Crowberry Bog Proposed Natural Area Preserve
Natural Area Recommendation

Submitted by Washington Natural Heritage Program
Presented to the Natural Heritage Advisory Council
December 5, 2014

Size

Three boundary options are presented in this document ranging in size from 248 to 469 acres. Option 1 is 258 acres, Option 2 is 348 acres and Option 3 is 469 acres.

Location

The site is located within the Pacific Coast ecoregion, approximately 2.5 miles east of Highway 101, 0.3 miles south of the Hoh River and 0.3 miles north of the Hoh Mainline Road in Jefferson County (Figures 1 and 2). The legal description for each option proposed boundary is: Option 1(Figure 3): portions of T27N R12W Sec 25; Sec 26; Sec. 35, and Sec 36. Option 2 (Figure 4): portions of T27N R11W Sec 31; T27N R12W Sec 25; Sec 26; Sec 35, Sec 36; T27N R11W Sec. 31. Option 3 (Figure 5): portions of T27N R11W Sec. 31; T27N R12W Sec 25; Sec 26; Sec 35; and Sec 36.

Ownership

Ownership is primarily Washington Department of Natural Resources (DNR) with the remainder including DNR-held conservation easements on private lands, and Fruit Growers Supply Co. (Figure 6).

Primary Features

Crowberry Bog may be the only known coastal plateau bog in the western conterminous United States and the southern-most known in western North America. The proposed NAP (pNAP) would provide an opportunity to protect this unique and very rare feature as well as three elements listed as priorities in the *2011 State of Washington Natural Heritage Plan* (Table 1; Figures 3-5): Forested Sphagnum Bog (Priority 2), Low Elevation Sphagnum Bog (Priority 3), and Makah copper butterfly (Priority 2). Peatland classification and knowledge of Washington's peatlands within a continental and global context has advanced since element priorities listed in the 2011 *Natural Heritage Plan* were initially identified. As such, many of the 'bog elements' in the *2011 Natural Heritage Plan* are today considered to be coarse concepts that encompass much diversity and variation. In addition, raised bogs were not known to occur in Washington when the element priorities listed in the *2011 Natural Heritage Plan* were identified. Thus, although Crowberry Bog elements are considered to be part of the Forested Sphagnum Bog and Low Elevation Sphagnum Bog elements in the *2011 Natural Heritage Plan*, the significance of this site is not entirely captured by those concepts. Given that Crowberry Bog appears to be the only coastal plateau bog in Washington State, it represents variation of the Forested Sphagnum Bog and Low Elevation Sphagnum Bog elements found nowhere else in the

Table 1. Priority Elements and Other Features within Crowberry Bog Proposed Natural Area Preserve

Element type	Name	Natural Heritage Plan Priority*	Global / State Rank**	State / Federal Status	Comments
Priority Elements	**Forested Sphagnum Bog** (plant associations listed below are part of this element)	**2**			
	Pinus contorta var. *contorta* - *Tsuga heterophylla* / *Gaultheria shallon* / *Sphagnum* spp. Woodland		GNR S1Q (Proposed)		There are 4 other occurrences in WA.
	Pinus contorta var. *contorta / Ledum groenlandicum* / *Xerophyllum tenax* / *Sphagnum* spp. Woodland		GNR S1Q (Proposed)		Only known occurrence in WA is Crowberry Bog.
	Tsuga heterophylla - (*Thuja plicata*) / *Ledum groenlandicum /* *Carex* (*obnupta, utriculata*) / *Sphagnum* spp. Woodland		GNR S1 (Proposed)		There are 10 other occurrences in WA. found at Hoh Bog
	Low Elevation Sphagnum Bog (plant associations listed below are part of this element)	**3**			
	Kalmia microphylla - *Vaccinium oxycoccos* / *Empetrum nigrum* / *Sphagnum* spp. Dwarf-shrubland		GNR S1Q (Proposed)		Only known occurrences in WA are at Crowberry and Hoh bogs.
	Kalmia microphylla - *Ledum groenlandicum* / *Xerophyllum tenax* Shrubland		G1 S1		At Crowberry Bog
	Makah Copper butterfly (*Lycaena mariposa charlottensis*)	**2**	G4T5 S2	State Candidate / Federal Species of Concern	Populations at Crowberry & Hoh bogs
Other features	***Sphagnum austinii*** (Austin's sphagnum moss)		G4 S1		Populations at Crowberry & Hoh bogs
	Splachnum ampullaceum (small capsule dung moss)		G5 SNR (only two known locations)		At Crowberry Bog

*based on 2011 State of Washington Natural Heritage Plan for the Pacific Coast ecoregion
** See http://www1.dnr.wa.gov/nhp/refdesk/lists/stat_rank.html for more information about Global and State ranks; generally G1 or S1 indicates something that is critically imperiled while G5 or S5 indicates something that is very common and demonstrably secure.

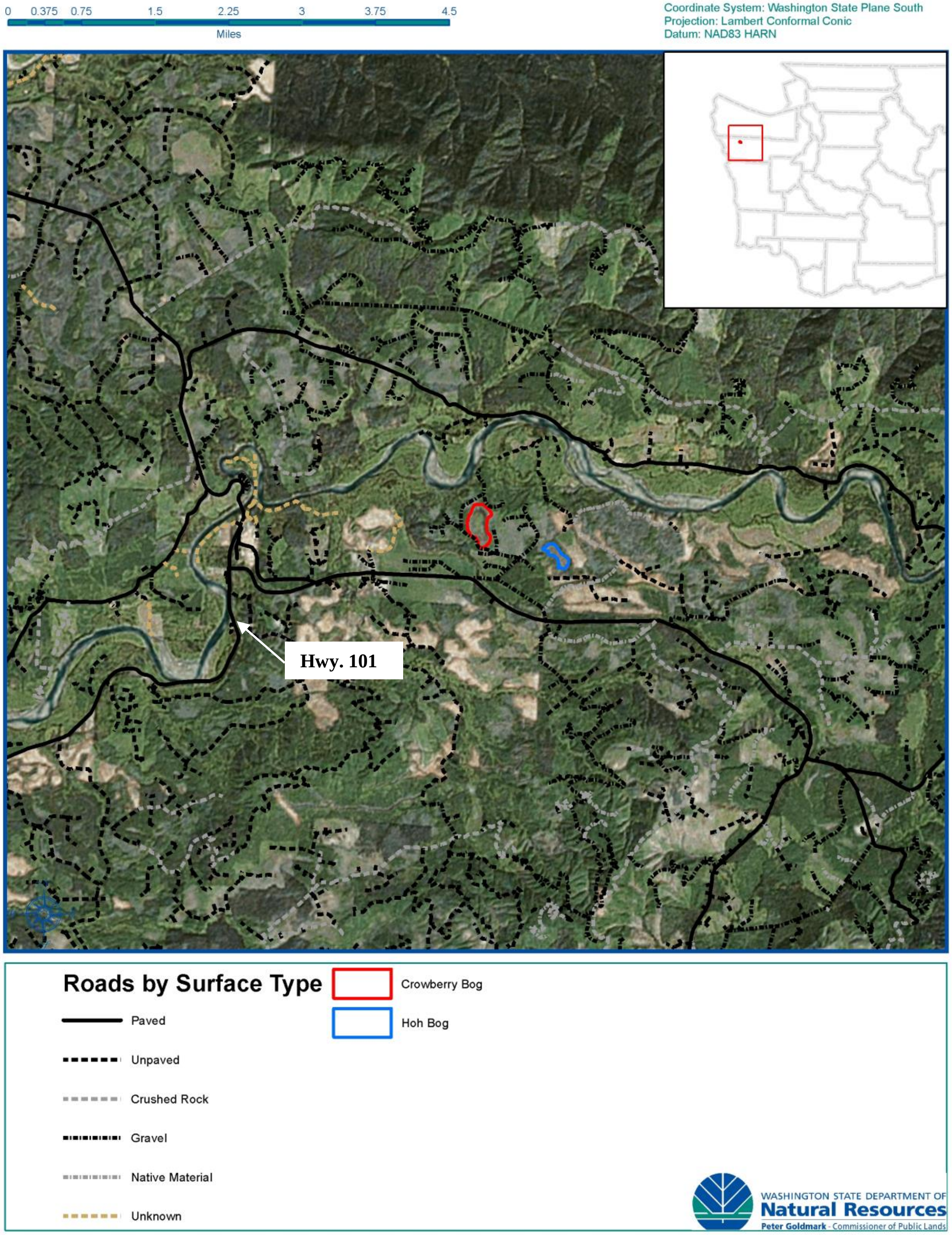

Figure 1. Location of Crowberry and Hoh bogs (aerial imagery)

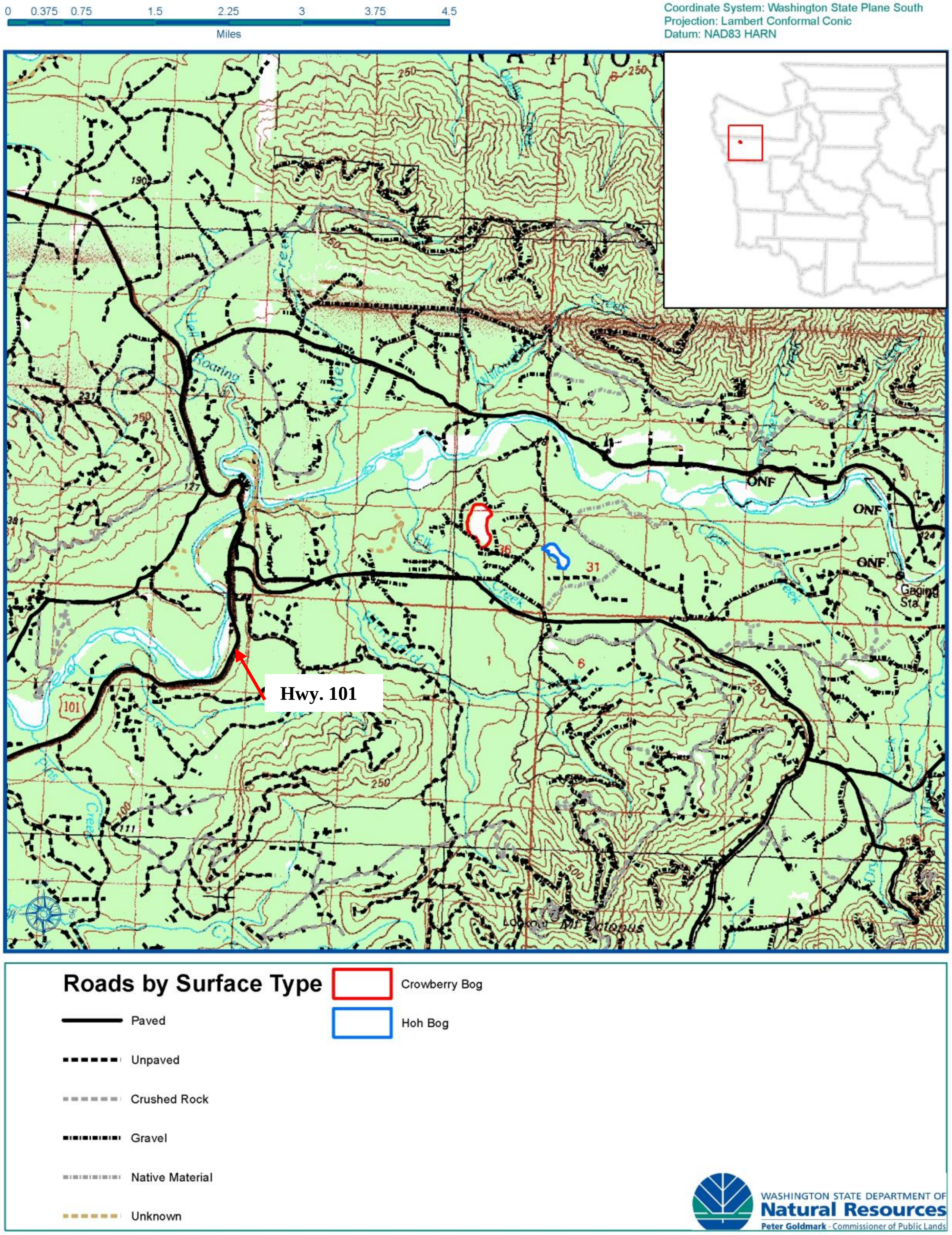

Figure 2. Location of Crowberry and Hoh bogs (USGS 1:24K Topo)

