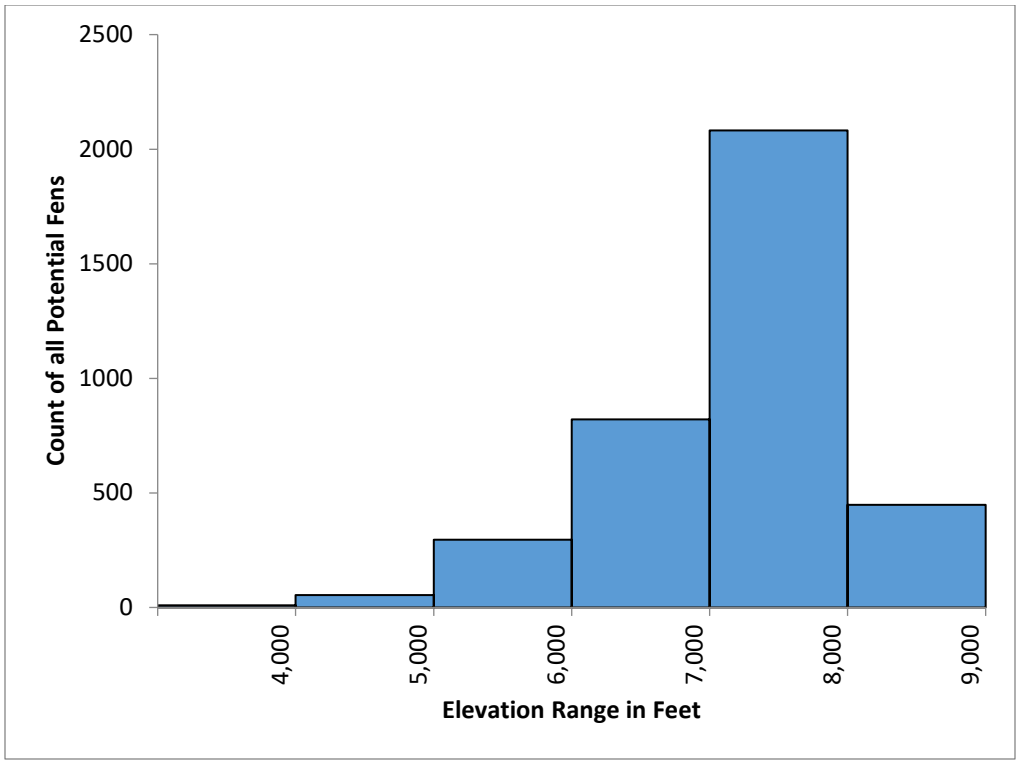

Figure 11. Histogram of all potential fens by elevation within the fen mapping study area.

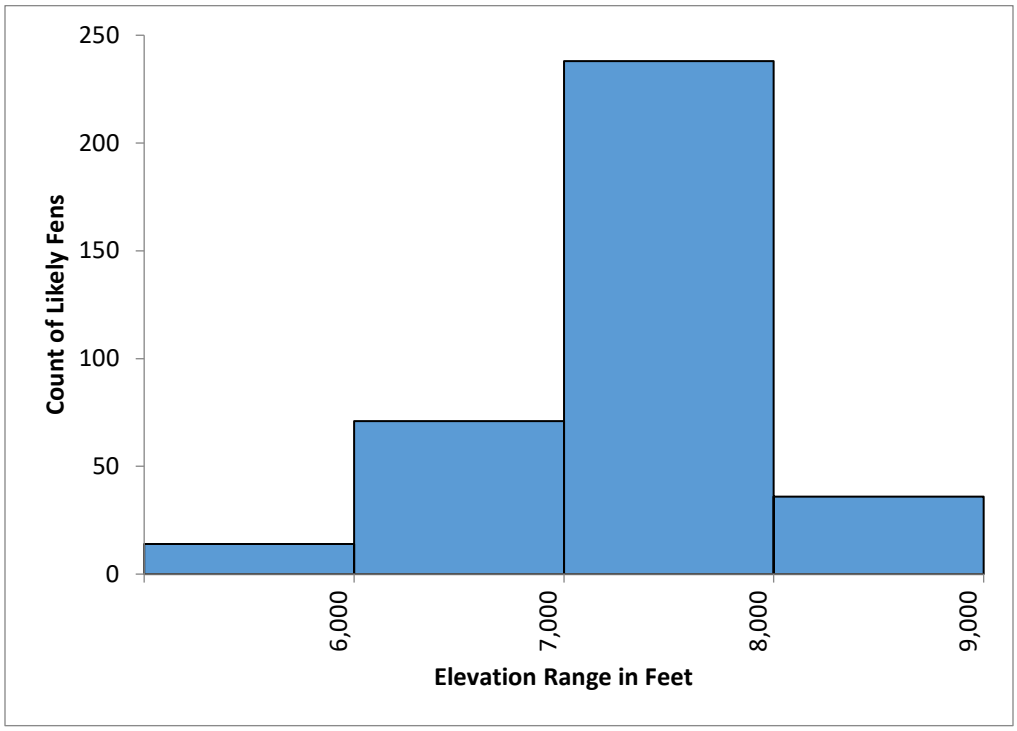

Figure 12. Histogram of the most likely fens by elevation within the fen mapping study area.

