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Natural Resource Stewardship and Science

Natural Resource Condition Assessment

Ebey's Landing National Historical Reserve

Natural Resource Report NPS/EBLA/NRR—2020/2102





ON THIS PAGE
Agricultural fields and coastal bluffs, Ebey's Landing. Photo by Marsha Davis.

ON THE COVER
Penn Cove view from Grassers Hill. Photo by Steve Olson.

Natural Resource Condition Assessment

Ebey's Landing National Historical Reserve

Natural Resource Report NPS/EBLA/NRR—2020/2102

Catherin A. Schwemm, Editor

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Publisher's Note: Natural Resource Condition Assessments provide a snapshot-in-time evaluation of park resource conditions. For this report, most or all of the data discovery and analyses occurred during the period of 2013 to 2019. Thus, park conditions reported in this document pertain to that time period. Due to revised publishing requirements and/or scientific delays, this report was not published until 2020.

Executive Summary

By Paul Adamus and Catherin Schwemm

The NRCA study team compiled existing data and information to characterize the condition and trends of high priority natural resources in Ebey's Landing National Historical Reserve. This report and the spatial datasets provided with it are intended to inform and support Reserve managers and scientists in developing recommendations for protecting and improving the condition of natural resources in the Reserve. The NRCA can also assist Reserve resource managers in meeting the reporting requirements of the Government Performance Results Act and Office of Management and Budget.

Resource elements selected for assessment were organized into nine sub-chapters in Chapter 4: 4.1 Air Quality; 4.2 Climate; 4.3 Freshwaters; 4.4 Wetland and Nearshore Vegetation; 4.5 Upland Vegetation; 4.6 Birds; 4.7 Vertebrates; 4.8 Natural Night Skies and Natural Quiet; and 4.9 Habitat Connectivity and Land Use.

Indicators (quantitatively measurable descriptors) were identified to evaluate the condition and trend of each resource. Using these indicators reference conditions were established for each resource in relation to what is known about the historic values or descriptions of indicators, allowing an assessment of current conditions. If sufficient data were available, the trend in resource condition was determined. However, in most cases sufficient data were not available to provide a quantitative evaluation of condition or trend, so qualitative information and expert opinion were used instead. A confidence level was assigned to each assessment based on the strength of available information.

The following table briefly summarizes the condition of assessed resources at EBLA. In no case was a natural resource determined to be in good condition, and in some cases ongoing or proposed human activities portend that conditions may decline in the future. Symbol descriptions are provided in Chapter 3, and the assessment process for each resource described in the relevant section (4.x) of Chapter 4.

Table ES.1. Summary of condition assessments for all focal resources at Ebey's Landing National Historical Reserve.

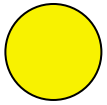
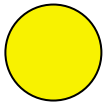
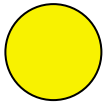
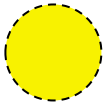
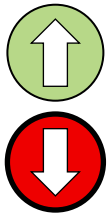
EBLA Resource	Assessment	Rationale
Air Quality (Section 4.1)		Air quality is not monitored at EBLA, but data from regional sites indicates air quality is generally good though visibility is of concern. No trends are apparent, and confidence is low.
Climate (4.2)		Given that the climate is changing rapidly from conditions to which organisms and biological systems have adapted, the condition of this resource is poor. The trend is increased diversion from natural conditions, and confidence in this assessment is moderate.
Freshwater Resources (4.3)		The extent of wetlands has declined substantially from historical conditions but appears stable. Surface water quality is of concern especially regarding nutrient and fecal coliform contamination. Groundwater quality is of serious concern, especially with recent discovery of the fluorosurfactant PFOS, an ingredient used in aviation firefighting fuel. Water management programs are ongoing and actively working to improve conditions. Groundwater quantities appear sufficient for now, though supplies are limited and climate change (reductions in rainfall), and increased demands are concerns. Confidence is moderate.
Wetland and Nearshore Vegetation (4.4)		The condition of wetland vegetation communities is of concern due to the presence of non-native species and limited habitat. No trends for freshwater wetlands, brackish lagoons or dune communities are apparent from the limited data. Seagrass appears to be stable or increasing around Whidbey Island; kelp populations may be stable. Confidence is moderate.
Upland Vegetation (4.5)		Native prairie communities are largely absent and at risk from Eurasian weed invasion, fire suppression and agricultural conversion, though recent intensive restoration efforts have improved prairie condition at some limited sites. Forest condition is somewhat concerning given the impacts that climate change, fire suppression, and weed invasion may have on survival and health of several tree species. The overall trend for the condition of endangered golden paintbrush populations is good; little is known about other rare species and concern is warranted. Confidence is moderate.
Birds (4.6)		Bird diversity in the Reserve is high, with several areas such as Crockett Lake providing important resources. Little is known regarding population trends for the majority of species, though most species of concern appear to be stable. Caution is warranted for forest and prairie-dependent species and seabirds. Threats include non-native species, disease, and ocean-related effects of climate change. Confidence is moderate to high given the presence of many bird enthusiasts on the island that maintain sighting records.
Vertebrates (4.7)		Almost nothing is known regarding terrestrial vertebrates in EBLA. Several species are known to be extirpated; native species that may be increasing are those tolerant of human presence (deer, raccoon, coyote). Very little is known regarding several rare amphibians. Confidence is low.

Table ES.1 (continued). Summary of condition assessments for all focal resources at Ebey's Landing National Historical Reserve.

EBLA Resource	Assessment	Rationale
Natural Night Skies and Natural Quiet (4.8)		The conditions of these two resources are quite different and require separate assessments. The condition of natural night skies is generally good in Reserve areas; sources of anthropogenic light are minimal outside of town centers. The condition may be improving given attention to this issue by local advocates; confidence is moderate. The condition of natural quiet is poor due to various sources of human-caused noise, especially low elevation military overflights. The presence of the Outlying Landing Field Coupeville and associated military aircraft operations creates an intermittent, extremely loud environment throughout the Reserve. The trend is declining, given Navy plans to expand operations. Confidence is high.
Habitat Connectivity and Land Use (4.9)		Land conservation efforts including purchase of development rights have the potential to reduce negative impacts on natural resources of adjacent land use. Habitat connectivity is of moderate concern given multiple land uses occurring in the Reserve that hinder animal movement, but trends appear to be stable or improving with ongoing land acquisition and habitat enhancement efforts. Confidence is moderate.

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C. Schwemm greatly thanks Marsha Davis and David Garcelon.

Prologue

Publisher's Note: Changes in publishing requirements, and in some cases scientific delays, resulted in several NRCA reports not being published in a timely manner. These publications reported on studies initiated in the 2013–2016 timeframe. Since Natural Resource Condition Assessments provide a snapshot-in-time evaluation of park resource conditions, it is important to note that data discovery and analyses for this study was conducted a few years prior to publication. Thus, park conditions reported in this document pertain to that time period. Please see the Publisher's Note at the beginning of the Executive Summary or Chapter 2 for dates specific to this report.

Acronyms and Abbreviations

ARD: Air Resources Division

CCAP: Coastal Change Analysis Program

CO_2: Carbon dioxide

DDT: Dichlorodiphenyltrichloroethane

EBLA: Ebey's Landing National Historical Reserve

EPA: Environmental Protection Agency

ESA: Endangered Species Act

GCM: General circulation model

GIS: Geographic information system

HUC: Hydrologic unit code

IPM: Integrated Pest Management

IPCC: Intergovernmental Panel on Climate Change

MYa: Millions of years ago

NCCN: North Coast and Cascades Network

NOAA: National Oceanic and Atmospheric Administration

NPS: National Park Service

NRCA: Natural Resource Condition Assessment NWI – National Wetlands Inventory

ppm: Parts per million

SLR: Sea level rise

USFWS/FWS: US Fish and Wildlife Service

USGS: US Geological Survey

WDE: Washington Department of Ecology

WSPRC: Washington State Park and Recreation Commission

WCLT: Whidbey Camano Land Trust

WRIA: Water Resource Inventory Area

Chapter 1. NRCA Background Information

Natural Resource Condition Assessments (NRCAs) evaluate current conditions for a subset of natural resources and resource indicators in national park units, hereafter "parks." NRCAs also report on trends in resource condition (when possible), identify critical data gaps, and characterize a general level of confidence for study findings. The resources and indicators emphasized in a given project depend on the park's resource setting, status of resource stewardship planning and science in identifying high-priority indicators, and availability of data and expertise to assess current conditions for a variety of potential study resources and indicators.