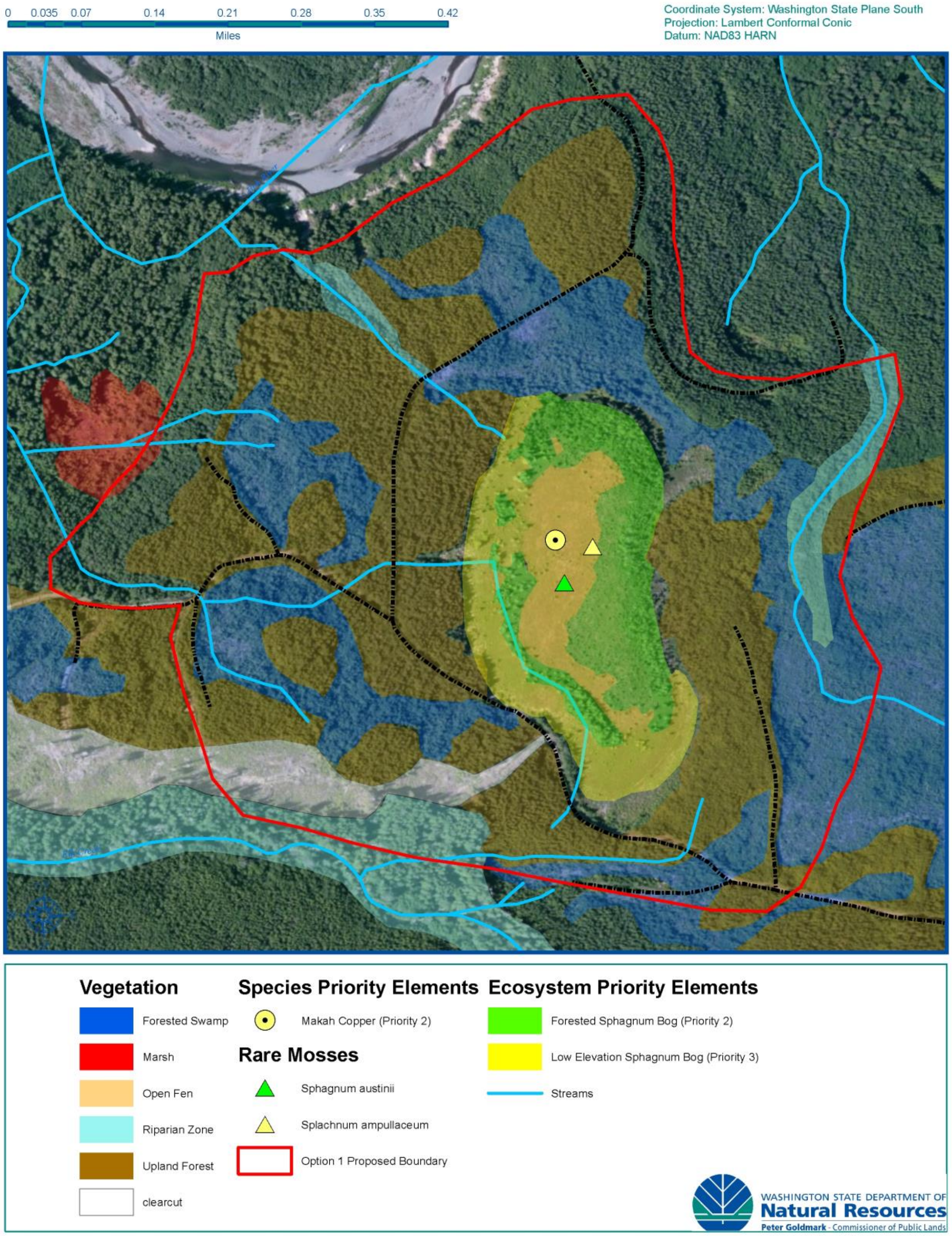

Figure 3. Crowberry Bog pNAP Option 1 Proposed Boundary

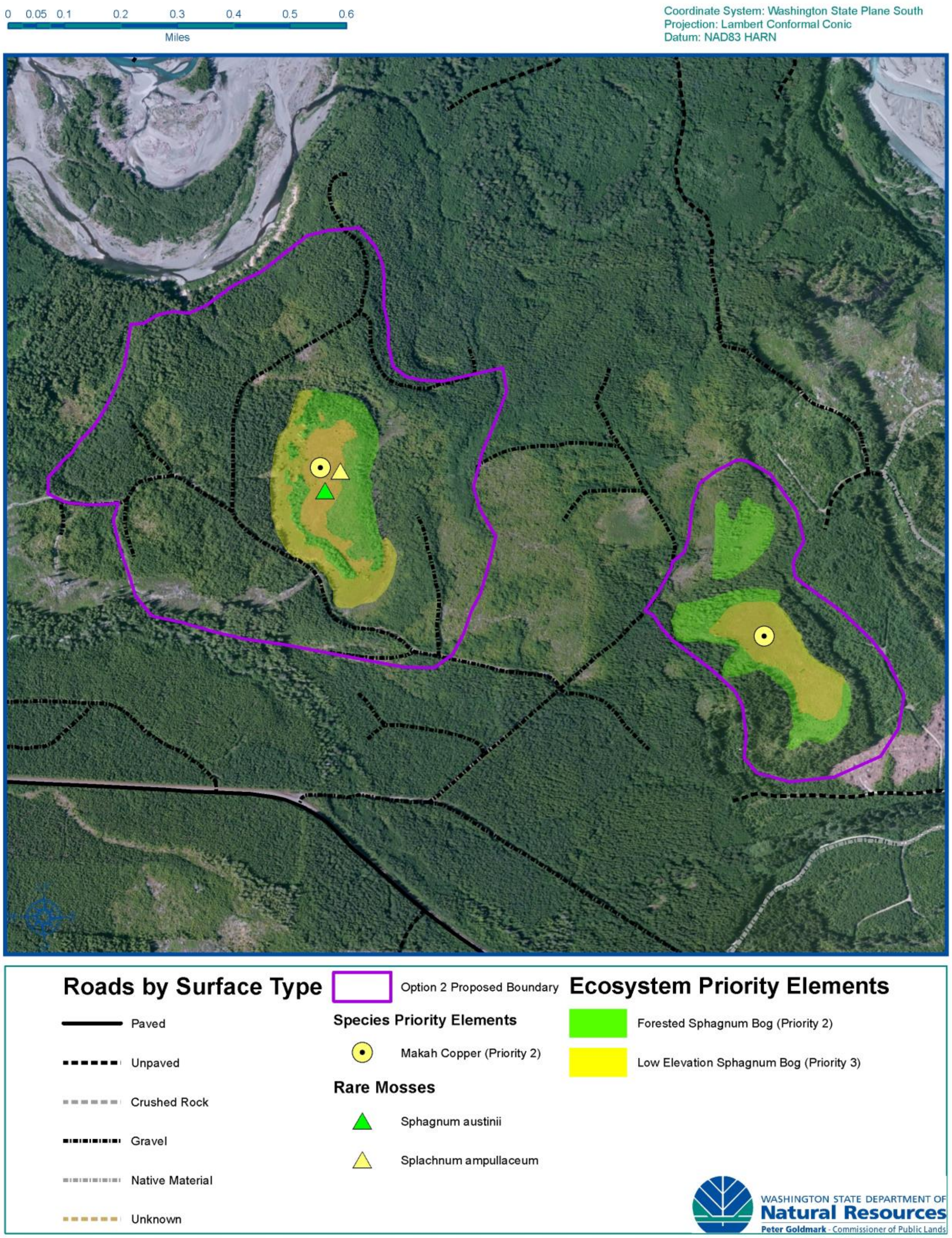

Figure 4. Crowberry Bog pNAP Option 2 Proposed Boundary

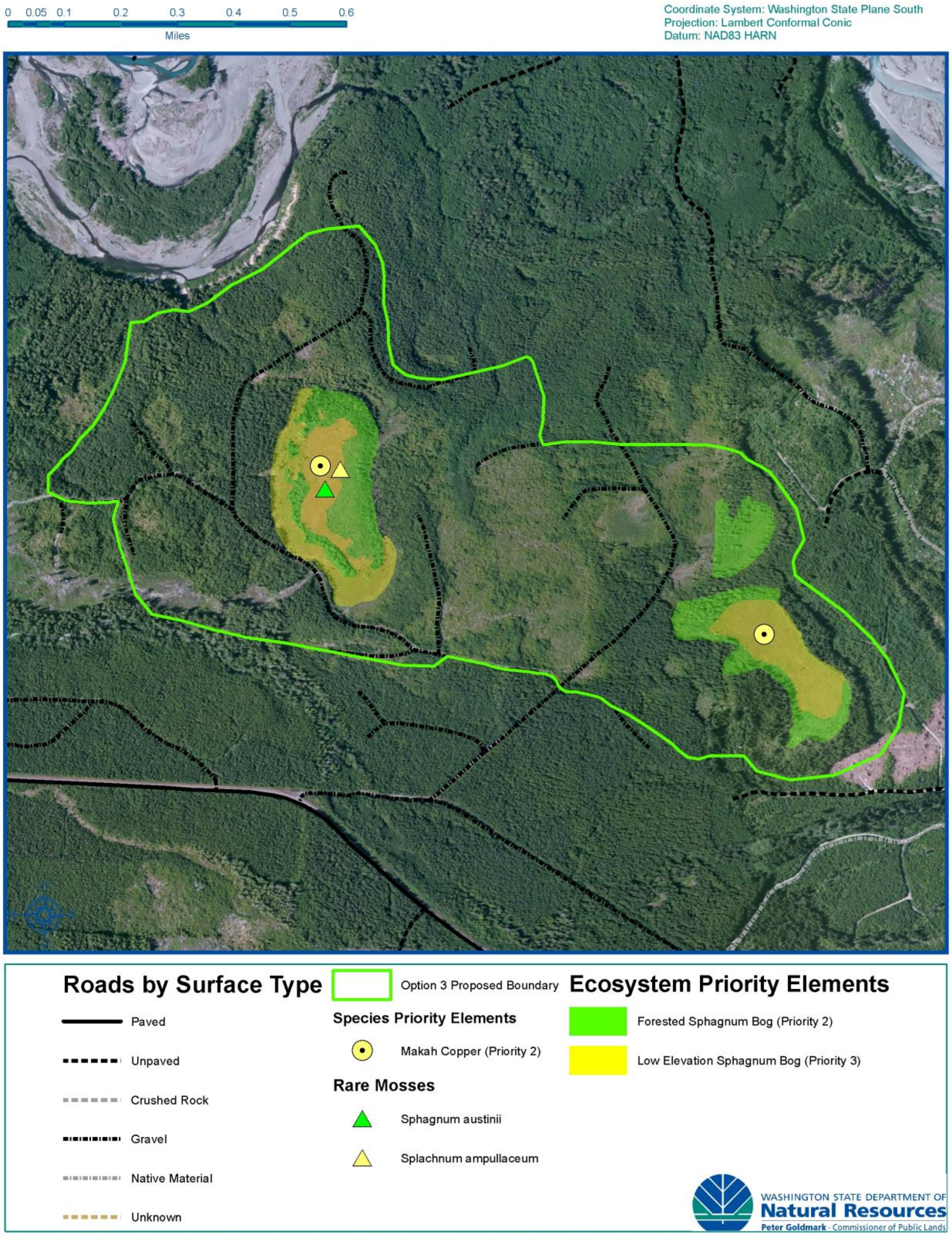

Figure 5. Crowberry Bog pNAP Option 3 Proposed Boundary

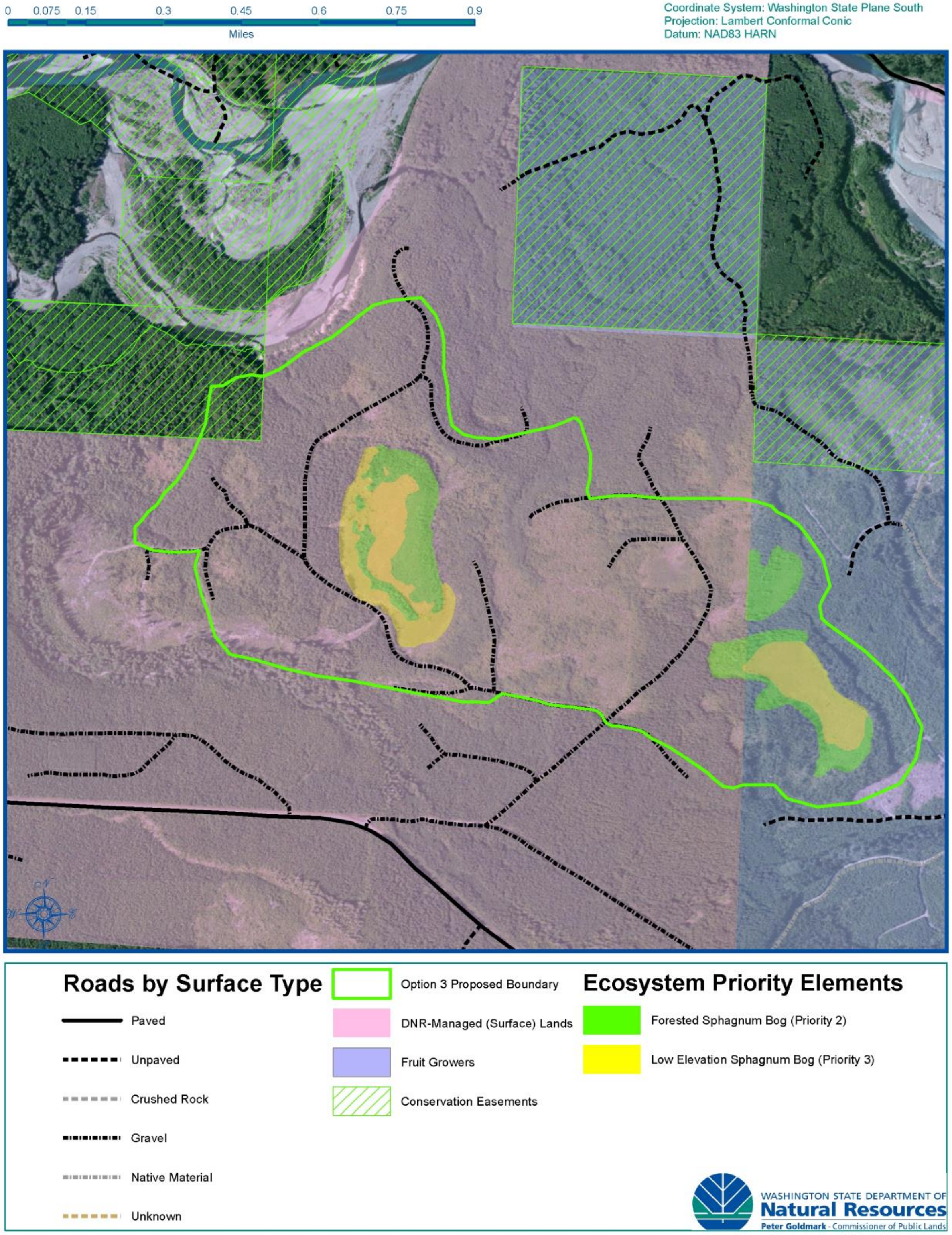

Figure 6. Ownership Patterns at the Crowberry Bog Proposed Natural Area Preserve

State. Furthermore, due to Crowberry Bog possibly being the only known plateau bog in the western, conterminous United States and the southernmost on the western North American continent, Dr. Ian Worley (Professor Emeritus, University of Vermont), an expert on Atlantic plateau bogs, noted that the bog has continental, national, and regional conservation significance (Dr. Ian Worley, *personal communication*). Two mosses, *Sphagnum austinii* and *Splachnum ampullaceum*), both rare within Washington; also occur in the pNAP (Table 1; Figures 3-5). These mosses are not currently listed as priority elements in the *2011 Natural Heritage Plan* but will likely be considered when a more thorough assessment of bryophytes is conducted.

Raised (Plateau) Bog

Although not identified in the *2011 State of Washington Natural Heritage Plan* as a priority element, the raised bog is the most significant feature within the pNAP. Early literature about Washington's peatlands (Rigg 1940; 1951; 1958) noted that two types of bogs were found in the State: (1) flat bogs and (2) raised bogs. Flat bogs have also been referred to elsewhere as "raised, level bogs" (Gawler and Cutko 2010), "gently convex bogs" (Davis and Anderson 2001), and "flat and basin bogs" (NWWG 1997). Based on recent research (Kunze 1994; Kulzer et al. 2001) and the author's experience, almost all bogs in Washington are flat bogs. These bogs are slightly raised, relatively flat across their surface but with a distinct hummock/hollow pattern, and never form distinctive convex surfaces. Flat bogs often have some presence of mineratrophic species (e.g., *Carex* spp., *Spiraea douglasii*, *Malus fusca*, etc.) suggesting groundwater/surface water is close enough to the upper peat body to affect species composition. Raised bogs are noticeably elevated above the level of the surrounding wetland/upland habitat (Rydin and Jeglum 2013). Raised bogs are a biological landform---they are formed by thousands of years of peat accumulation, primarily from dead remains of peat mosses (*Sphagnum* spp.). This process of peat accumulation creates a conspicuous raised surface that develops above the surrounding topography and isolates the bog surface from groundwater influence. This creates ombrotrophic conditions (meaning the bog only receives water and nutrients from precipitation), ecological characteristics limited to true bogs. There are generally three types of raised bogs recognized in circumboreal regions across the world: domed bogs, plateau bogs, and blanket bogs (Moore and Bellamy 1974; Rydin and Jeglum 2013).

There has been very little, if any, research to demonstrate the degree to which Washington's bogs are truly ombrotrophic. In lieu of those data, vegetation and surface contours are primarily used as surrogate indicators. Crowberry Bog is one of two Washington bogs that have conspicuous indicators of being raised— centimeter-accuracy GPS data show that the highest portion of Crowberry's central bog expanse is approximately nine feet (~2.7 meters) higher than the lowest portion of the bog edge, LiDAR imagery shows a clear raised surface (Figure 7) and vegetation patterns exhibit characteristics of raised bogs in Canada and Europe (Figure 12; Moore and Bellamy 1974; Damman 1977; NWWG 1997; Rydin and Jeglum 2013). More specifically, Crowberry Bog shows clear indicators of being a plateau bog which include: (1) relatively steep marginal slopes; (2) flat or plateau-like interior (e.g. bog expanse) with little hummock/hollow pattern; (3) close proximity to the open ocean; and (4) species limited to coastal peatlands (Ian Worley, personal communication; Worley 1980; and Damman 1977). Coastal plateau bogs are extremely rare within North America and have previously only been documented along a narrow coastal strip in Maine, New Brunswick, Nova Scotia, and the

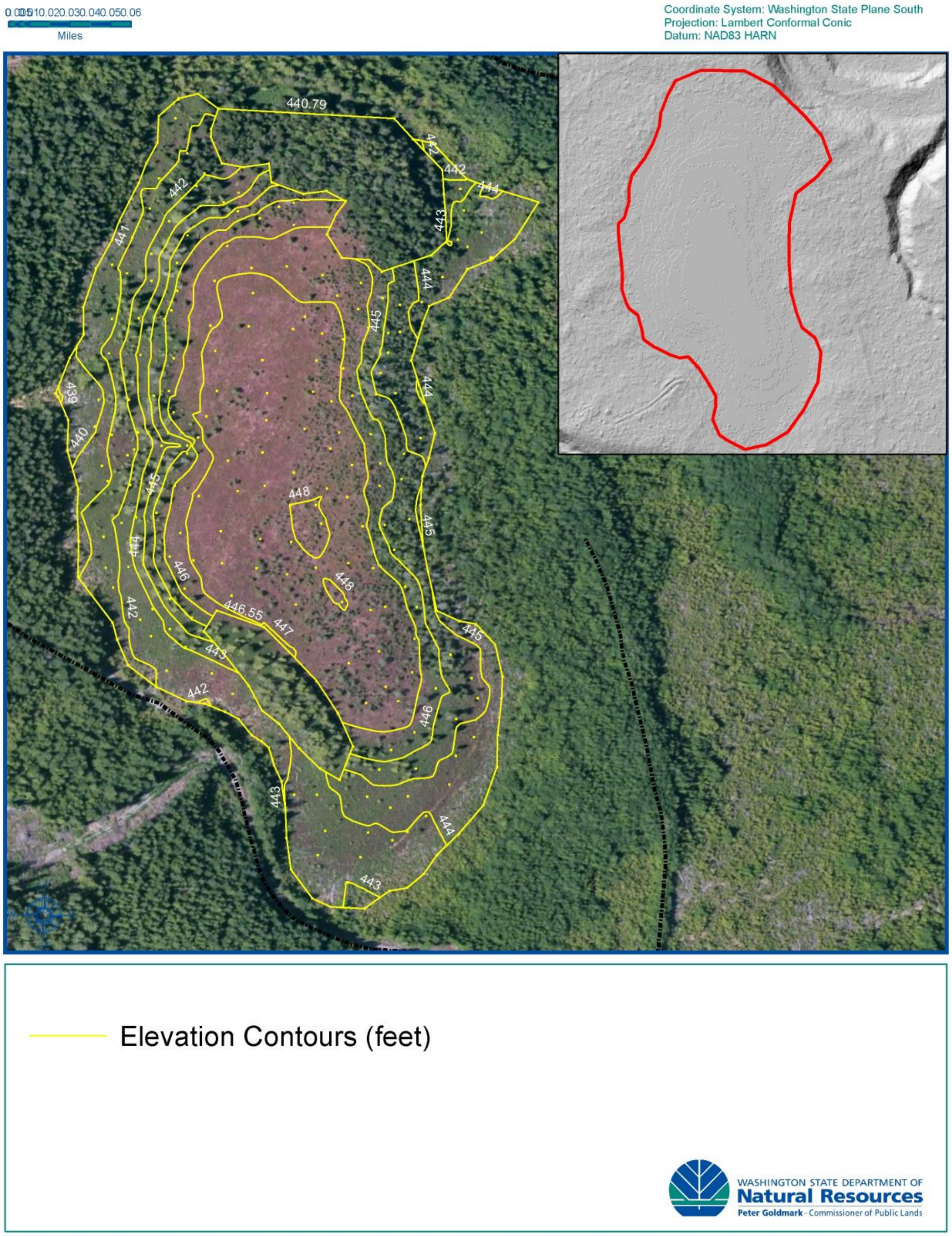

Figure 7. Elevation contours and LiDAR imagery (inset) exhibiting raised nature of Crowberry Bog (note: elevations derived from GPS (cm-accuracy) data collected by DNR surveyors.)