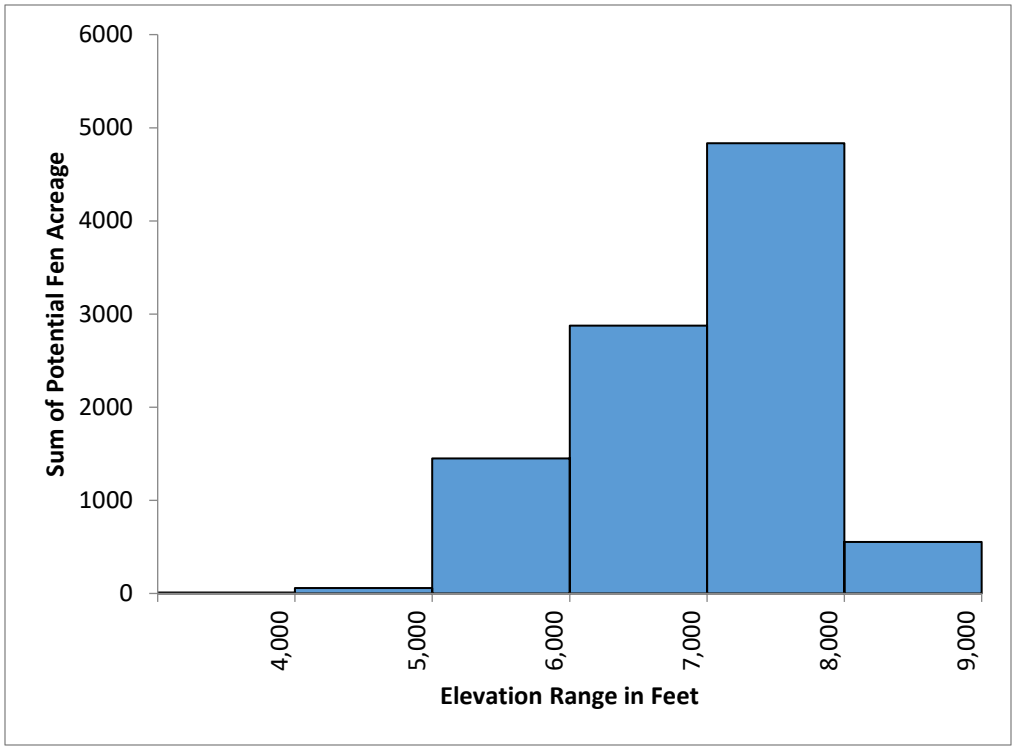

Figure 13. Graph of the sums of potential fen acreage by elevation within the study area.

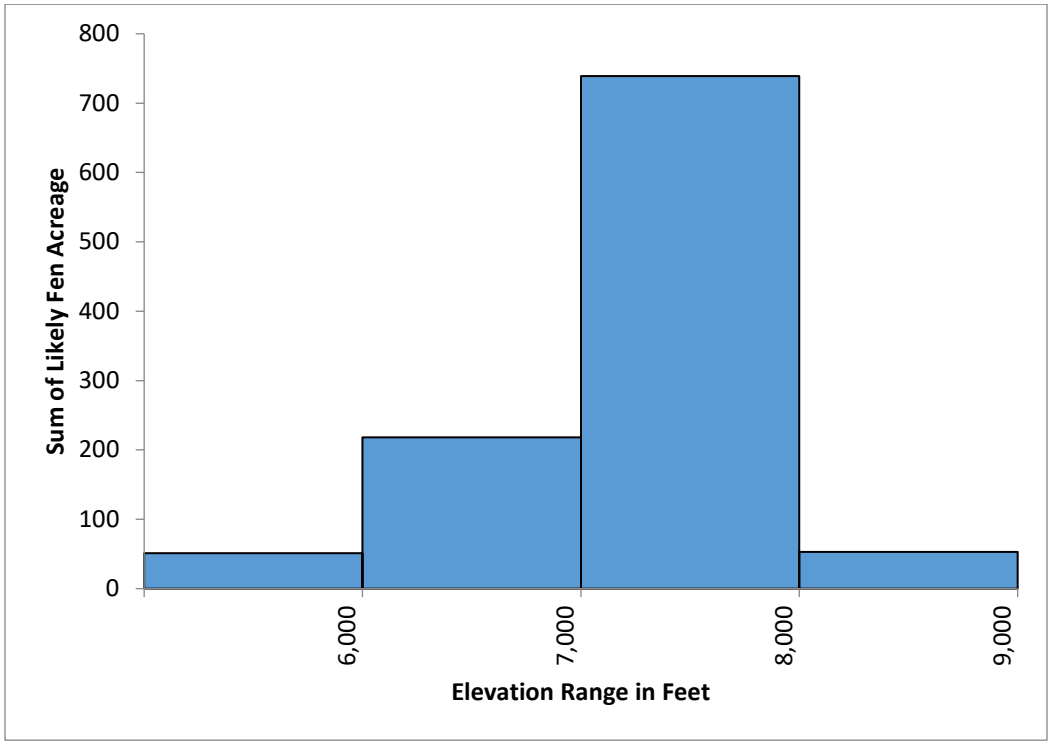

Figure 14. Graph of the sums of likely fen acreage by elevation within the study area.

4.3 Mapped Potential Fens by Geology

The most common geologic substrate under potential fens in Payette National Forest was the volcanic formation granodiorite, which underlies 2,001 mapped potential fens (5,036 acres). The most common geologic substrates under likely fens was also granodiorite, which underlies 231 mapped likely fens (680 acres) (Table 4). Granodiorite is the most common geologic substrate in the Forest, underling 41% of the Forest. These areas contain 54% of all potential fens and 64% of likely fens. Granodiorite is a volcanic rock formation that along with granite composes most of the Idaho batholith. Granite, granitoid and till underlies most of the remaining likely fen acres, with 63 likely fens and 174 likely fen acres on granite (16% of likely acres), 10 likely fens and 45 likely fen acres on granitoid (4% of likely acres) and 12 likely fens and 45 likely acres on till (4% of likely acres).