NRCAs Strive to Provide…

- *Credible condition reporting for a subset of important park natural resources and indicators*
- *Useful condition summaries by broader resource categories or topics, and by park areas*

NRCAs represent a relatively new approach to assessing and reporting on park resource conditions. They are meant to complement—not replace—traditional issue-and threat-based resource assessments. As distinguishing characteristics, all NRCAs:

- Are multi-disciplinary in scope;[1]
- Employ hierarchical indicator frameworks;[2]
- Identify or develop reference conditions/values for comparison against current conditions;[3]
- Emphasize spatial evaluation of conditions and GIS (map) products; [4]
- Summarize key findings by park areas; and [5]
- Follow national NRCA guidelines and standards for study design and reporting products.

Although the primary objective of NRCAs is to report on current conditions relative to logical forms of reference conditions and values, NRCAs also report on trends, when appropriate (i.e., when the underlying data and methods support such reporting), as well as influences on resource conditions. These influences may include past activities or conditions that provide a helpful context for

[1] The breadth of natural resources and number/type of indicators evaluated will vary by park.

[2] Frameworks help guide a multi-disciplinary selection of indicators and subsequent "roll up" and reporting of data for measures ⇨ conditions for indicators ⇨ condition summaries by broader topics and park areas

[3] NRCAs must consider ecologically based reference conditions, must also consider applicable legal and regulatory standards, and can consider other management-specified condition objectives or targets; each study indicator can be evaluated against one or more types of logical reference conditions. Reference values can be expressed in qualitative to quantitative terms, as a single value or range of values; they represent desirable resource conditions or, alternatively, condition states that we wish to avoid or that require a follow-up response (e.g., ecological thresholds or management "triggers").

[4] As possible and appropriate, NRCAs describe condition gradients or differences across a park for important natural resources and study indicators through a set of GIS coverages and map products.

[5] In addition to reporting on indicator-level conditions, investigators are asked to take a bigger picture (more holistic) view and summarize overall findings and provide suggestions to managers on an area-by-area basis: 1) by park ecosystem/habitat types or watersheds, and 2) for other park areas as requested.

understanding current conditions, and/or present-day threats and stressors that are best interpreted at park, watershed, or landscape scales (though NRCAs do not report on condition status for land areas and natural resources beyond park boundaries). Intensive cause-and-effect analyses of threats and stressors, and development of detailed treatment options, are outside the scope of NRCAs.

Due to their modest funding, relatively quick timeframe for completion, and reliance on existing data and information, NRCAs are not intended to be exhaustive. Their methodology typically involves an informal synthesis of scientific data and information from multiple and diverse sources. Level of rigor and statistical repeatability will vary by resource or indicator, reflecting differences in existing data and knowledge bases across the varied study components.

The credibility of NRCA results is derived from the data, methods, and reference values used in the project work, which are designed to be appropriate for the stated purpose of the project, as well as adequately documented. For each study indicator for which current condition or trend is reported, we will identify critical data gaps and describe the level of confidence in at least qualitative terms. Involvement of park staff and National Park Service (NPS) subject-matter experts at critical points during the project timeline is also important. These staff will be asked to assist with the selection of study indicators; recommend data sets, methods, and reference conditions and values; and help provide a multi-disciplinary review of draft study findings and products.

NRCAs can yield new insights about current park resource conditions, but, in many cases, their greatest value may be the development of useful documentation regarding known or suspected resource conditions within parks. Reporting products can help park managers as they think about near-term workload priorities, frame data and study needs for important park resources, and communicate messages about current park resource conditions to various audiences. A successful NRCA delivers science-based information that is both credible and has practical uses for a variety of park decision making, planning, and partnership activities.

Important NRCA Success Factors

- *Obtaining good input from park staff and other NPS subject-matter experts at critical points in the project timeline*
- *Using study frameworks that accommodate meaningful condition reporting at multiple levels (measures ⇨ indicators ⇨ broader resource topics and park areas)*
- *Building credibility by clearly documenting the data and methods used, critical data gaps, and level of confidence for indicator-level condition findings*

However, it is important to note that NRCAs do not establish management targets for study indicators. That process must occur through park planning and management activities. What an NRCA can do is deliver science-based information that will assist park managers in their ongoing, long-term efforts to describe and quantify a park's desired resource conditions and management

targets. In the near term, NRCA findings assist strategic park resource planning[6] and help parks to report on government accountability measures.[7] In addition, although in-depth analysis of the effects of climate change on park natural resources is outside the scope of NRCAs, the condition analyses and data sets developed for NRCAs will be useful for park-level climate-change studies and planning efforts.

NRCAs also provide a useful complement to rigorous NPS science support programs, such as the NPS Natural Resources Inventory & Monitoring (I&M) Program.[8] For example, NRCAs can provide current condition estimates and help establish reference conditions, or baseline values, for some of a park's vital signs monitoring indicators. They can also draw upon non-NPS data to help evaluate current conditions for those same vital signs. In some cases, I&M data sets are incorporated into NRCA analyses and reporting products.

NRCA Reporting Products…

Provide a credible, snapshot-in-time evaluation for a subset of important park natural resources and indicators, to help park managers:

- *Direct limited staff and funding resources to park areas and natural resources that represent high need and/or high opportunity situations* ***(near-term operational planning and management)***
- *Improve understanding and quantification for desired conditions for the park's "fundamental" and "other important" natural resources and values* ***(longer-term strategic planning)***
- *Communicate succinct messages regarding current resource conditions to government program managers, to Congress, and to the general public* ***("resource condition status" reporting)***

Over the next several years, the NPS plans to fund an NRCA project for each of the approximately 270 parks served by the NPS I&M Program. For more information visit the NRCA Program website.

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[6] An NRCA can be useful during the development of a park's Resource Stewardship Strategy (RSS) and can also be tailored to act as a post-RSS project.

[7] While accountability reporting measures are subject to change, the spatial and reference-based condition data provided by NRCAs will be useful for most forms of "resource condition status" reporting as may be required by the NPS, the Department of the Interior, or the Office of Management and Budget.

[8] The I&M program consists of 32 networks nationwide that are implementing "vital signs" monitoring in order to assess the condition of park ecosystems and develop a stronger scientific basis for stewardship and management of natural resources across the National Park System. "Vital signs" are a subset of physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values.

Publisher's Note: Natural Resource Condition Assessments provide a snapshot-in-time evaluation of park resource conditions. For this report, most or all of the data discovery and analyses occurred during the period of 2013 to 2019. Thus, park conditions reported in this document pertain to that time period. Due to revised publishing requirements and/or scientific delays, this report was not published until 2020.

Chapter 2. Resource Setting and Stewardship Context

By Catherin Schwemm and Paul Adamus

2.1. Introduction

Ebey's Landing National Historical Reserve ("Reserve") is located in the center of Whidbey Island in Puget Sound, Washington (Figure 2.1; Figure 2.2). Whidbey is one of the San Juan Islands within the Salish Sea, a region that includes Puget Sound, the Strait of Juan de Fuca, and the Strait of Georgia. The Reserve includes approximately 13% of the island (14,000 acres/5,666 hectares) with an additional 4,000 ac (1,619 ha) of water surface in Penn Cove within the Reserve. About 25 miles (40 km) of shoreline border the Reserve, and no place in the Reserve is more than a few miles from the ocean (Figure 2.3).