western coast of Newfoundland (Davis and Anderson 2001; Damman 1977; Damman and French 1987; Worley 1980). Globally, they have also been noted along the coast of southern Finland, southeast Sweden, and the eastern Baltic region (Davis and Anderson 2001; Damman 1977; Moore and Bellamy 1974). All of these locations share a few climatic similarities: (1) regionally high precipitation; (2) relatively long-growing season; (3) summer fog; and (4) salt spray. Although climatic conditions conducive for plateau bog formation are present in portions of coastal British Columbia, the raised bogs there have all been typed as domed bogs (NWWG 1988).

<u>Crowberry Bog appears to be the only plateau bog (and one of a few raised bogs) in western, conterminous United States and the southernmost (and thus far, the only documented) in western North America</u>. The author conducted field visits to the raised bogs referenced in Rigg (1940; 1951; 1958) and Bach and Conca (2004) and only one of those sites appeared to be raised based on contemporary criteria for those types of bogs (NWWG 1997; as reviewed in Rydin and Jeglum 2013). That site, Roose's Prairie, appears to be a domed bog but additional investigation needs to occur in order to confirm its morphology and ecological conditions.

As a plateau bog, Crowberry Bog supports vegetation communities that are restricted to coastal peatlands, it provides habitat for rare mosses more typical of northern peatlands, and represents a biological landform found nowhere else in Washington State. In addition, because the bog is no longer hydrologically connected to local surface and/or groundwater and because this site occurs within what may be its climatic limit, it provides an excellent site for monitoring climate-induced ecological changes.

<u>Priority Elements</u>

Table 1 lists the three Priority Elements listed in the *2011 State of Washington Natural Heritage Plan* found at the site: (1) Forested Sphagnum Bog (Priority 2), Low Elevation Sphagnum Bog (Priority 3) and Makah copper butterfly (Priority 2).

<u>Forested Sphagnum Bog</u> occurs around the edges of both Crowberry and Hoh bogs (Figures 3-5). There is also a small but high-quality occurrence of this element just north of, but apparently hydrologically distinct from, the occurrence of this element around Hoh Bog (Figures 3-5). This element is broadly defined as forest dominated peatlands that have an open structure with a conspicuous cover of *Sphagnum* species on the ground surface. Within the pNAP, there are three plant associations that are associated with the Forested Sphagnum Bog element. All three are considered to be critically imperiled within Washington due to their rare occurrence on the landscape (Table 1).

<u>Low Elevation Sphagnum Bog</u> occurs within the interior portion of both Crowberry and Hoh bogs (Figures 3-5). This element is broadly defined as herbaceous and shrub-dominated peatlands with *Sphagnum* species dominating the ground surface. The occurrence of this element at Crowberry is expressed as bog dwarf shrublands and herbaceous water track vegetation. Within the pNAP, there are two plant associations that are associated with the Low Elevation Sphagnum Bog element. Both are considered to be critically imperiled within Washington due to their rare occurrence on the landscape (Table 1).

Makah copper butterfly (*Lycaena mariposa charlottensis*) populations are found at both Crowberry and Hoh bogs (Figures 3-5 where it uses native cranberries (*Vaccinium oxycoccos*) as a larval host plant (Jordan and Fleckenstein 2011). The Makah copper has been listed by the USFWS as a Species of Special Concern because of limited distribution and threatened habitat. It is also on the Bureau of Land Management and U.S. Forest Service Sensitive Species lists and is a candidate for listing by the Washington Department of Fish and Wildlife (Fleckenstein 2009).

Other Features

Sphagnum austinii is a peat moss that has a circumboreal distribution but is primarily limited to areas with a strong oceanic influence. It forms large hummocks in ombrotrophic and blanket bogs. Although it is not considered rare across its entire range (G4), Andrus et al. (1992) considered *S. austinii* to be imperiled within the United States (N2). Within Washington the species is considered critically imperiled (S1) and is limited to four populations, most of which are located in acidic peatlands near Ozette Lake. The population at Crowberry Bog is the southernmost known in western North America. *Splachnum ampullaceum* is another rare moss found at Crowberry Bog. It only occurs on herbivore dung generally within peatlands. Although considered globally common, it has only been documented in one other location in Washington (Hutten et al. 2005).