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

Geology	*Acres of Geologic Substrate Within PNF*[1]	*# of All Potential Fens*	*All Potential Fen Acres*	*# of Likely Fens*	*Likely Fen Acres*
granodiorite	998,392	2,004	5,036	231	680
granite	253,291	641	1,916	63	174
rhyolite	192,802	189	262	11	16
basalt	302,302	158	422	7	36
quartzite	120,562	144	211	7	22
granitoid	44,366	103	170	10	45
tholeiite	149,866	94	185	--	--
till	34,369	91	752	12	45
mafic metavolcanic rock	70,530	85	126	3	2
quartz diorite	91,446	57	102	5	11
alluvium	33,173	41	318	2	9
metavolcanic rock	22,216	41	169	--	--
mica schist	12,748	27	49	2	3
water	6,401	11	38	4	13
syenite	39,809	8	8	--	--
tonalite	2,416	5	5	2	3
intermediate metavolcanic rock	3,998	3	<1	--	--
meta-argillite	17,104	3	4	--	--
stratified glacial sediment	899	3	3	--	--
greenstone	13,644	1	<1	--	--
		3,709	**9,777**	**359**	**1,061**

[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 Payette National Forest.

4.4 Mapped Potential Fens by Ecological Subsection

Fitsum Peak Glaciated Lands Ecological Subsection covers 18% of the Payette National Forest, but this Subsection contains 33% of potential fens (1,238) and 40% likely fen locations (143). The Chamberlain Basin Subsection covers 13% of the Forest and contains 21% of potential fens (779), and 17% of likely fens (62). The Bruin Mountains Subsection covers 9% of the Forest, yet it contains 427 mapped potential fens (1,544 acres) and 73 likely fens (270 acres) (Table 5).

Table 5. Potential and likely fens by ecological subsection within the fen mapping study area.

EcoMap Ecological Subsection Name	*Acres within Payette National Forest*[1]	*# of All Potential Fens*	*All Potential Fen Acres*	*# of Likely Fens*	*Likely Fen Acres*
Fitsum Peak Glaciated Lands	424,972	1,238	3,155	143	410
Chamberlain Basin	312,729	779	2,487	62	180
Monumental Summit Mountains	444,174	505	946	36	77
Bruin Mountain	222,563	427	1,544	73	270
Salmon River Canyonlands	306,926	225	338	15	44
Ant Butte-Meadows Valley	216,563	132	226	1	1
Snake River Canyons and Dissected Uplands	76,154	130	317	2	2
Powder-Burnt River Valleys	189,662	88	310	5	18
Long Valley Foothills	23,895	75	200	10	25
Bear Valley - Landmark Basin and Uplands	31,459	62	213	12	34
Weiser River Valley and Uplands	137,052	34	23		
Long Valley Basin	20,844	14	17		
Upper Salmon River Canyonlands	220	0	-		
		3,709	**9,777**	**359**	**1,061**

[1] Acres of Ecological Subsections 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 Payette National Forest.