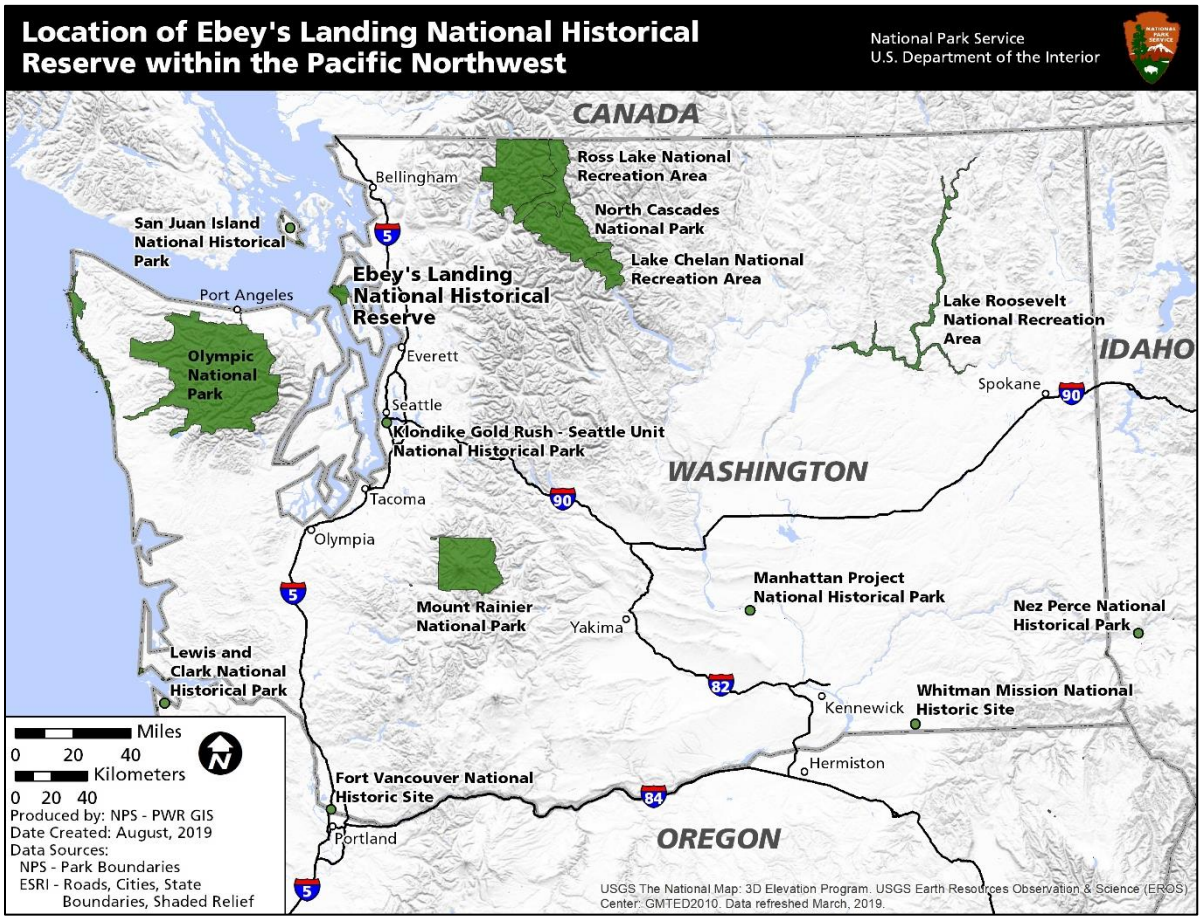


Figure 2.1. Location of Ebey's Landing National Historical Reserve within the Pacific Northwest (NPS).



Figure 2.2. Location of Ebey's Landing National Historical Reserve within Island County, Washington (NPS).



Figure 2.3. General features and place names within the Reserve (NPS).

The Reserve includes three state parks (Fort Ebey, Fort Casey, and Ebey's Landing), two county/municipal parks (Rhododendron, Oak Harbor Air Park), and lands owned or leased by The Nature Conservancy (Pratt Preserve) and the Whidbey-Camano Land Trust (Libbey Beach Tidelands, Krueger Farm, Ebey's Bluff access points, part of Crockett Lake). The entire Reserve is a National Register historic district known as the Central Whidbey Island Historic District.

2.1.1. Legislative History and Administration

The Reserve was established in 1978 to both preserve land and to interpret several historic periods, including the first exploration by Europeans in the late 1700s, the settlement by the Ebey family in the early 1800s, and settlement and development in the mid-1800s including the establishment of the town of Coupeville (NPS 2006).

The Reserve is one of the few NPS units within which most of the land (~85–90%) is outside NPS ownership (USCRS 2016), and is administered as a federal, state, and local partnership. A governing board ("Trust Board") comprised of four partners—Island County (4 Board members), Town of Coupeville (3 members), Washington State Parks (1 member) and National Park Service (1 member; 1988 Interlocal Agreement)—helps to coordinate the partnership. Via delegation of authority from NPS, The Board assists NPS with management and administration of NPS lands and interests. NPS has two permanent staff that manage NPS operations and provide technical assistance to the Reserve.

The Reserve includes private and public lands, including the County seat of Coupeville. Within the Reserve are areas devoted to agricultural, residential, commercial, recreational, and open space uses. Federal lands within the Reserve include 413 ac (167 ha) owned outright by NPS, and approximately 2,023 ac (819 ha) in NPS-held conservation easements. In addition, a flight training facility (Coupeville Outlying Landing Field – OLF), administered by the US Navy, adjoins the northeast edge of the Reserve.

2.1.2. Geographic Setting

Whidbey Island is located in an ecoregion known as the Puget Lowland (sometimes referred to as the Puget Trough). The closest large body of land to the west of the Reserve is the Olympic Peninsula, approximately 4 mi (6 km) across Admiralty Inlet. To the east is Camano Island and the continental mainland (approx. 7 mi/11 km). The highest elevation within the Reserve is 261 ft (80 m) above mean sea level, compared with a maximum elevation of 484 ft (148 m; "Goose Point") for all of Whidbey Island. The Cascade Range to the east of Puget Sound shelters the island from continental wind currents, while the Olympic Mountains to the southwest moderate marine influences and limit rainfall.

Penn Cove is the Reserve's predominant marine feature, situated generally east-west in the middle of the island and opening east to the Saratoga Pass and Skagit Bay. Penn Cove is approximately 5 mi (8 km) long, with approximately 3,955 ac (1,601 ha) of water bordered by a 10 mi (16 km) shoreline. Penn Cove supports an extensive commercial shellfish farm and recreational fisheries. Located where Puget Sound joins with the Strait of Juan de Fuca, the marine waters of Admiralty Bay on the Reserve's west side are flushed by strong tidal currents while Penn Cove is relatively calm.

2.1.3. Cultural Significance

Though human habitation on Whidbey Island likely goes back many thousands of years (Weiser and Lepofsky 2009), several distinct tribes of American Indians were present as early as 1300, including the Snohomish, the Kikiallus, and the Skagits. Natural resources such as fish, shellfish and game were abundant. The Indians burned the prairies to prevent woody species succession and maintain prairies and wetlands that provided herbaceous plants for food and medicine (discussed in Section 4.5). Initial contact by George Vancouver in the late 1790s noted several thousand Indians living in the region, however, most of these groups were gone by the early 1900s.

The explorations of George Vancouver in 1792 introduced Whidbey Island to potential settlers. Isaac Ebey was one of the first settlers on the island. Ebey farmed and became very active in early Euro-American settlement on the island, where new arrivals made use of marine resources such as salmon

and shellfish, and forests for timber and particularly shipbuilding. In the 1830s the Hudson's Bay Company established outposts in the region and began trading with local tribes, though eventually this partnership dissolved and descendants of Ebey and others became the sole landowners on the island. The County Seat Coupeville is named for Captain Thomas Coupe who settled in an area now within city limits in the 1850s, and Fort Casey was established in the 1890s. The history of land use on Whidbey Island and the history of Ebey's landing are well-documented by White (1980), Gilbert (1985), and Weiser and Lepofsky (2009).

2.1.4. Visitation

Data on annual visitation to EBLA are not collected by NPS due to the integration of Reserve lands with resident populations and because the Reserve contains lands jointly administered by different partnerships. NPS has started to collect information on visitation to NPS properties and estimates approximately >500k per year (R. Zipp pers. comm. 2019). A report published in 2008 (Papadogiannaki et al.) reported statistics from a one-week survey that included the home locations of visitors, how much time visitors spent in the Reserve and the primary activities visitors participated in. The investigators interviewed over 500 visitor groups and found that most (93%) were from the US, 73% of those were from Washington, and 26% of all visitor groups were from Whidbey Island. The primary activities of visitors were hiking on trails and visiting historic exhibits, and not surprisingly summer months see much more visitation that during November–February.

2.1.5. Relevant Regional and Landscape-scale Information

The Puget Sound region is home to more than six million people, concentrated in the major urban centers of Seattle, Washington and Vancouver, British Columbia. Whidbey Island comprises approximately 81% of the land area of Island County, which also includes Camano Island to the east. The population of Island County grew from <2000 in 1900 to ~ 83,000 in 2016, with projections for 2030 of between 69,000–115,000 (IC 2016). The annual growth rate was > 3% from 1940–1990 but has been < 2% since then and is projected to stay at about this level through 2030. Population density of Island County is currently about 150 people/km^2 and is projected to reach about 200 people/km^2 by 2030.