Climate

The nearest climate stations are (1) Spruce, which is approximately 7 miles due east of the pNAP along the Hoh River and (2) the city of Forks, about 12 miles northwest of the pNAP (Western Regional Climate Center 2014). The Spruce station does not have temperature data. Average maximum temperature for the Forks station is 58.5 ^{o} F and average minimal temperature is 40.7^{o} F. July and August are the warmest months while December and January are the coldest. The range of average maximum temperatures over the year is less than 30 ^{o} F. The range of average minimum temperatures over the year is approximately 16 ^{o} F. Average annual precipitation for the Spruce station is 123.4 inches and 117.89 inches at the Forks station. Most precipitation falls between October and April at both stations. Rainfall between May and September is similar at both stations. The difference in precipitation between the stations is most pronounced between December and February.

Geology

Crowberry Bog, Hoh Bog, and the other wetlands within the pNAP occur on glacial drift derived from alpine glaciers of Fraser age. These drift deposits occur on a plateau above surrounding deposits of glacial outwash and alluvial deposits associated with the Hoh River. The Olympic Mountains were covered by a solid ice cap during Quarternary glaciation (Heusser 1974). Alpine glaciers, derived from this ice cap, flowed down the major river valleys. More than 47,000 years ago, the Hoh river valley was glaciated to its present day mouth. About 19,000 years ago the retreating ice terminus stagnated in the general area in which the pNAP occurs (Heusser 1974). Ice blocks left in this area did not melt for another 3 to 4, 000 years at which point wetland development was initiated (Heusser 1974), ultimately leading to the development of the raised bogs that are present today. A morainal deposit is mapped as occurring on the eastern side of Hoh Bog. A similar landform occurs east of Crowberry Bog but is not mapped as morainal deposit.

Topography and Hydrology

The pNAP occurs in the Pacific Coast Ecoregion, just south of the Hoh River on a bench of glacial deposits. Topography is relatively flat except where glacial drift deposits slope steeply downward to glacial outwash and alluvial deposits (Figure 8). Elevation within the pNAP ranges from approximately 250 to 540 feet. The highest point occurs at the crest of the morainal deposit east of Hoh Bog while the lowest area occurs in the northwest portion of the pNAP where outwash deposits are in contact with Hoh River alluvial deposits. Based on a recent DNR topographic survey of Crowberry Bog, the highest portion of that bog (~448 ft. elevation) is ~9 ft. higher than the lowest portion of the lagg or outer margin of the bog (~439 ft.; Figure 7). Hoh Bog also shows elevation variation with the lowest point (approximately 482 ft.) being in the northwest portion of the bog and the highest point (approximately 486 ft.) in the southeast part of the bog.

Hydrological patterns associated with raised bogs are quite different than other wetlands. A common, generalized theory about raised bog hydrology classifies the peat body into two layers: acrotelm and catotelm (Figure 9; Ingram 1978). The upper layer, called the acrotelm, is relatively thin (often less than 50cm deep), and consists of living stems of *Sphagnum* mosses, recently dead plant material and water. The acrotelm is the aerated, upper portion of the peat that occurs above the lowest level of the ombrotrophic water table (Figure 9). The acrotelm is also known as the "active" layer as this is the zone in which plants are rooted and peat mosses are actively growing (Rydin and Jeglum 2013). It is also where most peat accumulation occurs within the bog (Malmer 2014). Permeability of the acrotelm is high near the surface but decreases with depth as the peat becomes more decomposed (humified) and consolidated (Damman 1986). Below the acrotelm is a much thicker peat body, known as the catotelm. The catotelm consists of much more decomposed and consolidated peat, although this can vary based on the source of peat (i.e., woody-, sedge- or moss-derived peat) Hydraulic conductivity is extremely slow in the catotelm due to the high water holding capacity of highly decomposed peat (Damman 1986). Because of this, the boundary between the acrotelm and catotelm, which is typically within < 1 meter of the peat surface, is relatively impervious. The relatively impermeable boundary creates a perched water table within the acrotelm. As the peat mound grows upward with time, this impervious layer also moves upward eventually resulting in a perched, ombrotrophic water table many meters above the influence of surface or groundwater from adjacent lands (Figure 9). This ombrotrophic water table fluctuates with seasonal and intense precipitation events within the acrotelm. In contrast to the fluctuating water within the acrotelm, the catotelm is where most of the water in the bog is stored and is always saturated. The amount of water held within this peat body is immense and often accounts for over 95% (by weight) of the peat mass (Charman 2002). Although the catotelm has very low hydraulic conductivity it does slowly lose water to seepage and evapotranspiration. The loss of this water is replaced primarily by slow infiltration from the acrotelm where precipitation enters the bog. This results in storage of ombrotrophic waters in the upper portions of the catotelm (Figure 9). The lower layers of the catotelm may receive groundwater and surface water inputs from surrounding uplands but this mineratrophic water is

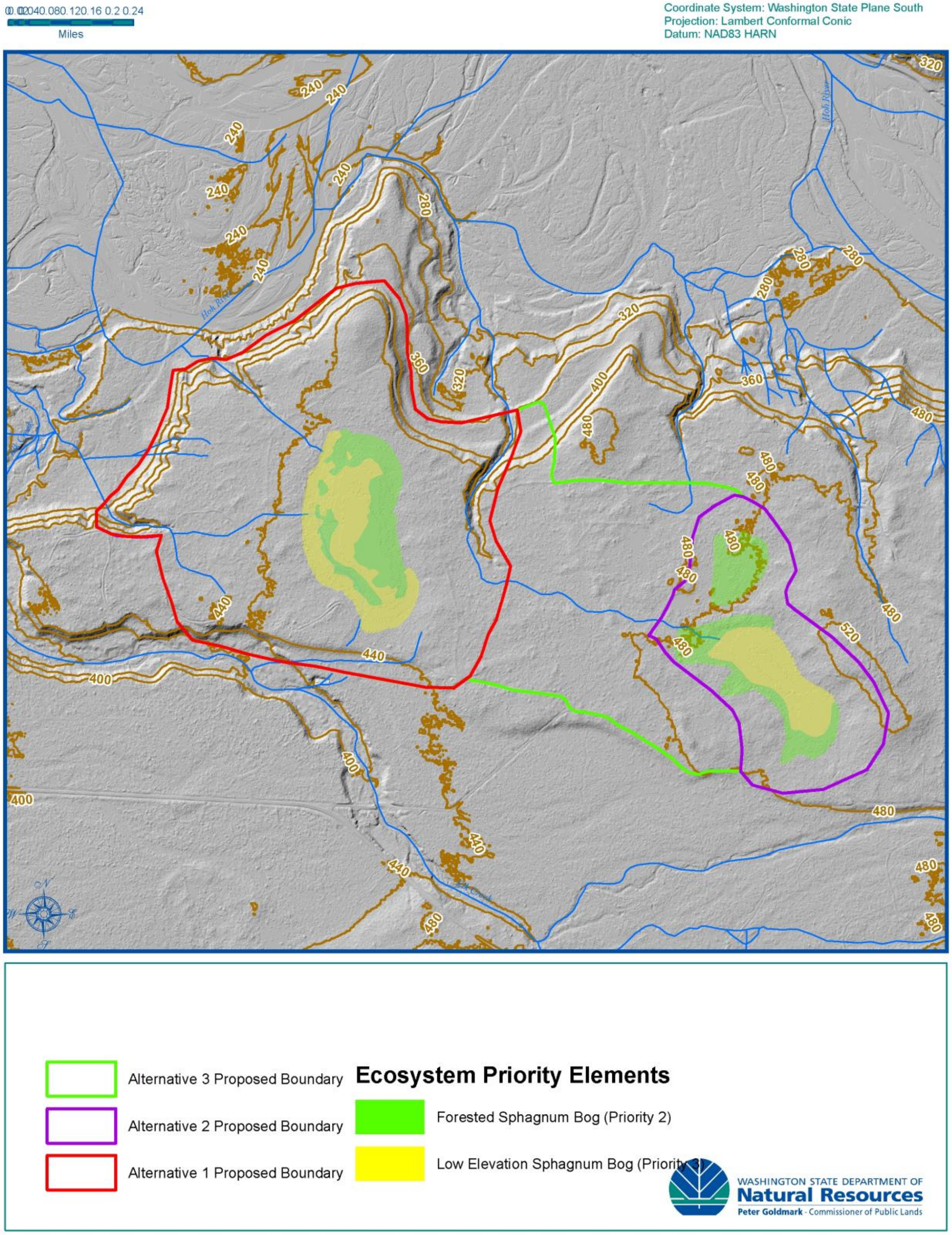

Figure 8. Topography and Surface Waters of Crowberry Bog Proposed Natural Area Preserve.

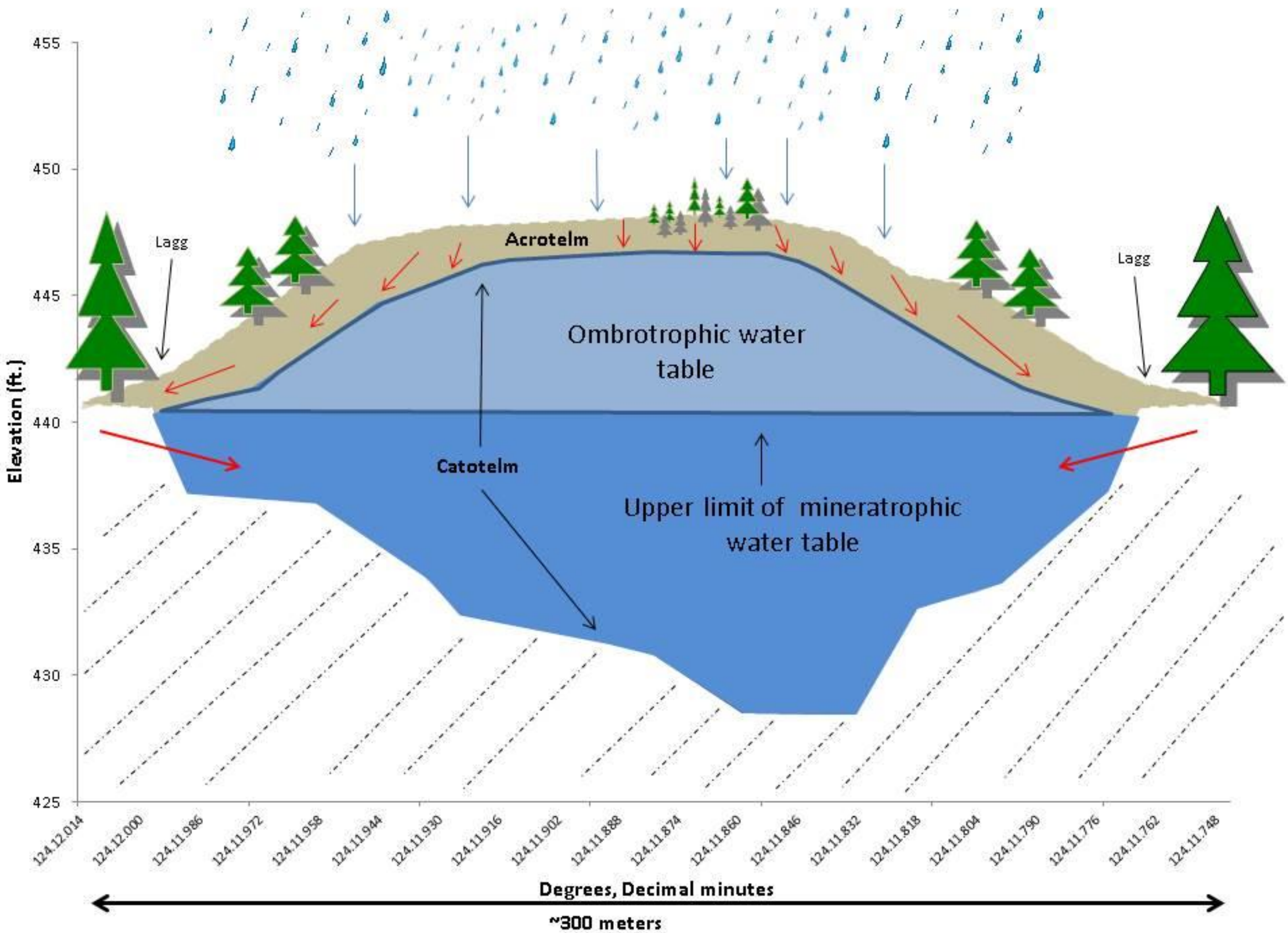

Figure 9. Generalized hydrological regime of Crowberry Bog

not in contact with the acrotlem and thus not accessible to plants growing on the bog surface (Figure 9). As such, conditions in the acrotelm are known as "ombrotrophic," meaning the only source of water is from precipitation which results in a very acidic and nutrient poor environment even though lower layers of the catotelm could be mineratrophic (Figure 9).