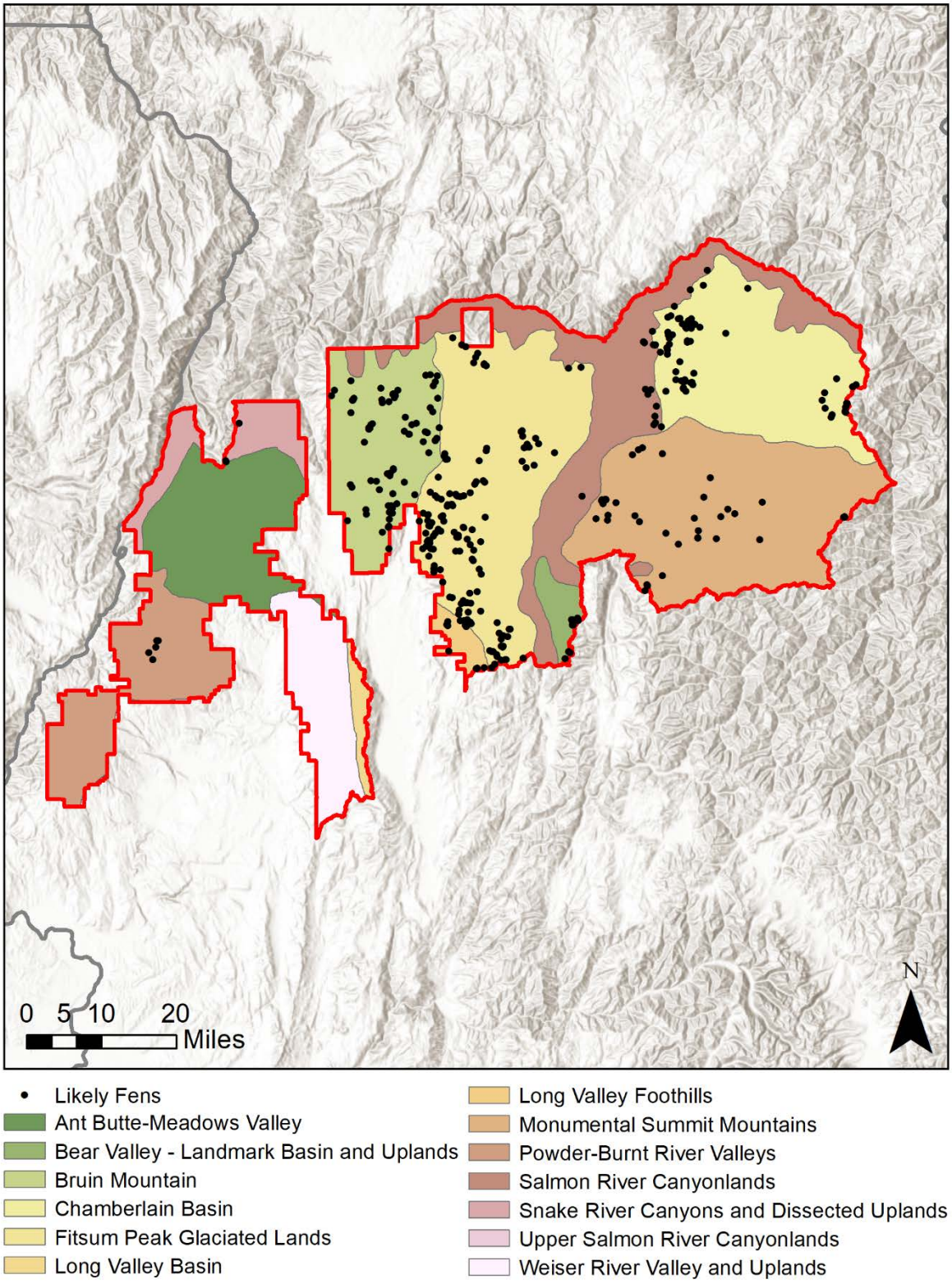

Figure 15: Likely Fens on Ecological Subsections. Note Fitsum Peak Glaciated Lands (yellow, center) has the highest number of likely fens and likely fen acres.

4.5 Mapped Potential Fens by Watershed

An analysis of likely fens in HUC12 (6th-field HU) watersheds revealed interesting patterns. Three watersheds in particular had significant numbers of likely fens (Figure 16). Upper Chamberlain Creek (HUC12: 170602070301) had 28 likely fens, which covered 0.27% of the landscape in this watershed. Payette Lake (HUC12: 170501230106) had 15 likely fens, covering 0.12% of the landscape. Box Creek – North Fork Payette River (HUC12: 170501230201) had 12 likely fens, representing 0.32% of the landscape. Fisher Creek (HUC12: 170501230103) watershed has the highest fen density (0.42%) with 8 likely fens at 49 acres. See Appendix A for the full HUC12 watershed and likely fens table.

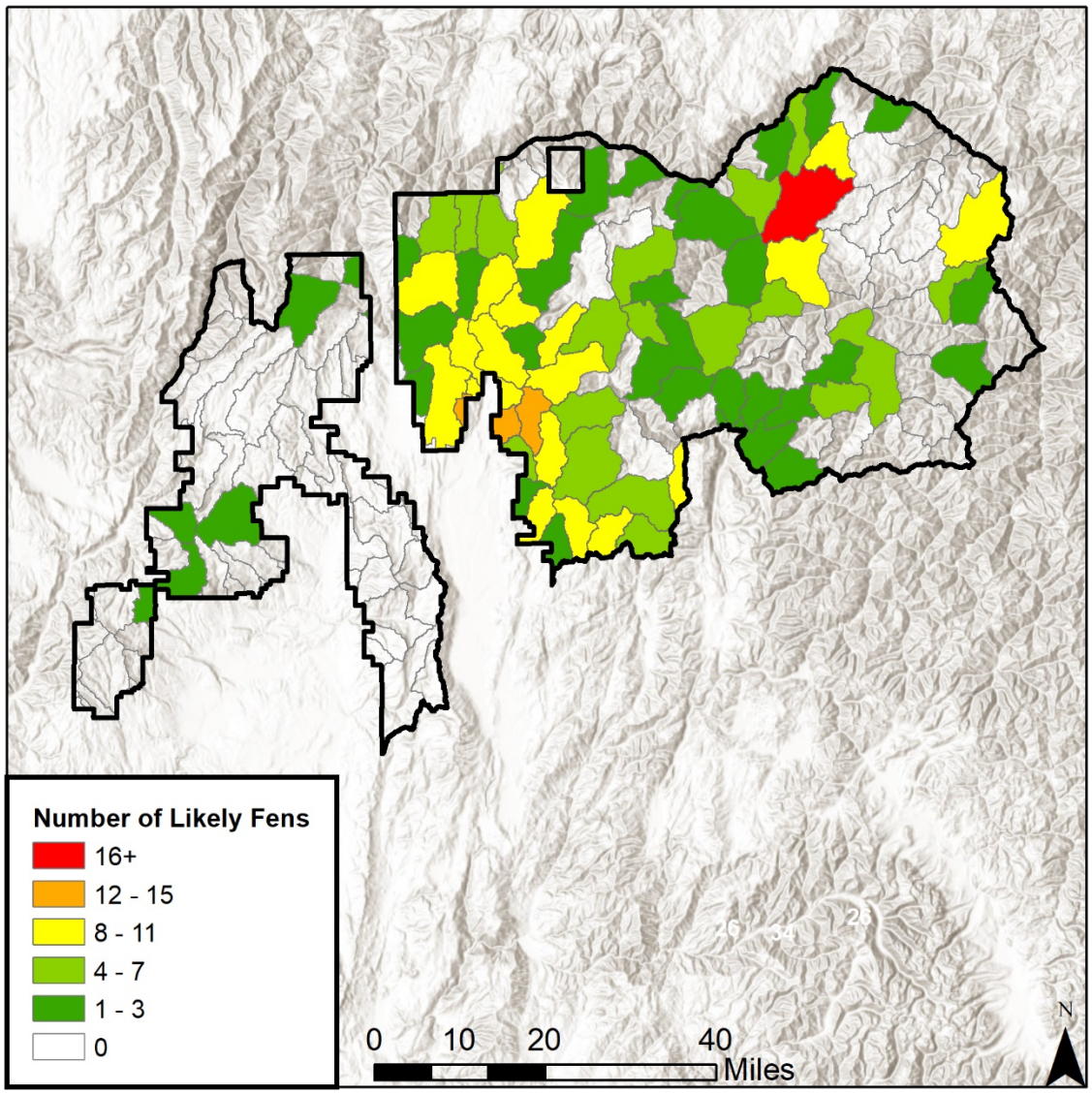

Figure 16. Likely fens by HUC12 watershed within the fen mapping study area.