Agriculture has been a primary land use on the island since settlement, for example in 2000 there were 3,355 ac (1,358 ha) in cropland, 1,138 ac (461 ha) in pasture, 1,437 ac (582 ha) in grassland, and 5,290 ac (2,141 ha) in woodland/forest. Crops grown in the Reserve include grass (for hay), corn, barley, alfalfa, cabbage, beets, lavender, strawberries, squash, peas, timber, and conifer seed. While there is still an active farming community on the island, the economic base has gradually shifted to vacation homes and recreation.

Natural resources within the Reserve are affected by an array of factors. A particularly contentious situation is the presence of the US Navy's Outlying Landing Field-Coupeville (OLFC), located in the center of the southern portion of the island, where the Navy maintains very loud jets called "Prowlers" and "Growlers." Local residents have long protested against the noise and water quality impacts of the Navy's Coupeville jet facilities (citizensofebeysreserve.com), particularly in the past several years as the Navy has proposed increasing its flight and training operations on the island (USN 2016). The potential impacts of OLFC are addressed in detail in Section 4.8.

Approximately 36,300 ac of ocean to the west and north of Fort Ebey State Park have been designated as the Smith and Minor Islands Aquatic Reserve by the Washington Department of Natural Resources (WDNR). The general purposes of this reserve are to preserve and protect the natural features and processes of the waters and shorelines within the reserve and to facilitate research and monitoring of those resources (WDNR 2010).

2.2. Physical Resources

2.2.1. Air Quality

Winds originating in the atmosphere over the Pacific Ocean in the Strait of Juan de Fuca result in air quality in the region that is generally very good (PSCAA 2003). Overall air quality in the Pacific Northwest is good compared with many other areas of the United States, and data from nearby monitoring stations at Oak Harbor, Anacortes, Port Townsend, and Mount Vernon do not exceed National Ambient Air Quality Standards (NAAQS) for particulate matter or ozone. Air resources are assessed in Section 4.1.

2.2.2. Climate

The Reserve is dominated by a mild, warm summer Mediterranean climate with temperature variation mediated by the surrounding sea. The Olympic Mountains to the southwest affect the climate of the San Juan Islands by impeding moisture-laden storms that would otherwise bring precipitation. The summers on Whidbey Island are short and cool with little precipitation, while winters are mild but include most of the precipitation events. Snowfall occurs occasionally, but most winter precipitation falls as rain. Annual precipitation in the Reserve from 1971–2000 averaged 21.5 inches (546 mm). In Island County, the average growing season (daily minimum temperature above freezing) is 206 days (NRCS 2008). An average of 255 days per year have cloud cover, while only 43 days have clear skies. Climate is assessed in Section 4.2.

2.2.3. Natural Night Skies and Natural Quiet

Dark night skies and natural quiet have been identified by NPS as important natural resources in addition to their values as part of the visitor experience. These resources are assessed in Section 4.8.

2.2.4. Geology

Three distinct periods of geologic development are responsible for the formation of the San Juan Islands. Tectonic processes resulting from the interaction of the North American and Farallon plates dominated during the Paleozoic and Mesozoic periods approximately 100 to 84 million years ago (mya). Subsequent strong glacial events during the Pleistocene deposited approximately 1,800 m of ice over what are now the islands (McKinley 1993). As these ice masses moved they carved the bedrock leaving glacial moraines, resulting in much of today's visible landscape (Clague and James 2002). The glacial period ended approximately 13,600 mya and then the land lifted, followed by coastal erosion and glacial stream deposition. Glacial deposits form the constraining layers of the island's aquifers. A series of faults in the region could cause devastating earthquakes, in particular the shallow South Whidbey Fault poses significant danger (Johnson et al. 1996).

2.2.5. Hydrology/Water Quality

The Reserve has no perennial streams and only one perennial freshwater body (Lake Pondilla). Many small water channels of natural or human origin flow seasonally into marine waters but there are few extant estuaries. A low ridge oriented generally along the north-south axis of Whidbey Island divides the Reserve such that roughly half the runoff can be expected to flow westward into Admiralty Inlet and the other half eastward (and northward and southward) into Penn Cove. Groundwater from one primary aquifer provides most of the drinking water for the island, and groundwater quality is a significant resource of concern (Spivak et al. 1988). Freshwater resources are assessed in Section 4.3.

2.2.6. Soils, Erosion, and Coastal Geomorphology

Nearly all soils on the island are of glacial origin (Copass and Ramm-Granberg 2016), with small areas of tidal soils along the coast, and sites where burning by Indians left layer of rich, organic surface soils (Weiser and Lepofsky 2009).

Shorelines and Bluff Erosion

The coastal sites of Whidbey Island (and within the Reserve), including elevated bluffs and low-lying beaches, are morphologically dynamic. Due to the lack of rivers on Whidbey Island, beaches depend solely on bluff erosion for sediment. Feeder bluffs, which are steep, naturally eroding glacial deposits that intersect tidal waters, comprise 35% of Island County's shoreline, a percentage among Puget Sound counties that is exceeded only by nearby Jefferson County. Nearly all the shoreline in EBLA is designated as "Unstable Slope" (IC 2016), compared with a maximum (for Puget Sound) of 58% in King County and a minimum of 3% in San Juan County (Shipman 2004).



Cobble beach and coastal bluff composed of poorly sorted glacial deposits (Photo by Marsha Davis).

No other county in Washington has a higher percentage of “exceptional” feeder bluffs (elevated sites that provide sediment to underlying beaches; MacLennan et al. 2013). Nearly the entire western shoreline north of Crockett Lake is comprised of feeder bluff, most of it mapped as “exceptional” (Figure 2.4). Around Penn Cove, an exceptional feeder bluff is present on Penn Cove Road east of Fossil Lane, and feeder bluffs occupy at least one-third of the Penn Cove shoreline within the Reserve.

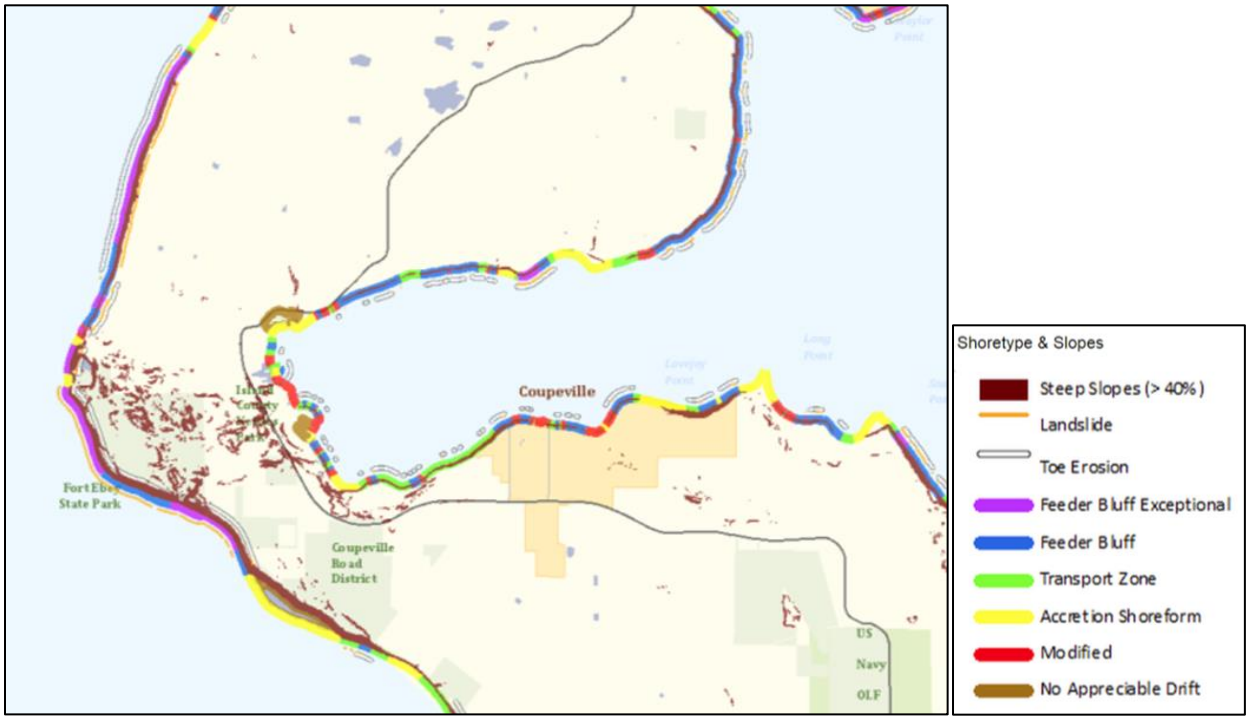


Figure 2.4. Shoreline types within the Reserve. Source: https://fortress.wa.gov/ecy/coastalatlas/tools/Map.aspx.