Because of its very low hydraulic conductivity, only an estimated 1% of total discharge from raised bogs is from the catotelm (Bragg 2002). Most water discharging from raised bogs is from the acrotelm, where runoff can be rapid following heavy rainfall, especially once the acrotelm is saturated (Bragg 2002). Essentially, as the acrotelm becomes saturated, the path of least resistance for water flow is through the relatively permeable acrtolem rather than into the impermeable catotelm. The raised morphology of the peat body directs this water to the margins of the bog (Figure 9). Observations from Crowberry Bog indeed suggest that saturation of the acrotelm and water flow out of the bog is much greater during the rainy season rather than late summer when conditions in the bog are relatively dry. As such, surface and groundwater flow moves away from Crowberry Bog. Most of this drainage appears to move west and north, ultimately draining into the Hoh River (Figure 8). Due to relatively flat topography surrounding Crowberry and Hoh bogs, it appears that very little upland surface water flows into the bogs. The exceptions are the upland areas (morainal deposits) on the eastern side of the bogs where sheetflow may move into the outer edge of the bog's lagg (Figure 9). The lagg collects water from both the raised portion of the bog and the adjacent upland. As such the hydrology, acidity, and nutrient status of the lagg is transitional between the bog and upland and is integral to maintaining hydrogeochemical conditions in the bog system (Howie and Tromp-van Meerveld 2011). The degree to which groundwater from adjacent uplands may move into lower portions of the catotelm is not currently known. Understanding the hydrogeochemical dynamics between the acrotelm, catotelm, lagg and surrounding upland is important for ensuring that future management activities maintain the natural hydrology of Crowberry Bog.

Until additional data can confirm whether or not Hoh Bog is also raised, it is difficult to generalize about that bog's hydrology. If Hoh Bog is found to be raised or ombrotrophic, then general hydrological patterns will be similar to those described above for Crowberry Bog. If Hoh Bog is determined to be a flat bog or poor fen then groundwater discharge will be of more significance to understanding the site's hydrology.

Forested swamps are abundant in the pNAP and are likely supported by both surface and groundwater (Figure 10). The glacial deposits and associated soils (see next section) limit water infiltration creating shallow water tables throughout much of the pNAP. Even in areas of upland forest, wetland species such as *Lysichiton americanus* (skunk cabbage) are found growing in swales and small depressions that are often only a foot or so below where upland species are growing. This suggests water tables are high even in areas where upland species predominate.

Soils

Soils in Crowberry and Hoh Bogs are mapped as Orcas peat deposits which are derived from *Sphagnum* species (USDA 1975). A peat core from Crowberry Bog indicated that *Sphagnum*-derived peat extends to a depth of 12.5 feet (3.8 meters; Heusser 1974). Below the *Sphagnum* peat is a layer of muck extending another three feet (1 meter) in depth followed by a mix of muck and clay which extends to the bottom of the wetland basin at a depth of 19 feet (5.8 meters; Heusser 1974). A core from Hoh Bog showed *Sphagnum*-derived peat to a depth of 6.5 feet (2 meters) followed by 2 feet (70 cm) of muck then 1.5 ft. (50 cm) of muck/clay mix and at the bottom was a clay layer (Heusser 1974). Soils around the bogs and on top of the glacial drift are mapped as the Lagitos-Klone-Tealwhit soil complex which consists of clayey or fine-texture old alluvium (USDA 1975; DNR 2014). This complex consists of poorly drained, somewhat poorly drained silty loam over sand and gravel, and well-drained gravelly loam derived from glacial outwash (DNR 2014). The entire soil complex is indicated as having "difficult soil conditions for forest operations" (DNR 2014).

Vegetation

Crowberry Bog exhibits many ecological patterns typical of raised bogs found elsewhere in the world, including a relatively open central bog expanse, a wooded "rand", and a lagg around the outer perimeter of the bog (Crum 1992; Moore and Bellamy 1974; Damman 1977; NWWG 1997; Rydin and Jeglum 2013; Figure 11). The central bog expanse at Crowberry Bog, where ombrotrophic conditions are presumed to exist, is dominated by the *Kalmia microphylla - Vaccinium oxycoccos* / *Empetrum nigrum* / *Sphagnum* spp. Dwarf-shrubland plant association (Figure 12). Dominant species include very short statured (<30cm) *Ledum groenlandicum* and *Kalmia microphylla*, *Vaccinium oxycoccos*, and *Empetrum nigrum* with a nearly continuous carpet of *Sphagnum fuscum* and *S. rubellum*. *Xerophyllum tenax* and *Lysichiton americanum* are also scattered throughout this association. A few hummocks of the rare *Sphagnum austinii* as well as a few patches of the rare moss, *Splachnum ampullaceum*, were found in this community type. Embedded within this association are small hollows (low points) or linear water tracks dominated by *Eriophorum chamissonis*, *Rhynchospora alba*, and *Sphagnum* cf. *angustifolium* (Figure 13). Also occurring within the interior, highest portion of the bog is a *Pinus contorta* var. *contorta / Ledum groenlandicum* / *Xerophyllum tenax* / *Sphagnum* spp. Woodland (Figure 14). This woodland consists of open, stunted *Pinus contorta* var. *contorta*. Despite not being very tall many of these trees appear to be relatively old. The understory is similar to that of the central raised bog. Along the inclined or outwardly sloping margin of the bog is the rand (Damman 1977; Crum 1992; Howie and Tromp-van Meerveld 2011) where closed forest or woodland is dominant (Figure 15). The *Pinus contorta* var. *contorta* - *Tsuga heterophylla* / *Gaultheria shallon* / *Sphagnum* spp. Woodland is the dominant association on the rand. Tree, shrub, and herbaceous vigor and density conspicuously increase where the rand occurs due to a generally lower water table than that which occurs in the central bog expanse (Howie and Tromp-van Meerveld 2011). Tree cover in the rand is continuous and dense in some areas and open and discontinuous in other areas. The closed rand forests are dominated by *Pinus contorta* var. *contorta* and *Tsuga heterophylla* with a very sparse understory of *Gaultheria shallon*, *Xerophyllum tenax*, and occasional *Ledum groenlandicum* and *Vaccinium parviflorum*. *Xerophyllum tenax* can be quite abundant in some areas. Feather mosses dominate the forest floor and patches of *Sphagnum* cf. *pacificum* occur around some tree bases or in windthrow hollows. The open portions of the rand have similar composition, although *Tsuga heterophylla* is the more abundant tree in western portions of the rand. The open nature of these areas also allows for a more robust and vigorous understory than in the closed forests. The lagg is a transition zone at the margin of bogs which receives water from both the bog and surrounding uplands resulting in slightly less acidity and often more nutrient rich water chemistry than the

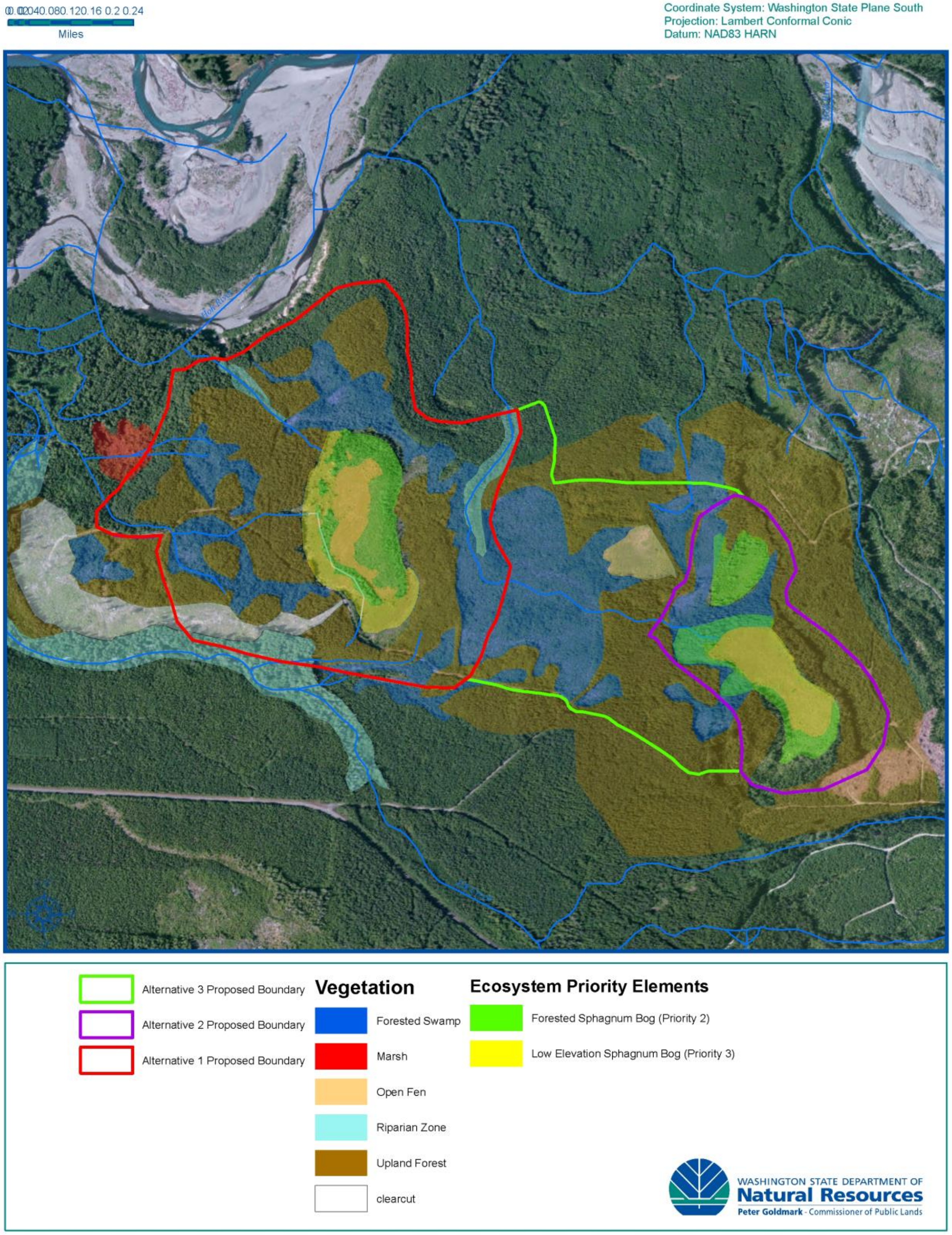

Figure 10. Vegetation of the pNAP.

central bog expanse (Howie and Tromp-van Meerveld 2011). As a result, vegetation in the lagg is characterized by fen or swamp vegetation. At Crowberry Bog, the lagg is dominated by the *Kalmia microphylla - Ledum groenlandicum* / *Xerophyllum tenax* Shrubland plant association (Figure 16). Although overall species composition is similar to open areas of the rand and even the central bog expanse, lagg vegetation differs in a few characteristics: (1) the lack of *Empetrum nigrum*; (2) individuals of *Ledum groenlandicum*, *Kalmia microphylla*, *Xerophyllum tenax*, and *Lysichiton americanum* are taller and more vigorous than individuals in the central bog expanse, and (3) a different *Sphagnum* composition than the central bog expanse with *Sphagnum* cf. *angustifolium* being more dominant and *S. fuscum* and *S. rubellum* less abundant, the presence of *S. capillifolium* hummocks, and presence of other yet to be identified *Sphagnum* species that appear to be lacking in the central bog expanse.

Although LiDAR (light detection and ranging) imagery suggests Hoh Bog may also be a raised bog, the ecological patterns are not as conspicuous as at Crowberry (Figure 17). The distinction between the central bog area and marginal features such as the rand and lagg are not as abrupt as at Crowberry Bog. The distinction between rand and lagg is even less obvious and whether both occur at Hoh Bog is uncertain. Like at Crowberry Bog, the central portion of Hoh bog is dominated by the *Kalmia microphylla - Vaccinium oxycoccos* / *Empetrum nigrum* / *Sphagnum* spp. Dwarf-shrubland plant association. This community has a slightly different expression here than at Crowberry Bog. *Pinus contorta* is not found at Hoh bog; instead numerous, stunted but seemingly old *Tsuga heterophylla* trees are scattered throughout the central bog area (Figure 17). Second, *Pteridium aquilinum* and *Xerophyllum tenax* are much more abundant at Hoh Bog compared to Crowberry Bog. At Crowberry Bog, these species are abundant in the rand and lagg but only scattered in the central bog area. These species are known to respond positively to fire. Also, the peat surface at Hoh Bog seems more compact and firm compared to Crowberry Bog which might also be explained by recent fire activity that may have burned off the top, less relatively undecomposed layers of peat, leaving deeper, more humified, and thus more compact peat layers at the contemporary surface. Many of the larger snags around the periphery of the bog also show abundant fire scars and charring, some of which are located near the top of 30 to 40 foot snags. There is a slight shift in vigor and composition around the outer periphery of the bog which is assumed to be the transition from bog expanse to the lagg/rand (Figure 17). Here *Tsuga heterophylla* trees and other species become more vigorous and taller. The influence of mineratrophic groundwater in this area also becomes apparent with the presence of mineratrophic species such as *Carex utriculata*, *Camassia quamash* ssp. *azurea*, *Sanguisorba officinalis*, *Gentiana sceptrum*, *Carex echinata* cf. ssp. *phyllomanica*, and *Hypericum anagalloides*. *Sphagnum papillosum*, *Sphagnum cf. angustifolium*, and *Sphagnum cf. pacificum* are also more abundant here than the central bog area. Within the central bog expanse is a tree "island". This upland knoll appears to be associated with bedrock or possibly the top of a large erratic protruding to the surface in this area of the bog. Mineratrophic species occur around the southern and southwest portion of this island suggesting runoff from the island and groundwater in contact with underlying bedrock are influencing vegetation composition in this area. The southwest and northwest portions seem to be the major "outlets" of Hoh Bog (Figure 17). Between and around the two bogs is a mosaic of previously logged/burned upland and swamp forests. The uplands are dominated by dense stands of mostly *Thuja plicata* (western redcedar).