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 6), 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 National Forests throughout the intermountain region (Kate Dwire, Research Ecologist at the US Forest Service Rocky Mountain Research Station, *personal communications in 2016*). Twenty potential fens (47 acres) and eight likely fens (34 acres) were identified as potential floating mat fens. Figure 17 shows two likely fens that show floating mat characteristics located in Idaho County, Idaho about 1 km west of Big Hazard Lake.

Springs and fens are both important components of groundwater-dependent ecosystems (GDEs) and are of particular interest to the U.S. Forest Service (USFS 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. One hundred and thirty-one potential fens and one likely fen were observed in proximity to springs. Figure 18 shows a 1-acre likely fen mapped in Idaho County that is located on a NHD mapped spring point.

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. Twenty-six potential fens (352 acres) showed some evidence of beaver influence.

Table 6. 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	131	56	1	5
Possible Floating Mat	20	47	8	34
Beaver Influence	26	352	--	--
Total	**177**	**455**	**9**	**39**

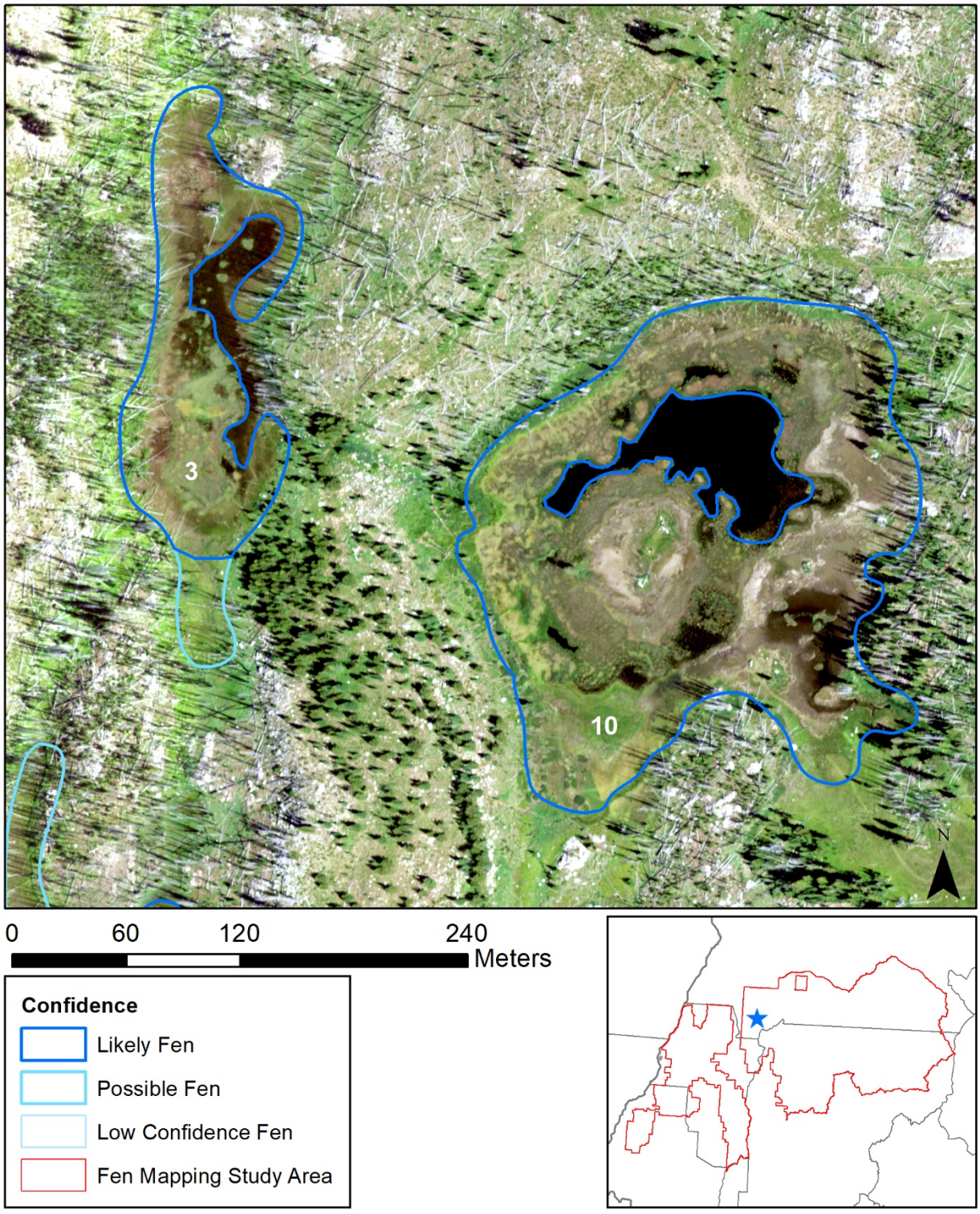

Figure 17: Two likely fens with possible floating mat components located in Idaho County, Idaho west of Big Hazard Lake. The likely fen on the right at 10 acres is the largest mapped likely fen with floating mat characteristics.