Segments of shoreline where sediment moves mostly in one direction parallel to the shore are called drift cells. Drift cells typically include 1) a sediment source (usually a feeder bluff); 2) a transport zone where sediments are moved along the shoreline over time; and/or 3) a depositional area. Drift cells around Whidbey Island move generally southward on the Reserve’s western shoreline along Admiralty Bay, westward along the north shore of Penn Cove, and both westward and eastward along the rest of Penn Cove (Figure 2.5).

The transport by marine currents of sediments affects light penetration depth in offshore habitats, creates beaches, structures communities of aquatic plants and fish, and distributes beneficial as well as toxic materials (Fresh et al. 2004, Thom et al. 2005, Mumford 2007, Sobocinski et al. 2010, Brennan et al. 2009, Parks et al. 2013). When drift cell currents carrying sediment encounter a feeder bluff, bedrock formation, pier or other sizeable structure perpendicular to the shore, some of the sediment is deposited but much may be transported offshore and is permanently “lost” from the nearshore environment.

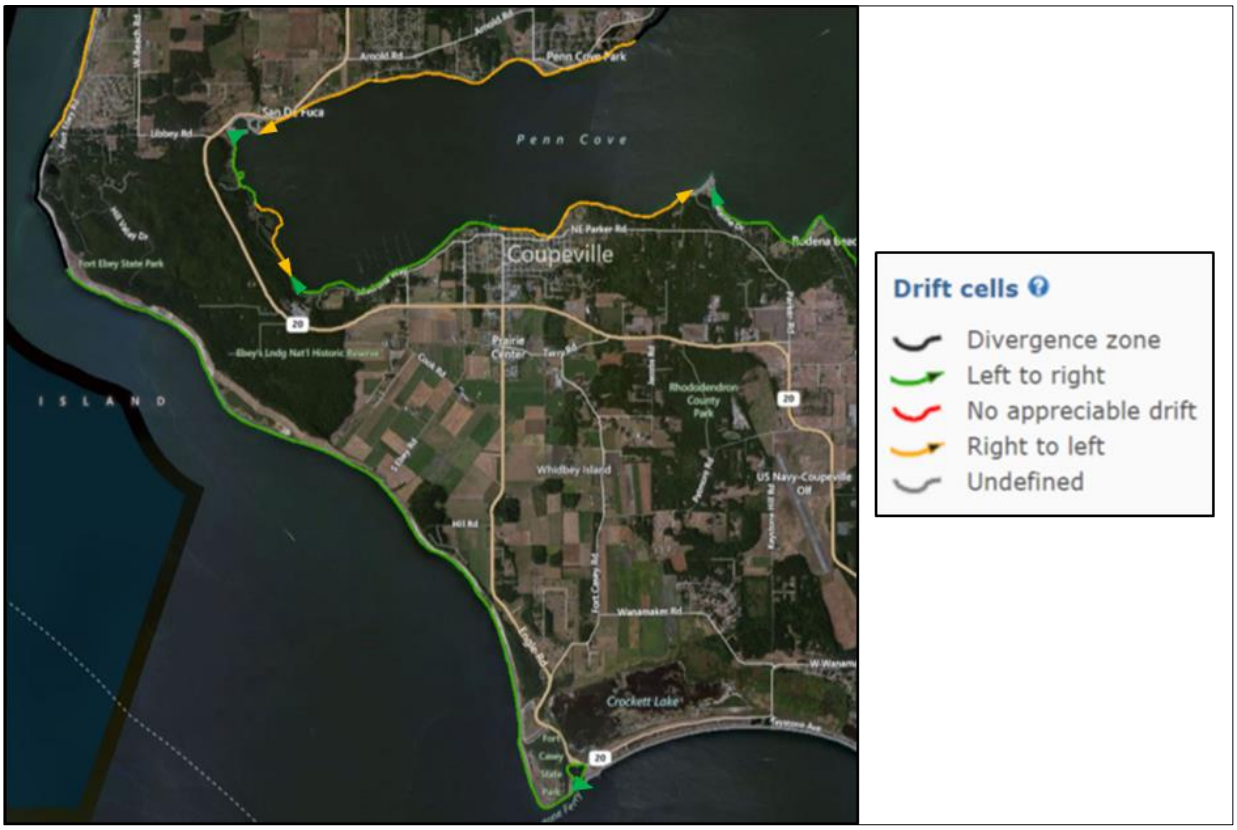


Figure 2.5. Drift cell flow direction within the Reserve; direction is as viewed from the water. Source: Washington Coastal Atlas https://fortress.wa.gov/ecy/coastalatlas/tools/Map.aspx.

Lagoons

Lagoons are coastal ponds usually formed by accretion of deposited sediment that forms a beach and separates the lagoon from the open ocean environment. There are two lagoon sites of significant size in the Reserve: Perego's Lagoon and Keystone Spit/Lake Hancock. Lagoons such as Perego's Lagoon receive tidal water only infrequently, while those like Kennedy's lagoons receive tidal water more regularly, even daily, but are largely enclosed by land. Lagoons are recognized by the Washington Department of Ecology as particularly important natural features because of their unique geochemistry and relative scarcity in Puget Sound. Perego's Lagoon (including the associated berm/strand) has been nominated as a coastal wetland sanctuary (Kunze 1984).



Kennedy's Lagoon panorama (Photo by Steve Olson).

Strand and spit communities are especially vulnerable to changes related to geomorphic landform, hydrology, and hydrologic events. These communities are closely dependent on natural processes of beach formation, storm surge disturbance, sea level fluctuations, sediment erosion/deposition, and wind-mediated sand transport (Gallucci 1980). Predicted future sea level rise, combined with potentially larger storms, may threaten the stability of strand/spit communities simply through inundation or via higher and more frequent storm surges. Coastal morphology in general could be significantly altered by such events, and thereby alter the distribution and composition of coastal spits and strand (Huppert et al. 2009). Potential impacts to coastal resources from climate change effects are discussed in Chapter 5.

2.2.7. Fire

Because lightning is not a major source of wildfires on the San Juan Islands, the fire history of the Reserve is almost entirely related to intentional burning of the prairies and woodlands by Native Americans (Chappell et al. 2001, Spurbeck and Keenum 2003, Gray and Daniels 2006, Storm and Shebitz 2006, Sprenger and Dunwiddie 2011). Fires were deliberately set to create conditions that favored the growth of many plants that were important sources of food or medicine to native cultures, such as camas (*Camassia quamash* and *Camassia leichtlinii*), strawberries (*Fragaria* species), bracken (*Pteridium aquilinum*), yampah (*Perideridia gairdneri*) and chocolate lily (*Fritillaria affinis*) which thrive in recently burned-over areas (Turner 1995). Wildfires are now rare on the island.

2.3. Biological Resources

2.3.1. Upland Vegetation Communities

The central part of Whidbey Island is characterized by broad prairies, low rolling hills, and productive farmland. Prior to establishment of the Reserve a significant portion of the land was logged (Table 2.1), grazed, and/or farmed, practices that greatly altered native ecosystems. In particular, the prairies and open landscapes seen today are largely remnants of human practices that incorporated fire to retard woody species encroachment and leave open spaces for farming and harvesting (Weiser and Lepofsky 2009). Timber harvest from private lands, agricultural and residential land uses continue (Table 2.1), alongside many ecological restoration efforts that have improved the natural character of many sites.

Table 2.1. Timber harvest (volume in thousand board feet) in Island County in 2012, by species. Source: Washington Department of Natural Resources.

Ownership (all private)	Species								Total
	Douglas Fir	Western Hem-lock	Cedar	Ponder-osa Pine	Other Pine	Other Conifers	Red Alder	Other Hard-woods	
Industrial	0	0	0	0	0	0	0	0	0
Large	0	0	0	0	0	0	0	0	0
Small	325	267	280	0	0	3,388	622	368	5,250
Unknown	85	0	0	0	0	0	0	0	85
Total	**410**	**267**	**280**	**0**	**0**	**3,388**	**622**	**368**	**5,335**

2.3.2. Plant Diversity

Rochefort (2010) reported a total of 352 species compiled from various sources which documented collections and records primarily from native-dominated habitats. For this report additional records from surveys of the Robert Y. Pratt Preserve (The Nature Conservancy), the Pacific Rim Institute on Smith Prairie (Dunwiddie et al. 2013), Ft. Casey and Ft. Ebey State Parks (R. Fimbel, WA State Parks), and the Naas Preserve were included for assessment. Compiling records from all those sites results in a total species count of 445, 64% of which are native (Table 2.2). A cursory examination of local herbarium records (http://www.pnwherbaria.org/data/search.php), indicates that this total represents approximately one-quarter of the entire Island County flora.