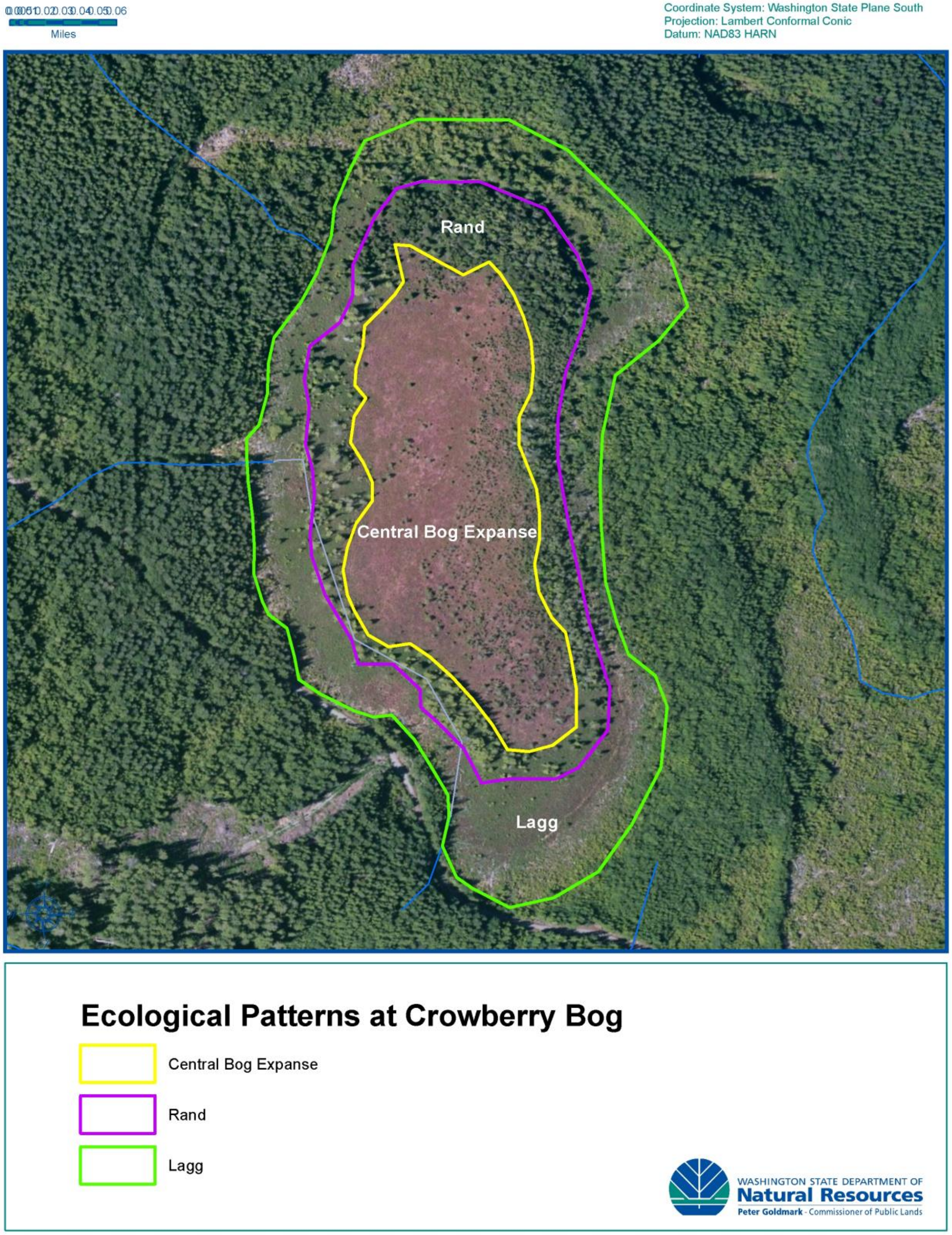

Figure 11. Ecological Patterns at Crowberry Bog

Figure 12. *Kalmia microphylla - Vaccinium oxycoccos* / *Empetrum nigrum* / *Sphagnum* spp. Dwarf-shrubland plant association at Crowberry Bog.

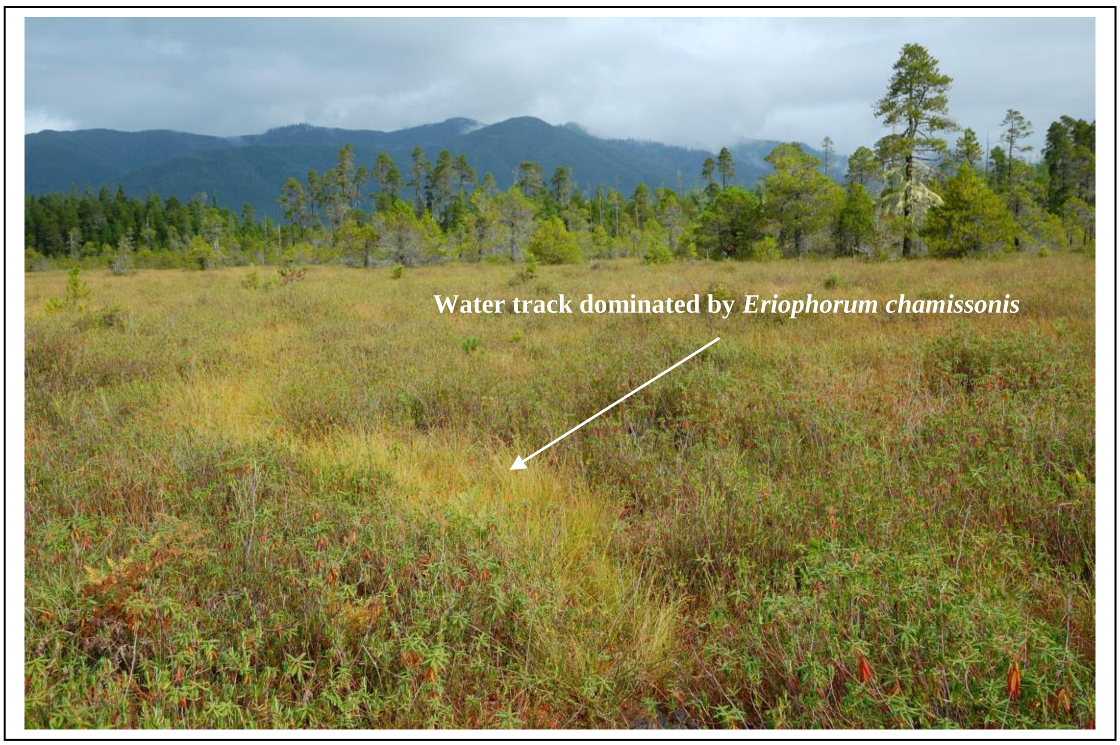

Figure 13. Water tracks at Crowberry Bog

Figure 14. *Pinus contorta* var. *contorta / Ledum groenlandicum* / *Xerophyllum tenax* / *Sphagnum* spp. Woodland

Figure 15. *Pinus contorta* var. *contorta* - *Tsuga heterophylla* / *Gaultheria shallon* / *Sphagnum* spp. Woodland dominates many areas of the rand at Crowberry Bog.

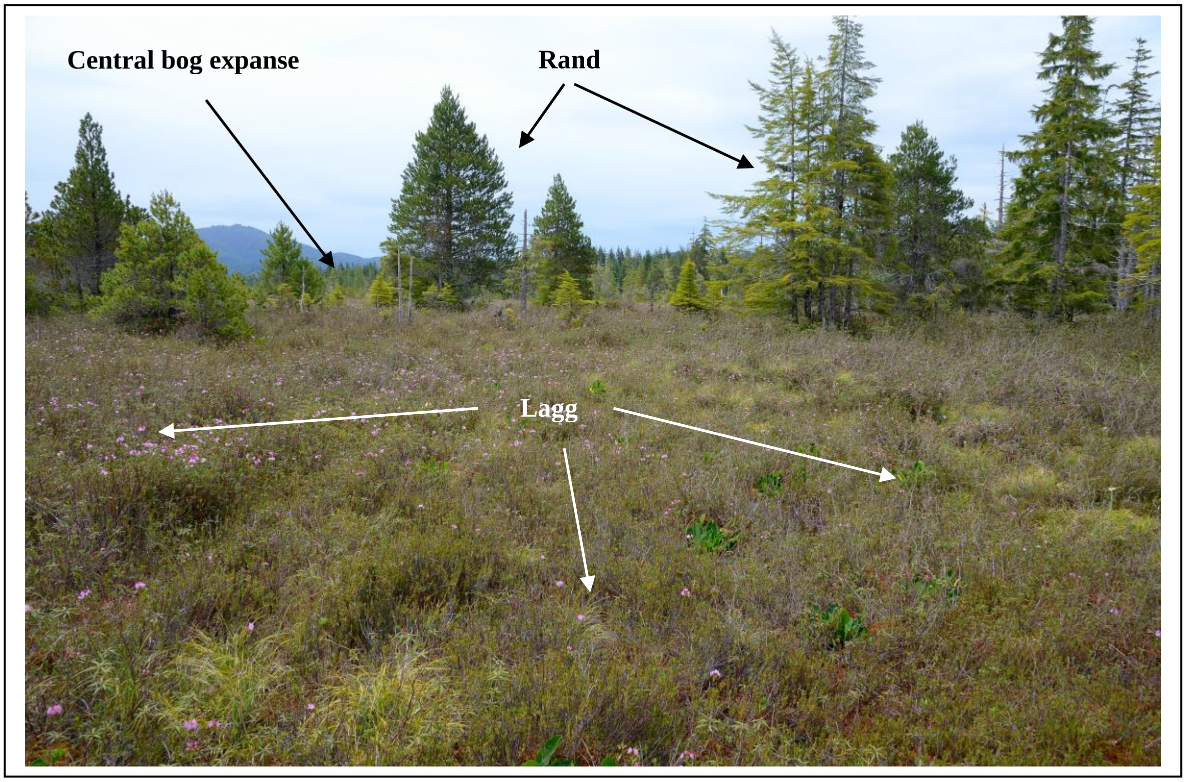

Figure 16. *Kalmia microphylla* - *Ledum groenlandicum* / *Xerophyllum tenax* Shrubland plant association in the lagg at Crowberry Bog.

Historical aerial photography indicates that almost all of these stands have been previously logged within the past 50 years. Within these stands are very large *Thuja plicata* stumps, most of which have fire scars. The stands are so dense that very little grows in the understory. In swales or small depressions, scattered individuals of *Lysichiton americanus* can be found. *Gaultheria shallon* (salal) is occasionally found in the understory. The historical aerial photos show that most of the contemporary forested wetlands were closed canopy forests prior to logging. Whether these areas were wet, upland forests or forested swamps is unknown (a series of soil pits could solve the mystery) but today, these areas exhibit characteristics of wooded fens. The removal of large trees likely resulted in an increase in local water tables (due to reduced evapotranspiration) allowing wetland species to establish. Currently, small and stunted as well as taller and more vigorous individuals of *Tsuga heterophylla* and *Thuja plicata* create a structurally varied but open canopy in these logged swamps (Figure 19). The understory has an abundance of *Sphagnum capillifolium* hummocks, *Sphagnum papillosum*/*S. cf. angustifolium* lawns, a dense shrub understory of *Gaultheria shallon*, *Ledum groenlandicum* and *Kalmia microphylla*, and an open canopy structure. Other species in these areas includes *Juncus effusus* (disturbance indicator), *Pteridium aquilinum*, *Frangula purshiana*, *Gaultheria shallon*, *Blechnum spicant*, *Cornus canadensis*, stands of *Carex obnupta* in the lowest areas. Whether these forested wetlands ultimately mature into closed-canopy, forested swamps or remain wooded fens is not known.