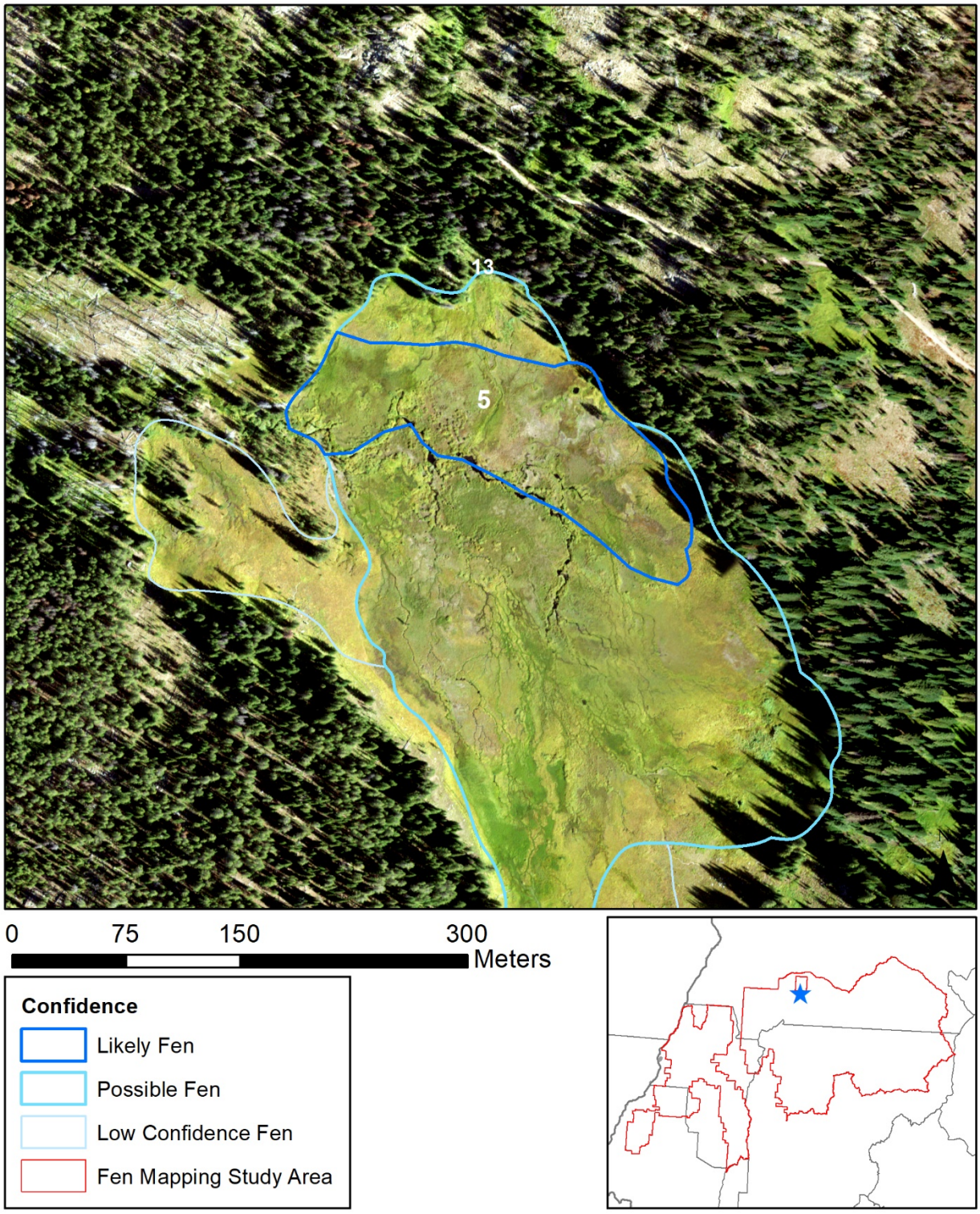

Figure 18: Largest spring influenced likely fen located in Idaho County, Idaho along Willow Creek.

5.0 Discussion

The Payette National Forest contains a relatively small number of potential fen wetlands, covering up to 9,777 acres across its jurisdiction. While the potential fen resource represents a very small portion of the entire landscape, these fen wetlands are an irreplaceable resource for the Forest and the citizens of Idaho. 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, 3,709 potential fens were mapped throughout the Payette National Forest, of which 359 were most likely to be fens. While uncommon across the Forest, analysis of the potential fen data showed clear hotspots in the Payette National Forest. There is a strong elevation pattern found within the mapping, with 66% of likely fens falling between 7,000 and 8,000 feet and nearly all likely fen acres occurring above 6,000 ft. Specific watersheds also stood out for fen abundance. In particular, the Upper Chamberlain Creek and Fisher Creek watersheds had either high numbers of fens or a high density of fen acres. Lastly, specific fens identified though this study appear to have notable characteristics, such as floating mats or direct association with springs. Available field data support these finding. A 2021 Forest Service GDE Level 1 inventory of the two likely fens displayed in Figure 16, which were located in the Vance Creek – Hazard Creek (HUC12: 170602100302) watershed, confirmed the presence of more than 40 cm of peat within the mapped polygon, as well as floating mat components. The inventory documented several rare and uncommon plant species that occur on floating mats, including *Carex limosa, Comarum palustre, Drosera anglica, Menyanthes trifoliata and Schoenoplectus subterminalis* (Williams et al, 2021-2022). These are only two of many potential fens across the Forest that may support rare 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). Human stressors were observed in some fen wetlands while mapping fens on the Payette National Forest, such as impoundments or excavated ponds, and those observations were captured in the “Notes” field of the GIS dataset accompanying this report. However most potential fens in Payette National Forest showed little sign of human disturbance, particularly at higher elevations.

This report and associated dataset provide the Payette National Forest with a critical tool for conservation planning at both a local and Forest-wide scale. These data will be useful for the Payette National Forest assessment required by the 2012 Forest Planning Rule, by being used to prioritize sites for future field surveys on fens.

6.0 LITERATURE CITED

Chimner, R. A. (2000) Carbon dynamics of Southern Rocky Mountain fens. Carbon dynamics of Southern Rocky Mountain fens, Ph.D. Dissertation, Colorado State University, Ft. Collins, CO.

Chimner, R.A. and D.J. Cooper. (2002) Modeling carbon accumulation in Rocky Mountain fens. Wetlands 22: 100-110.

Chimner, R.A., J.M. Lemly, and D.J. Cooper. (2010) Mountain fen distribution, types, and restoration priorities, San Juan Mountains, Colorado, USA. *Wetlands,* **30:** 763–771.