Table 2.2. Number of vascular plant species in the Reserve (adapted from Rochefort 2010).

Growth Form	Total (no.)	Native Species	Non-native Species
Forbs	236	150	86
Graminoids	74	43	31
Shrubs and vines	41	34	7
Trees	23	21	2
Total	**374**	**248 (75%)**	**96 (25%)**

2.3.3. Marine Invertebrates

Nearshore areas of EBLA that support marine invertebrates include those within Penn Cove and on the west side of Whidbey Island. The west coasts are exposed to marine conditions in the Strait of Juan de Fuca, while Penn Cove is fairly protected from ocean influences. Nearshore invertebrates include marine species that inhabit the intertidal or shallow subtidal zones and utilize marsh vegetation as protective habitat, attaching to rocks or burrowing in soft sediments (Dethier 2006, Table 2.3). Common groups present at various sites around Whidbey Island include mollusks (barnacles, clams, oysters, and abalone), crustaceans (crabs) and echinoderms (sea urchins, sea stars). Most nearshore invertebrates utilize tidal marsh vegetation as habitat and/or as foraging sites, and either attach to rocks or burrow in soft sediments.

Mollusks and crustaceans—often referred to as "shellfish" though they are not fish—are an extremely important economic resource in the region. A major commercial aquaculture operation for mussels exists in Penn Cove, and recreational harvest of shellfish occurs elsewhere in the Reserve. Three aquaculture districts exist within the waters surrounding the Reserve: District 1E is in Penn Cove on the south shore west of Coupeville and is permitted to Penn Cove Shellfish; LLC. District 2C has no current regulated activities, however geoduck harvesting has been allowed under previously issued shoreline permits; District 3E, which is located offshore from Fort Ebey State Park, was harvested for geoducks by state and tribal officials several years ago. Although District 3E is a significant bed, the geoducks are too small and not of high commercial value.

Table 2.3. Common and economically important marine invertebrates found around Whidbey Island and particularly in Penn Cove.

Species	**Common Name**
Protothaca staminea	Native littleneck clam
Nuttalia obscurata	Varnish clam
Saxidomus gigantea	Butter clam
Panopea generosa	Geoduck clams
Venerupis philippinarum	Manila clam
Crassostrea gigas	Pacific oyster
Mytilus trossulus	Bay mussel
Haliotis kamtschatkana	Pinto abalone
Cancer magister	Dungeness crab
Pandalus goniurus	Pandalid shrimp (humpy shrimp)
Dendraster excentricus	Sand dollar
Strongylocentrotus spp.	Sea urchins

2.3.4. Vertebrates

Fish

Fish communities adjacent to Reserve shorelines include several salmonid species and ESUs, (Evolutionarily Significant Units), and many species of smaller, prey species, often called forage fish (Table 2.4). In general, species in the Salmonidae family spawn (lay eggs) in fresh water but spend some portion of their life at sea. After hatching and early development, juvenile salmonids (smolts) mature for a period of time (less than one to several years) in tidal estuaries or other freshwater sites before migrating to the ocean, though use patterns and behavior in estuaries is extremely species specific (Weitkamp et al. 2014). Juvenile salmon, including chum, chinook, and coho, are often found in Penn Cove, along Admiralty Inlet and occasionally in Grasser's Lagoon (Beamer et al. 2006, Fradkin 2011). Non-salmonids including surf smelt and sand lance utilized Penn Cove areas for spawning.

Table 2.4. Common fish species occurring around Whidbey Island.

Species	Common Name	Notes/Locations/References
Oncorhynchus keta	Chum	–
O. gorbuscha	Pink salmon	–
O. nerka	Sockeye salmon	–
O. kisutch	Coho salmon	–
O. tshawytscha	Chinook salmon	–
Hypomesus pretiosus	Surf smelt	Smelt use nearshore habitat for all their life-history stages;
Clupea pallasii	Pacific herring	Pacific herring are a Federally designated Species of Concern, and require nearshore waters for all life-history stages; Penttila 2007
Ammodytes hexapterus	Pacific sand lance	Use nearshore habitat for all their life-history stages

Birds

At least 85% of the bird species known to occur on Whidbey Island have been documented from the Reserve. Crockett Lake in particular provides habitat for migratory shorebirds, and shorelines near Keystone and Fort Casey support exceptional numbers of several regionally declining loon, grebe, and alcid species. Penn Cove supports high concentrations of sea ducks (e.g., scoters), western grebe, and black turnstones; prairies within the Reserve support nesting northern harriers, a raptor species that appears to be declining in much of western Washington. Birds are assessed in Section 4.6.

Terrestrial Vertebrates (Amphibians, Reptiles, Mammals)

Very little is known regarding the condition of any terrestrial vertebrate species or group. Though amphibians are common in much of the PNW, amphibian diversity on Whidbey Island is relatively low due to limited sources of freshwater. Reptile diversity is even lower with only a few species recorded from all the San Juan Islands. Mammal communities include small and medium-size species, but most of the large mammals other than black-tailed deer (*Odocoileus hemionus columbianus*) have been extirpated. Non-native species, in particular eastern cottontail (*Oryctolagus floridanus*), have negative impacts on vegetation resources. Though deer are native, in the absence of large predators, populations of deer have increased to levels where they also cause damage to vegetation. The vertebrate resource of EBLA is assessed in Section 4.7.

Marine Mammals

Cetaceans (whales, dolphins, and porpoises) and pinnipeds (seals, sea lions and walruses) all spend some portion of the year in the waters around Whidbey Island. Cetaceans include killer whales (Southern Resident Ecotype; *Orcinus orca*), gray whales (*Eschrichtius robustus*), humpback whales (*Megaptera novaeangliae*), minke whales (*Balaenoptera acutorostrata*) Dall's porpoise (*Phocoenoides dalli*), and harbor porpoise (*Phocoena phocoena*). Orcas in particular were highly exploited in the region, for example over 100 were netted and many of those transported for use in captivity from Penn Cove as recently as the 1970s (Bigg and Wolman 1975). Though southern

resident killer whales are in decline (Ruggerone et al. 2019), a few transient whales still visit Penn Cove annually (R. Zipp pers. comm. 2019).

Species that haul-out on land and thus might occur in the Reserve include Steller's sea lion (*Eumetopias jubatus*), California sea lion (*Zalophus californianus*), and harbor seals (*Phoca vitulina*). Sea otters (*Enhydra lutris*) may be present but if so are quite rare in island waters (R. Zipp pers. comm 2019). Haul-out locations occur on mudflats and sandbars, and these species can often be seen on offshore rocks. Harbor seals are most abundant during the pupping season (June–August), and during the molt (August–October).

2.3.5. Resources of Concern

Plant Communities

Many native vegetation communities, representative of the Pacific Northwest and the San Juan Islands are present in EBLA, but these sites are small, and in most areas, vegetation consists of a mix of native and non-native species (R. Zipp pers. comm. 2019). Copass and Ramm-Granberg (2016) identified seventeen plant associations that are imperiled either locally or globally. Prairies that once covered many areas of the region, but now are rapidly disappearing, are a key feature of the Reserve. The Reserve's coastal strand/spit habitat is of local conservation concern. Two herbaceous plant associations occurring within this habitat in the Reserve are of particular note according to the Washington NHP: *Festuca rubra – Ambrosia chamissonis*—globally critically imperiled; *Leymus mollis* ssp. *mollis – Abronia latifolia* globally imperiled association. Other communities of conservation concern include the dry forests and woodlands which only occur in a limited range in the Olympic Mountains rain shadow and several wetland types. Upland plant communities are assessed in Section 4.5.

Plant Species

Four of the world's 12 remaining populations of golden paintbrush (*Castilleja levisecta*), a species considered rare throughout most of the Pacific Northwest and listed as Threatened by the USFWS, occur within the Reserve. (Though rare, several restoration efforts have been very successful at increasing overall abundance of this species; Gamon 1993, Lawrence and Kaye 2011). Three other plants considered to be rare in Washington currently occur in the Reserve: shortspur white plectritis (*Plectritis brachystemon*), white-top aster (*Sericocarpus rigidus*), and Scouler's catchfly (*Silene scouleri* ssp. s*couleri*). Although not listed by the Washington NHP, several other species that are known to occur in prairie habitats at the Reserve are of conservation concern due to their scarcity on Whidbey Island and would be important elements to consider in restoration of native prairies (Table 2.5). Rare plants are also discussed in Section 4.5.