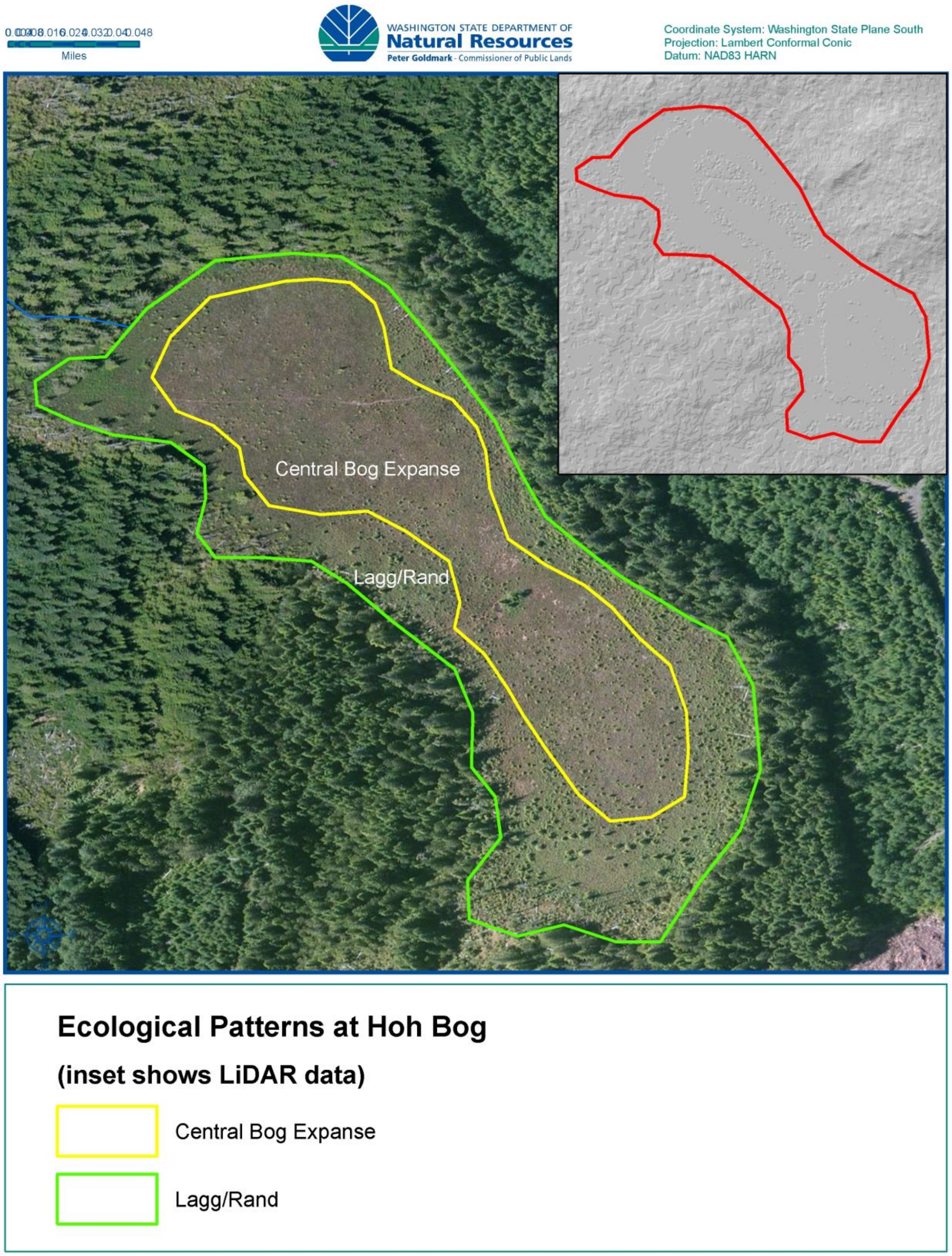

Figure 17. Ecological Patterns at Hoh Bog.

Figure 18. Central bog area of Hoh Bog. Trees are stunted *Tsuga heterophylla*.

Figure 19. Previously logged forested swamp between Crowberry and Hoh Bog.

Condition

The overall ecological condition of Crowberry Bog is excellent. Species composition, vegetation structure, and ecological processes all appear to be as expected under minimally disturbed conditions. No non-native species or invasive species were observed within the bog communities but do occur along the road system that occurs within and outside the pNAP. However, these roadside populations do not seem to pose any threat to the bog or swamp habitats as those habitats are not suitable for the non-native species observed (*Digitaria purpurea*, *Cytisus scoparius*, and various non-native grasses). Trails that originate in a parking area on the southwest side of Crowberry bog. The trails appear to be used by hunters or possibly beargrass (*Xerophyllum tenax*) or salal pickers. In some areas the trails are so well-used that bare peat is being exposed (Figure 20). Although the overall surface area of this disturbance is quite small, these conditions could allow for oxidation of peat and thus allow formation of surface rills and small, incised streams that could potentially exacerbate drainage of water off the bog. At this time, such human-induced erosion is not occurring but is a possibility if this disturbance expands or intensifies. Past logging has also affected portions of the lagg around Crowberry Bog where, historically, forested swamp occurred. Today, this area has a few cut stumps and fire-scarred snags and varies in width around the bog. The widest area affected appears to be in the southern portion of the site. This disturbance has effectively converted those specific areas from forested swamp to open poor fen. Other than the stumps and snags, the only other sign of past disturbance are scattered clumps of *Juncus effusus*, a native species known to tolerate and thrive in disturbed areas.

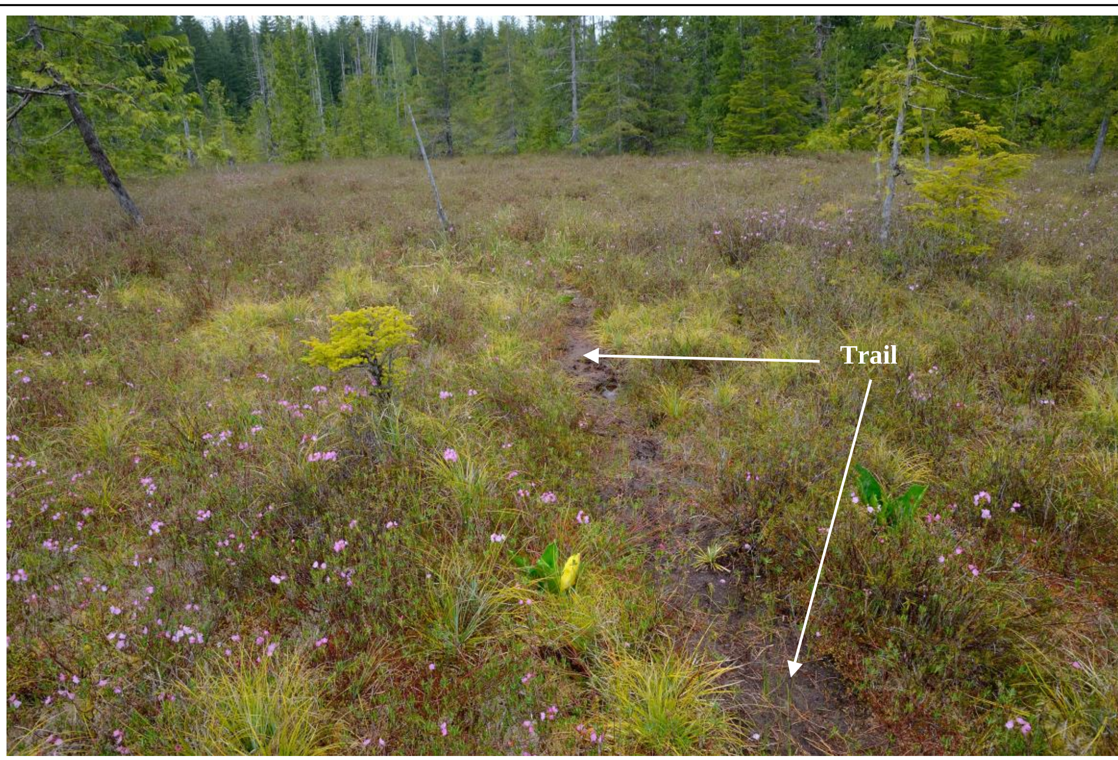

Figure 20. Trail with exposed bare peat at Hoh Bog.

Peatland communities at Hoh Bog are also primarily intact with species composition, vegetation structure, and ecological processes within or near the range of historic, minimally disturbed conditions. Fire, however, may have had a more recent impact on the central bog area at Hoh Bog as suggested by the abundance of *Pteridium aquilinum* and *Xerophyllum tenax*, relatively firm substrate, and abundant fire scars on snags around the bog. Such a fire may have been associated with timber harvest activities in the past 100 years. If fire did carry through the interior portion of the bog then a lasting impact would be any peat loss that occurred from combustion (this is speculation based on firmness of peat substrate). If this occurred, the only conspicuous, subsequent impact on vegetation is a possible shift in abundance of *Pteridium aquilinum* and *Xerophyllum tenax*. Trails exposing bare peat also occur at Hoh Bog and similar concerns, as noted above for Crowberry Bog, apply to these areas as well (Figure 20). Ongoing research on methods to install vibration fencing (a small wire/cord that is inserted into the peat body) has resulted in a variety of small and localized impacts such as trampling and small piles of soil debris.

The upland and forested swamp areas around and between both bogs have been logged and burned. Very large *Thuja plicata* stumps occur in both areas and fire-scars are common on stumps and snags. The upland forests are very dense and dominated by small *Thuja plicata* trees with very little in the understory. Disturbance-tolerant *Juncus effusus* is abundant in many of the previously logged swamp areas. The logging of these swamp forests has shifted ecological conditions in these areas by creating a more open woodland habitat allowing *Sphagnum* species to spread and cover the ground surface and create conditions suitable for peatland species such as *Ledum groenlandicum* and *Kalmia microphylla*. There is also a suspiciously incised creek within the northwest buffer of Crowberry Bog. This creek is not a perennial stream and the depth of the channel seemed to be too great for a seasonal creek to create.

Landscape Context

The lands to the north of the pNAP are in public (DNR) and private ownership (Figure 6). The private parcels to the north are under a conservation easement held by DNR (Figure 6). The remaining surrounding landscape is under both DNR and private ownership and managed for timber production.

A relevant question about surrounding land use is whether and to what extent such activities affect the integrity of the bogs as well as the connectivity between the bog and adjacent natural habitats. Past and ongoing timber management is the predominant land use of surrounding areas. Timber harvesting includes many activities that could have potential effects on local hydrology, sediment cycling, nutrient cycling, and connectivity for wildlife and plant species (Adamus 2014). Direct removal of trees and construction of logging roads can alter groundwater water tables, stream flow, sediment/nutrient retention or discharge, microclimate, soil integrity, and species composition. These effects can be detrimental to wetland and landscape integrity. The probability of these changes occurring and the intensity, duration, and frequency in which they occur is dependent on a variety of factors such as topography, soil permeability, soil depth, slope stability, local climate, location of roads, vegetated buffer, and proximity of activities to the resource of interest (Adamus 2014).

Washington Administration Code (WAC 222) addresses potential impact from timber harvest related stressors through a series of rules. The rules are intended to achieve no net loss of wetland function by avoiding, minimizing, or preventing sediment delivery and hydrologic disruption from roads, timber harvest, and timber yarding and by providing wetland buffers (Adamus 2014). Additional measures aimed at minimizing adverse effects from timber harvest activities on Washington Department of Natural Resources' managed lands are found in the agency's Habitat Conservation Plan (WA DNR 1997). The rules don't necessarily preclude timber harvesting but they can restrict the type and quantity of harvest as well as require certain buffer widths around wetlands and streams.

CURRENT USE:

Crowberry Bog receives occasional use by hunters, berry pickers, and/or beargrass (*Xerophyllum tenax*) pickers. Occasional motorized recreation occurs on the road network within DNR lands within the pNAP. Occasional small-scale piles of debris/trash are in areas where recreation and/or vegetation gatherers park their vehicles.

Access to Hoh Bog is controlled by Fruit Growers Supply, Inc. They've indicated that beargrass/salal pickers often trespass into Hoh Bog, especially from the abandoned logging road to the northwest of the bog (Figure 6). Fruit Growers has also permitted some research at Hoh Bog that entails installing a narrow cable into the peat body. Essentially a large tool similar to a "table-saw" was used to cut a narrow strip into the peat body to create a crevice in which the cable is buried. The surficial impact of these cut areas is surprisingly very little—the peat body hasn't "healed" entirely over the cut but in many places there is no observable evidence that a cut was even made into the surface. The most obvious impacts observed from the research include isolated areas of trampling, especially near the boardwalk researchers constructed to enter the bog, a small pile of sand that was deposited in the bog, and a few areas where excavated peat appears to have been dumped. The holes from which the peat may have been excavated were not located. The sand pile is of more concern as it is of unknown origin and, if derived from alkaline bedrock, could alter local chemistry around the pile and might kill nearby *Sphagnum* species.

OTHER KNOWN EXAMPLES:

<u>Raised (Plateau) Bog</u>: Regionally, raised (specifically domed) bogs have been documented in the Fraser lowlands of British Columbia (Hebda et al. 2000) and along the outer coast of British Columbia (NWWG 1988). Very few have been referenced as occurring in Washington (Rigg 1940;1951; 1958; Bach and Conca 2004). Upon recognizing that Crowberry Bog was raised, a concerted effort was made to search for additional raised bogs in Washington. This process entailed literature review and scrutinizing aerial and LiDAR imagery to look for patterns suggestive of raised bogs. LiDAR suggested that Hoh Bog, which sits about 1 km to the southeast of Crowberry Bog, may also be raised (Figure 17). Ground verification wasn't conclusive and hdyrogeochemical data and fine-scale elevation data are needed to confirm whether this site is a raised, ombrotrophic bog. Rigg (1940; 1951; 1958) and Bach and Conca (2004) reported raised bogs as occurring within Washington but field verification by DNR-Natural Heritage ecologists concluded that only one of these sites, Roose's Prairie (Bach and

Conca 2004), may exhibit a raised surface. The sites referenced by Rigg as “raised” bogs were determined to be either sloping fens that have terraced peat bodies (e.g. Cape Alava Prairie, Olympic National Park and Lost Creek Bog, Pend Oreille County) or sites that more closely represent contemporary definitions of flat bogs (Rydin and Jeglum 2013; NWWG 1997).