Cleland, D.T.; Avers, P.E.; McNab, W.H.; Jensen, M.E.; Bailey, R.G., King, T.; Russell, W.E. 1997. National Hierarchical Framework of Ecological Units. Published in, Boyce, M. S.; Haney, A., ed. 1997. Ecosystem Management Applications for Sustainable Forest and Wildlife Resources. Yale University Press, New Haven, CT. pp. 181-200.

Cooper, D.J. (1996) Water and soil chemistry, floristics, and phytosociology of the extreme rich High Creek Fen, in South Park, Colorado, USA. *Canadian Journal of Botany*, **74**, 1801-1811.

Heidel, B. (2019) Botany Inventories in Select Fens of the Payette and Bridger-Teton National Forests, Sublette and Teton Counties, Wyoming. Wyoming Natural Diversity Database, University of Wyoming, Laramie, Wyoming.

Jankovsky-Jones, M. (2001) A Preliminary Summary of Peatlands on the Payette National Forest. Idaho Conservation Data Center, Idaho Department of Fish and Game, Payette, ID.

Johnson, J.B. and Steingraeber, D.A. (2003) The vegetation and ecological gradients of calcareous mires in the South Park Valley, Colorado. *Canadian Journal of Botany*, **81**, 201-219.

Lemly, J. (2007). Fens of Yellowstone National Park, USA: regional and local controls over plant species distribution. Master's Thesis. Graduate Degree Program in Ecology, Colorado State University, Fort Collins, CO.

Lemly, J. (2012) Assessment of Wetland Condition on the Rio Grande National Forest. Colorado Natural Heritage Program, Fort Collins, CO.

Lemly, J.M. and D.J. Cooper. (2011) Multiscale factors control community and species distribution in mountain peatlands. *Botany,* **89:** 689–713.

Lemly, J.M., R.E. Andrus, and D.J. Cooper (2007) *Sphagnum lindbergii* Schimp. in Lindb. and other new records of *Sphagnum* in geothermal fens, Yellowstone National Park, Wyoming, USA. *Evansia*, **24:** 31–33.

Malone, D., E. Carlson, G. Smith, D. Culver, and J. Lemly. (2011) Wetland Mapping and Fen Survey in the White River National Forest. Colorado Natural Heritage Program, Fort Collins, CO.

McKinstry, M.C., W.A. Hubert and S.H. Anderson (eds.) (2004) *Wetland and Riparian Areas of the Intermountain West: Ecology and Management.* University of Texas Press, Austin, TX.

Millennium Ecosystem Assessment (2005) *Ecosystems and Human Well-Being: Biodiversity Synthesis*. Island Press, 2005.

Mitsch, W. J., and Gosselink, J. G. (2007). *Wetlands, Fourth Edition.* Louisiana State University, Baton Rouge, LA.

Redlefs, A.E. (1980) Wetland values and losses in the United States. M.S. thesis. Oklahoma State University, Stillwater, OK.

Moseley, R.K., R. Bursik, F. Rabe and L. Cazier. (1994) Peatlands of the Payette Valley, Custer and Blaine Counties, Idaho. Idaho Department of Fish and Game, Payette, ID.

Smith, G. J. Lemly, P. Smith, and B. Kuhn. (2016) Fen Mapping for the Rio Grande National Forest. Colorado Natural Heritage Program, Colorado State University, Fort Collins, Colorado.

Smith, G. J. Lemly, and K. Schroder. (2017) Fen Mapping for the Salmon-Challis National Forest. Colorado Natural Heritage Program, Colorado State University, Fort Collins, Colorado.

Smith, G. and J. Lemly. (2017a) Fen Mapping for the Ashley National Forest. Colorado Natural Heritage Program, Colorado State University, Fort Collins, Colorado.

Smith, G. and J. Lemly. (2017b) Fen Mapping for the Manti-La Sal National Forest. Colorado Natural Heritage Program, Colorado State University, Fort Collins, Colorado.

Smith, G. and J. Lemly. (2018a) Fen Mapping for the Bridger-Teton National Forest. Colorado Natural Heritage Program, Colorado State University, Fort Collins, Colorado.

Smith, G. and J. Lemly. (2018b) Fen Mapping for the Dixie National Forest. Colorado Natural Heritage Program, Colorado State University, Fort Collins, Colorado.

Smith, G. and J. Lemly. (2019a) Fen Mapping for the Humboldt-Toiyabe National Forest. Colorado Natural Heritage Program, Colorado State University, Fort Collins, Colorado.

Smith, G. and J. Lemly. (2019b) Fen Mapping for the Fishlake National Forest. Colorado Natural Heritage Program, Colorado State University, Fort Collins, Colorado.

Smith, G. and J. Lemly. (2020b) Fen Mapping for the Caribou-Targhee National Forest. Colorado Natural Heritage Program, Colorado State University, Fort Collins, Colorado.

Smith, G. and J. Lemly. (2020b) Fen Mapping for the Sawtooth National Forest. Colorado Natural Heritage Program, Colorado State University, Fort Collins, Colorado.

Smith, G. and J. Lemly. (2021) Fen Mapping for the Boise National Forest. Colorado Natural Heritage Program, Colorado State University, Fort Collins, Colorado.

Soil Survey Staff. (2014) *Keys to Soil Taxonomy, Twelfth Edition.* USDA Natural Resources Conservation Service, Washington, DC.

U.S. Forest Service (USFS) (2012) Groundwater-Dependent Ecosystems: Level 1 Inventory Field Guide. *Gen. Tech. Report WO-86a.* U.S. Department of Agriculture, Forest Service, Washington, DC.

USFS (2017) Ecological Subregions: Sections and Subsections for the Conterminous United States. U.S. Department of Agriculture, Forest Service, ECOMAP Team, Washington, DC.