Table 2.5. Rare plant species recorded from Island County, Washington. From: https://www.dnr.wa.gov/NHPlists.

Scientific Name	Common Name	State Status	Federal Status	County-listed	Historical Only
Agoseris elata	tall agoseris	S	–	X	H
Balsamorhiza deltoidea	Puget balsamroot	R2	–	–	H
*Castilleja levisecta**	golden paintbrush	E	LT	X	–
Ceratophyllum echinatum	smooth hornwort	R1	–	–	H
Cicuta bulbifera	bulb-bearing water-hemlock	S	–	X	H
Erythronium revolutum	pink fawn-lily	S	–	–	H
Fritillaria camschatcensis	black lily	S	–	X	H
Leptosiphon minimus	true babystars	R1	–	–	–
Meconella oregana	white meconella	T	SC	X	–
*Plectritis brachystemon**	shortspur white plectritis	R1	–	–	–
Ranunculus californicus var. *californicus*	California buttercup	T	–	–	H
*Puccinellia nutkaensis**	Alaska alkaligrass	–	–	X	–
*Sericocarpus rigidus**	white-top aster	S	SC	X	H
Silene scouleri ssp. *scouleri**	Scouler's catchfly	S	–	–	H
Solidago missouriensis	Tolmie's goldenrod	R2	–	–	H

* Indicates species with current records in the Reserve. State status abbreviations are as follows: E=Endangered, S=Sensitive, T=Threatened, R1 and R2=Review groups of potential concern, H=Historic, recorded only prior to 1977. Federal Status: LT=Listed Threatened, SC=Species of Concern.

Marine Invertebrates

Pinto abalone are federally listed as a Species of Concern. Commercial harvest of pinto abalone has never been allowed in Washington, and recreational fisheries have been closed since this species was listed in 1994. Populations along the west coast of the United States and Canada have experienced dramatic declines in the last few decades, and current population levels are likely too low to support effective reproduction (Dethier et al. 2006, NMFS 2007, NOAA et al. 2010). In the inside waters of Washington, pinto abalone are currently found only along Whidbey Island, the San Juan Islands, and a few areas within the Strait of Juan de Fuca (Dethier 2006).

Terrestrial Invertebrates

Taylor's checkerspot butterfly, (*Euphydryas editha taylori*), a subspecies of Edith's checkerspot, is in imminent danger of extinction. In October 2013 the US Fish and Wildlife Service designated this species as Endangered under the ESA and the WDFW lists it as a Species of Concern. Only 14 populations are known, all in Washington and Oregon, with almost three-quarters of the known populations at only two sites. Although historically present in prairie habitats on Whidbey Island (Stinson 2005, Sheehan 2007), Taylor's checkerspots are not currently known to be present in Island County, and intensive surveys for the species in the past few years have failed to find them within the Reserve. Golden paintbrush (discussed above), is likely one of the few plants that serve as a larval food plant for checkerspots (Dunwiddie et al. 2016). Some populations in other parts of the species'

range appear to be dependent on the non-native English plantain (*Plantago lanceolata*), a non-native species (Dunwiddie and Rogers 2017).

Birds

The marbled murrelet (*Brachyramphus marmoratus*) is the only bird species in the Reserve currently listed federally as Threatened or Endangered. Marbled murrelets do not nest in the Reserve (due to lack of old-growth forest which they require) but feed regularly in marine waters adjoining Whidbey Island.

Fish

The only Federally Endangered fish (non-salmonid) in Puget Sound is the Puget Sound/Georgia Basin Boccaccio (*Sebastes paucispinis*) that occurs in kelp forests and seagrass beds nearshore.

Federally Threatened fish species in Island County include Coastal-Puget Sound bull trout (*Salvelinus confluentus*), Hood Canal summer chum salmon (*Oncorhynchus keta*), Puget Sound Chinook salmon (*O. tshawytscha*), and Puget Sound steelhead (*O. mykiss*). The Puget Sound Salmon Recovery Plan (SSPS 2007) suggests overall goals and objectives for salmon protection and conservation in Island County. The western part of the Reserve is within Geographic Area 3 which the County considers to be of lower priority because it is not adjacent to any of the rivers with natal populations of salmon and most habitats are impacted by currents and high wave energy (SSPS 2007). However, the geographic priorities in the Salmon Recovery Plan have not been updated to include data from more recent surveys of the nearshore and associated streams.

Marine Mammals

The Southern Resident killer whale (*Orcinus orca*) is federally listed as Endangered and the shoreline of Whidbey Island is within the designated Critical Habitat zone for this species (NMFS 2008). This orca population declined almost 20 percent from 1996 to 2001, increased until about 2011, but now appears to be in serious decline (https://www.westcoast.fisheries.noaa.gov/protected_species/marine_mammals/killer_whale/). Humpback whales (*Megaptera novaeangliae*) are also endangered but are rarely observed nearshore.

Steller sea lions (*Eumetopias jubatus*) were federally listed as Threatened in 1990. Critical Habitat was designated in 1999 but does not include any locations in Washington State, though WDFW continues to designate it as Threatened. The Eastern North Pacific population of gray whales (*Eschrichtius rocustus*) was delisted from federal endangered status in 1994 but is still listed as Sensitive by WDFW. The species is often sighted as individuals pass through Island County marine waters during their migration between feeding grounds in Alaska and breeding grounds in Mexico.

2.4. Primary Threats to Natural Resources

Farming and other agricultural practices are an important element of the cultural history and landscape of EBLA. However, the presence of such highly managed lands does reduce the abundance of native plant and animal species. But open space settings provided by rural landscapes have lower impacts than other uses, particularly conversion of agricultural land to various forms of urban development. Noise levels from intense Navy aircraft operations present not only a

socioeconomic issue, but acoustic research in general shows that excessive noise also impacts wildlife (Francis and Barber 2013), and even plants (Francis, et al. 2012). Throughout the Reserve, several invasive plant species have likely reduced the diversity of native prairie, wetland, and woodland plant communities (Section 4.5).

Artificial structures such as bulkheads, docks, and other types of shoreline infrastructure have the potential to alter drift current direction and speed, and thus the amount, type, and location of sediment that is transported and deposited. This in turn influences the subsurface penetration of light necessary for underwater productivity. Shoreline armoring in parts of Penn Cove may be interfering with normal sediment dynamics of these feeder bluffs. Moreover, development at the top of a feeder bluff can accelerate natural erosion by modifying runoff patterns, placing extra weight on the top of a bluff, and removing stabilizing soil and vegetation (Shipman 2004). Also, on-site septic systems associated with bluff-top residences introduce significantly more water into the bluff soils, promoting accelerated erosion and occasional slope failure. Approximately 9–16% of Whidbey Island's shoreline was converted from a natural to an artificial geomorphic condition from the late 1800s to present times (Thom et al. 2011). Another type of artificial structure—the tide gates on Crockett Lake—also affect water circulation and thus salinity, water levels, and habitat conditions within that lagoon (Section 4.3).

Plastic and other solid debris enter marine waters from sources both near to (e.g., recreational and commercial boats, ferries) and removed from EBLA (e.g., fishing fleets, aquaculture, ocean dumping; Andrady 2011, Hirai et al. 2011, Hammer et al. 2012). Many studies have documented harmful effects of marine debris (especially microscopic-sized plastics) on marine mammals, seabirds, and ocean food chains (e.g., Tanaka et al. 2013).

Within the coming decades, the Reserve's nearshore marine life will be affected by increasing ocean temperature and acidity, both associated with global climate change (Okey et al. 2012, Doney et al. 2012, Mauger et al. 2015, Cooley et al. 2017). Because of their dependence on acid-soluble calcium carbonate for shell-building, species greatly threatened by ocean acidification include crabs, oysters, clams, barnacles, mussels, starfish, and zooplankton. Acidification has already been documented in Puget Sound and on the Washington side of the entrance to the Juan de Fuca Strait, with consequent changes in the marine fauna (Wootten et al. 2008, Alin et al. 2014, Bianucci et al. 2018). Penn Cove in particular, and also Perego's Lake, regularly experience harmful algal blooms (HABs) that have myriad impacts on marine and freshwater organisms and systems (Anderson et al. 2008, Van Alstyne 2016).