Roose’s Prairie, which is located within the coastal strip of Olympic National Park (northwest of Ozette Lake), was visited during the summer of 2014 to confirm a report of it being “raised” (Bach and Conca 2004). A portion of Roose’s Prairie appears to have a convex surface; however, other ecological patterns typical of raised bogs are not conspicuous at the site. LiDAR is not available for this area but aerial photography and field observations suggest that a marginal slope may occur around a central, raised bog area but the transition is not as well-defined as at Crowberry Bog. As for Hoh Bog, definitive evidence of Roose’s Prairie being a raised bog would include highly accurate elevation and hydrogeochemical data.

In summary, even if Roose’s Prairie and Hoh Bog are demonstrated to be raised bogs, they have very different morphology than Crowberry Bog. Crowberry Bog is the largest of the three sites, is the only site that meets the definition of a plateau bog and thus is the only such site in the conterminous, western United States.

<u>Forested Sphagnum Bog</u>: Forested Sphagnum Bog is an element that contains ecological and floristic variation across, and even within, ecoregions. Within the Pacific Coast ecoregion, Forested Sphagnum Bogs are relatively abundant on continental and alpine glacial deposits of the coastal plain of the western Olympic peninsula. Examples of Forested Sphagnum Bogs are protected within five other Natural Areas Preserves/Natural Resource Conservation Areas (NAP/NRCAs) within the Pacific Coast ecoregion: Carlisle Bog NAP, Clearwater Bogs NAP, Devil’s Lake NRCA, North Bay NAP, and South Nolan NRCA. However, the occurrences at the pNAP are ecologically and floristically unique among those sites, presumably due to occurring within a raised bog system. As noted previously, the three plant associations associated with this element are considered to be critically imperiled within Washington due to their rare occurrence on the landscape.

<u>Low Elevation Sphagnum Bog</u>: Low Elevation Sphagnum Bog exhibits significant ecological and floristic variation across, and even within, ecoregions. Within the Pacific Coast ecoregion, Low Elevation Sphagnum Bogs are relatively abundant on continental and alpine glacial deposits of the coastal plain of the western Olympic peninsula. Floristically, Low Elevation Sphagnum Bogs in the Pacific Coast ecoregion support numerous species (e.g., *Carex livida*, *Empetrum nigrum*, *Myrica gale*, *Sanguisorba officinalis*, *Sphagnum austinii*, *Xerophyllum tenax*, and numerous rare plants) that are rarely or never found in Low Elevation Sphagnum Bogs in other ecoregions in the State. Examples of Low Elevation Sphagnum Bogs are protected within four other Natural Areas Preserves/Natural Resource Conservation Areas within the Pacific Coast ecoregion: Carlisle Bog NAP, Clearwater Bogs NAP, North Bay NAP, and South Nolan NRCA. However, the occurrences found at the pNAP are ecologically and floristically unique among those sites, presumably due to occurring within a raised bog system. As noted previously, the two plant associations associated with this element are considered to be critically imperiled within Washington due to their rare occurrence on the landscape.

Makah Copper: The distribution of the Makah copper butterfly ranges from southwest Washington, and western British Columbia northward into the Yukon Territory. Within Washington it is found in coastal areas from the Strait of Juan de Fuca to the mouth of the Columbia River in low elevation, coastal and inland peatlands where native cranberries (*Vaccinium oxycoccos*) are present (Jordan and Fleckenstein 2011). The Makah copper has been found at 19 western Washington sites, but only observed at 13 of those since 2000 (Fleckenstein 2009). Populations of the Makah copper are protected within three other Natural Areas Preserves within the Pacific Coast ecoregion: Carlisle Bog NAP, Clearwater Bogs NAP, and North Bay NAP.

NATURAL AREA DESIGN:

The objective of designing boundaries for the Crowberry Bog Proposed Natural Area Preserve is to maintain current ecological integrity and long-term viability of the elements on the site and to represent a rare ecosystem type in the natural areas system for research and education. Designing boundaries for wetlands is often focused on the surrounding lands that are the source of surface and/or groundwater inputs into the wetland. Although raised bogs surely receive hydrological input from surrounding lands, because they have a convex water mound they are also the source for outflowing water from the bog. As such, areas where surface and/or groundwater may flow away from the bogs were considered when delineating the boundary options presented below. The presumption is that protecting these areas would ensure that hydrological connections between the bog and adjacent lands would remain intact. In addition, raised bogs not only grow upward but they also tend to expand laterally into adjacent forested uplands, a process called paludification. Although paludification is a very slow process, boundary delineation also attempted to provide sufficient areas around the bog to allow lateral expansion to occur unimpeded. Primary threats to the elements involve land conversion and fragmentation, direct physical disturbance from recreational activities, and hydrological alteration from roads, culverts, ditches, land conversion, etc. Three boundary options are proposed:

Option 1 (limited to Crowberry Bog): This option focused solely on a boundary for protecting Crowberry Bog. The bounded area is 258 acres and encompasses the entire footprint of the bog as well as surrounding upland and forested swamp areas thought to be necessary to maintain natural hydrology (Figures 3). Protection of surrounding streams and wetlands are presumably important for protecting natural hydrological outflow from the bog (Figure 3; Morgan-Jones et al. 2005). The upland areas around the bog and between streams and wetlands appear to have a relatively shallow water table (as indicated by small depressions where skunkcabbage was occassionally found growing). As such, they were included within this boundary to conservatively capture any areas that might be conducting subsurface flow away from the bog (Figure 3). The boundary on the east was limited to the upland (possibly morainal) deposit immediately adjacent to the bog to ensure surface water flowing from this area into the bog originates in natural conditions. The boundary on the north and northeast captures swamp and upland forest to the edge of the bluff. Most of the outflow from Crowberry Bog appears to exit from the western portion of the bog. Field investigations did not find perennial or even obvious surface channels that extend more than 10-20 meters from the bog edge. However, water visibly exits the bog and presumably infiltrates into surrounding soils and laterally flows as shallow groundwater toward the west and north and ultimately empties into Elk Creek or smaller tributaries to the Hoh River. A primary outlet appears on the north and northwest corner into a substantial forested swamp. No significant surface outlet was observed exiting this swamp. Soils data indicate that some areas of the western and northern slopes, which lead down from the bluff toward the Hoh River, have high mass wasting potential. The boundary captures these slopes to ensure that land uses capable of inducing, or contributing to natural processes capable of inducing, landslides are excluded from these areas. Landslides have the potential to move the bluff edge toward the bog, especially on the northeastern edge which could be detrimental to the long-term viability of the bog.

Option 2 (Crowberry and Hoh bogs): This bounded area is 348 acres and includes the areas necessary to protect Crowberry and Hoh bogs as individual wetland basins (Figures 4). The boundary for the Crowberry portion of this option is the same as Option 1. The boundary for Hoh bog followed the same rationale and captures the morainal deposit to the east as this appears to be a significant source of incoming water to the bog. Surrounding lands to the north and west that serve as conduits for outflowing surface and/or groundwater from Hoh Bog and the nearby, old growth, intact wooded fen were included. The western boundary stops at an abandoned logging road. Hydrological outflow from Hoh Bog likely extends west of this point but the area between the road and the edge of Hoh Bog was hypothesized as a minimal area needed to be included in the boundary.

Option 3 (Crowberry and Hoh bogs and intervening areas): This option is the largest (469 acres) and encompasses both Crowberry and Hoh bogs, the Forested Sphagnum Bog north of Hoh Bog, as well as the forested swamps and upland forests between each site (Figure 5). Options 1 & 2 are included plus the area between them. The north and south boundary of the intervening areas between the bogs was delineated based on topographic connectivity as indicated by LiDAR (Figure 8). The intent of this boundary was to be more inclusive and provide protection for natural hydrology across a larger landscape than encompassed in the other options. The boundary also provides an opportunity for long-term monitoring of natural succession following previous logging in most of the forested swamp areas.

MANAGEMENT CONSIDERATIONS:

The primary management needs are associated with user-created trails, roads and associated culverts, nonnative species along roads, and the need to more fully understand hydrological dynamics of both bogs. As noted previously, the trails appear to have been created by hunters or beargrass (*Xerophyllum tenax*) pickers. In some areas the trails are so well-used that bare peat is being exposed. Although the overall surface area of this disturbance is quite small, these conditions could allow for oxidation of peat and thus allow formation of surface rills and small, incised streams that could potentially exacerbate drainage of water off the bog. At this time, this human-induced erosion is not occurring but is a possibility if the disturbance expands or intensifies. Management actions should focus on ensuring that these areas are allowed to heal. If foot traffic in these areas ceased, *Sphagnum* would likely recolonize within a relatively short timeframe (maybe 5-10 years).

The most significant impact of hunting is most likely associated with trampling and subsequent creation of bare peat patches. It is not known how frequently hunters use either bog or how many elk or other animals are taken. Elk have been frequently observed by the author at each bog and some effects on the vegetation appear to be a result of elk use, e.g. the elk seem to preferentially browse the skunkcabbage within the bog. However, the current level of elk use in the bogs compared to historical conditions is unknown and does not appear to be significantly impacting the sites. Periodic assessment of elk use should be included in any future site monitoring.

Along some of the logging roads, especially in areas where vehicles can be parked, trash piles (ranging from water bottles to televisions) are occasionally found. These areas are conspicuous but not very large. Electronics such as televisions could be leaking metals or other contaminants into wetland areas and should be a priority for removal.

Management to address the above issues should include: limiting access in the bogs to approved research and education uses; closing/abandoning any roads not needed for management access to the natural area or adjacent lands; gating other access roads to control motorized vehicle use of the area and discourage unauthorized access (beargrass picking, hunting, trash dumping); and installing standard informational and regulatory natural areas signs. A plan for directing permitted access into the bog should be developed to ensure that trampling impacts are dispersed or otherwise mitigated.

The effect of culverts on bog hydrology should be considered and replacement or removal implemented as necessary. While invasive species are currently not an issue at the site and bogs are typically resistant to invasion by most introduced species, the site should be monitored periodically to provide early detection of any potential invaders. Nonnative species such as Scot's broom (*Cytisus scoparius*) and foxglove (*Digitalis purpurea*) that occur along roads or disturbed upland areas do not threaten bog habitats, but eradication or controlling additional expansion should be considered.

Upland forest areas should be assessed for potential restoration needs, e.g. gap creation, density reduction, snag creation, DWD recruitment, using recently-developed natural areas program guidance ("*Restoration of forest stands within natural area preserves or natural resources conservation areas"*). Assessment should consider how any restoration activities might affect ecological interactions between the uplands and bogs.

Powell (2002) notes that Crowberry Bog (erroneously indicated in the report as occurring within Sec. 27; Jay Powell *personal communication*) was one of the important "prairies" for traditional Quileute uses. A few Hoh Tribal members still use Crowberry Bog to gather cranberries in the autumn (Jill Silver, *personal communication*). It is possible other individuals may gather cranberries or other plant materials from either Crowberry or Hoh bogs. Having a better understanding of the number of individuals and frequency in which they gather from the bogs would be helpful for monitoring potential impacts from such activities.

Historical aerial photos indicate most areas around the bogs have been clearcut sometime in the past 50 years. A review of forestry impacts to wetlands suggests most adverse impacts associated with changes in hydrology, sedimentation, and nutrient enrichment are undetectable for only a few years after harvest (Adamus 2014). Thus, any impact from past logging is unlikely to be ongoing. However, the inclusion of these areas within the pNAP provides an opportunity to monitor long-term changes in forest development, especially in areas that appear to have historically been forested swamps/wet upland forests but are now in a wooded fen phase.

Understanding the hydrogeochemical dynamics between the acrotelm, catotelm, lagg and surrounding uplands would be useful for informing future management activities to maintain the natural hydrology of Crowberry and Hoh bogs. Establishing a hydrogeochemical monitoring network at both bogs would allow for conclusively determining the degree to which each site is ombrotrophic and/or to understand the influence of groundwater on bog integrity. A series of nested piezometers could be established across the length and width of each bog, extending from the bog edge into the lagg, through the rand, and into the central bog area. Monthly water table, pH, and conductivity measurements and seasonal water chemistry measurements would provide the necessary data to understand primary hydrogeochemical characteristics of the bog. These data would help inform future management actions within and adjacent to the bog to maintain hydrological integrity of these sites. Such data would also contribute toward better understanding the ecological characteristics of Washington’s peatland resource.

Prepared by Joe Rocchio.
November 25, 2014

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