USFS (2019) HT LTA Development. *GTAC-10xxxx-Brief 1.* U.S. Department of Agriculture, Forest Service, Geospatial Technology and Applications Center, Salt Lake City, UT.

U.S. Geological Survey (USGS) (2004) *1:500,000 Scale Geology for the Southwestern U.S.* RS/GIS Laboratory, College of Natural Resources, Utah State University, Salt Lake City, UT.

Williams, K., H. Giard, W. June, T. McKellips and B. Brown. (USFS) (2021-2022) Forest Service GDE Level 1 Inventory on Payette National Forest, Idaho.

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

HUC12 Code	HUC12 Name	Watershed Acres	Likely Fen Count	Likely Acres	Fen Density (Fen Acres/Watershed Acres
170602070301	Upper Chamberlain Creek	36,911	28	100	0.27%
170501230106	Payette Lake	25,289	15	30	0.12%
170501230201	North Fork Lake Fork	12,186	12	39	0.32%
170501230105	Box Creek-North Fork Payette River	12,560	11	33	0.26%
170501230301	Upper Kennally Creek	13,060	11	16	0.12%
170602080506	Lick Creek	21,808	11	25	0.11%
170501230302	Rapid Creek	14,762	10	35	0.24%
170602080408	Blackmare Creek	11,235	10	22	0.19%
170501230101	Headwaters North Fork Payette River	11,240	9	31	0.27%
170602080301	Caton Creek	17,793	9	18	0.10%
170602080501	Lake Creek	29,397	9	36	0.12%
170501230103	Fisher Creek	11,578	8	49	0.42%
170602080504	Loon Creek	11,266	8	16	0.14%
170602090102	Upper French Creek	14,634	8	22	0.15%
170501230104	Brush Creek-North Fork Payette River	21,512	7	26	0.12%
170501230202	East Fork Lake Fork	14,418	7	17	0.12%
170602060601	Beaver Creek	28,019	7	27	0.10%
170602070204	Cottonwood Creek	39,402	7	12	0.03%
170602070302	West Fork Chamberlain Creek	14,385	7	17	0.12%
170602100104	Little Goose Creek-Goose Creek	28,801	7	18	0.06%
170602100302	Vance Creek-Hazard Creek	27,789	7	30	0.11%
170501230203	Little Payette Lake	11,139	6	23	0.21%
170602060702	West Fork Monumental Creek	14,243	6	11	0.08%
170602070706	Fivemile Creek	18,109	6	8	0.04%
170602080410	Buckhorn Creek	31,006	6	29	0.09%
170602080411	Fitsum Creek	20,004	6	14	0.07%
170602080505	Enos Creek-Secesh River	23,362	6	10	0.04%

170602080603	Elk Creek	27,970	6	15	0.05%
170602090201	Elkhorn Creek	13,959	6	40	0.29%
170602060704	Lower Monumental Creek	33,878	5	5	0.01%
170602070801	Upper Warren Creek	24,971	5	10	0.04%
170602080602	Bear Creek	10,225	5	14	0.13%
170602060503	Smith Creek	12,946	4	16	0.13%
170602060901	Cave Creek	11,602	4	14	0.12%
170602070703	Trout Creek-Salmon River	26,224	4	19	0.07%
170602080407	Goat Creek-South Fork Salmon River	17,886	4	22	0.12%
170602080409	Fourmile Creek-South Fork Salmon River	27,637	4	7	0.02%
170602090103	Lower French Creek	21,746	4	17	0.08%
170602090202	Partridge Creek	20,253	4	4	0.02%
170501230102	Twentymile Creek	10,122	3	11	0.11%
170501240302	Upper Hornet Creek	27,957	3	12	0.04%
170602060803	Lower Rush Creek	18,437	3	1	0.00%
170602060902	Cabin Creek	15,940	3	2	0.01%
170602070701	Richardson Creek-Salmon River	23,745	3	6	0.02%
170602070704	Lemhi Creek-Salmon River	18,475	3	10	0.05%
170602071102	California Creek	22,567	3	13	0.06%
170602080205	Quartz Creek	12,280	3	8	0.07%
170602080206	No Mans Creek-East Fork South Fork Salmon River	19,730	3	11	0.06%
170602090101	Little French Creek	12,835	3	17	0.13%
170602100301	Hard Creek	24,083	3	6	0.03%
170602100401	Headwaters Rapid River	26,746	3	2	0.01%
170501230303	Lower Kennally Creek	19,207	2	4	0.02%
170602080203	Tamarack Creek	11,713	2	3	0.03%
170602080204	Profile Creek	12,464	2	3	0.02%
170602080502	Summit Creek-Secesh River	27,728	2	3	0.01%
170602080607	Porphyry Creek	22,053	2	4	0.02%
170602100502	Elk Creek-Little Salmon River	28,437	2	2	0.01%
170501230207	Boulder Creek	34,887	1	13	0.04%
170501240501	Upper Pine Creek	26,721	1	4	0.01%

170502010505	Lower Wildhorse River	14,006	1	2	0.02%
170602060703	Snowslide Creek	13,345	1	1	0.01%
170602070503	Hot Springs Creek-Salmon River	16,732	1	1	0.01%
170602071101	Indian Creek-Salmon River	33,087	1	12	0.04%
170602080201	Headwaters East Fork South Fork Salmon River	16,013	1	1	0.00%
170602080601	Sheep Creek	16,254	1	5	0.03%
170602080604	Rock Creek-South Fork Salmon River	31,070	1	4	0.01%
170602080605	Pony Creek	11,170	1	4	0.04%
170602100201	Sixmile Creek-Little Salmon River	18,809	1	2	0.01%
170602080608	Raines Creek-South Fork Salmon River	30,347	1	1	0.00%