2.5. Resource Stewardship

2.5.1. Management Directives and Planning

The Reserve has completed its General Management Plan (NPS 2006) which provides guidance for decisions regarding management of natural and cultural resources, visitation, and development for the next 15 to 20 years. Among many goals stated in the Plan, the following are most pertinent to natural resources: 1) Natural resource conditions in the Reserve are maintained for natural processes

and healthy ecosystems; 2) Natural landscapes of bluffs and beaches are maintained in natural conditions with minimal structural intrusions.

In 2008 the Washington State Parks and Recreation Commission (WSPRC) published a management plan for the central Whidbey state parks entitled Central Whidbey State Parks Land Classes, Resource Issues and Management Approaches (WSPRC 2008). This document addressed natural resources in Fort Casey, Ebey's landing, and Fort Ebey State Parks, which are all within EBLA. (The plan also included Joseph Whidbey State Park which is outside the EBLA boundary). Management objectives for natural resources highlighted in the plan included:

- Potection of native plant and animal communities (all sites)
- Protect and participate in the recovery of golden paintbrush, *Castilleja levisecta* (Fort Casey)
- Manage vegetative succession and remove weeds through IPM (Fort Casey)
- Protection of Crockett Lake and Keystone Spit (Fort Casey)
- Control noxious weeds through IPM and maintain healthy native plant communities (Ebey's Landing)
- Preservation of beach ecology (Ebey's Landing)
- Manage seaweed harvest to protect the resource (Fort Ebey)
- Control noxious weeds through IPM and protect sensitive/unique plant communities (Fort Ebey)
- Protection of Lake Pondilla (Fort Ebey)

2.5.2. Supporting Science

I&M Program

Existing information on coastal water resources and watershed conditions in the Reserve was compiled by Klinger et al. (2007). An inventory of the Reserve's flora has been completed (Rochefort 2010) and a vegetation mapping project completed in 2016 (Copass and Ramm-Granberg 2016). Amphibians were inventoried for the NPS by Samora et al. (2013). No systematic surveys have been conducted of intertidal invertebrates, seaweeds, marine birds, marine mammals, terrestrial mammals, reptiles, or butterflies and other terrestrial invertebrates. Monitoring of visibility and air quality and the soundscape of the Reserve specifically (as opposed to the entire island or areas within the OLF study zone) have been limited, and there has been no systematic monitoring of natural night skies inside the Reserve.

Ongoing Research/Restoration

- The NPS Exotic Plant Management Team has worked closely with State Parks, Island County, and The Nature Conservancy to control several noxious weeds within the Reserve, particularly poison hemlock.
- The Whidbey-Camano Land Trust has undertaken extremely intensive actions to restore prairie, and particularly habitat for golden paintbrush, at the Naas/Admiralty Head Natural Area Preserve (Lowe and Sheehan 2010). Their work has focused on aggressive removal of Douglas-fir that have overtaken the prairie remnant over the last several decades; mowing, burning, and herbicide

applications have been incorporated using integrated pest management methods to reduce overall cover of shrubs and non-native species. Subsequent planting of a diverse suite of native prairie grasses, sedges, and forbs has followed extensive soil preparation applied to enhance establishment and survival of new plantings. This work has significantly enhanced the condition of and expanded an existing prairie community.

- Ecologists with Washington State Parks have worked with state Reserve staff to enhance about 6 ac of degraded prairie in front of the gun batteries at Ft. Casey SP. This has primarily involved regular mowing to control extensive encroachment of shrubs, as well as planting of golden paintbrush plugs and seed, and fencing to exclude grazers (Robert Fimbel, pers. comm. 2015).
- The National Park Service, in cooperation with the University of Washington, has conducted experimental prairie restoration trials in research plots at the Prairie Overlook and these efforts are now being used to inform long-term stewardship of the area as a demonstration site. Treatments have included herbiciding, hand-weeding, and other site-preparation treatments to control non-native grasses, and extensive planting of several native species such as Roemer's fescue.
- In Smith Prairie, the Pacific Rim Institute has worked to enhance the condition of the existing prairie remnant using burning, mowing, herbiciding, and seeding of native species, and herbicides. In cooperation with the University of Washington, this core area is being expanded as part of study to develop techniques for restoring native prairie in abandoned agricultural fields (Delvin 2013). Several additional acres are in the process of being restored. Delvin's studies also began to restore native prairie in a small area on The Nature Conservancy's Robert Y. Pratt Preserve.
- Most weed control within the Reserve is done by private landowners. However, one species—poison hemlock (*Conium maculatum*)—has been the focus of a multi-landowner coordinated effort, primarily centered around the bluffs at Ebey's Landing.

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Chapter 3. Study Approach

By Catherin Schwemm and Paul Adamus

3.1. Background

This project was conducted in three phases. The first phase, started in 2008 by the University of Washington (School of Forest Resources), was designed around a mixed group of graduate and undergraduate students in a for-credit class. The original intent was to complete a multi-park project for Ebey's Landing National Historical Reserve (EBLA), Fort Vancouver National Historic Site (FOVA), San Juan Island National Historical Park (SAJH), and Lewis and Clark National Historical Park (LEWI). A variety of limitations prevented completion of the multi-park project for EBLA and SAJH.

The second phase, started in 2012 by Oregon State University, focused on EBLA and SAJH. A scoping workshop including the study team and NPS resource specialists form the North Coast and Cascades Inventory and Monitoring Network (NCCN) and the regional office in Seattle (M. Bivin, J. Boetsch, T. Cummings, M. Davis, E. Gasser, C. Holmquist, K. Kopper, R.Kuntz, M. Larrabee, A. McCoy, T. Neel, A. Rawhouse, R.Rochefort, J. Riedel, L. Taylor, C. Thompson, and J. Weaver) and other scientists from the two parks was held at Ebey's Landing National Historical Reserve. The session included a discussion of NRCA objectives, potential data sources, and field visits to both the park and Reserve.

The phase two study team was coordinated by Paul Adamus of Oregon State University. Under his guidance the vegetation information was collected and summarized by Peter Dunwiddie of the University of Washington, the air quality information organized by Tonnie Cummings of the National Park Service, and the climate change information collected and summarized by Paul Adamus and Anna Pakenham (of Oregon State University). The remainder of the second phase of the study was assessed and written primarily by Paul Adamus.

NPS review findings of the interim and final draft reports for this phase determined that additional data inclusion and assessment was needed to both update and provide a more in-depth analysis of the Reserve's resources. The Phase II report also was not delivered in the format specified in the NPS NRCA guidance to meet publication requirements, though this is partly due to the project spanning a time period when the report format was updated.

A third phase was initiated in 2017 to revise and update the phase two reports. This phase included a review and modification of the resource topics, reorganization of the material into the required NPS NRCA structure, an extended literature search for additional data and information to enhance the condition assessment of some of the Reserve's resources, and additional writing and editing to update the report. This phase also enabled input from new park staff who brought to light emerging issues and a re-emphasis on resources of current major concern. The third phase was coordinated by Marsha Davis (NPS) and conducted by Cathy Schwemm of the Institute for Wildlife Studies.

3.2. Study Design

3.2.1. Focal Study Resources

In 2005, the NPS North Cascades Network's Vital Signs program (Weber et al. 2009) identified the following as important natural resource concerns at EBLA:

- Land-use changes in parts of the Reserve not owned by NPS
- Endangered plants
- Prairie restoration
- Changes in visibility due to airborne particulate matter
- Exotic plants

More recently, natural resource issues in the Reserve were prioritized by the National Park Service staff involved with the Reserve, using a structured input process with stakeholders. In no particular order, the 12 "focal themes" that were ranked highest (3 on a scale of 0 to 3) from a list of 48 themes considered potentially applicable to resource lands in this region were:

- Urban encroachment/rural development
- Habitat conversion (farms, logging, etc.)
- Wetlands & riparian areas
- Traditional land uses (historic, farming, grazing, etc.)
- Invasive species (plant and animal)
- Areas with evidence of invasive plant or animal species
- Shoreline erosion
- Soil erosion
- Water quality
- Pesticide runoff
- Saltwater intrusion
- Groundwater flow

Integrating the results of the above efforts with reviews of new information, and for compliance with the revised NPS NRCA guidance, the final report is organized around the focal natural resources presented in Table 3.1.

3.2.2. Indicators and Reference Conditions

For each priority resource the team identified multiple indicators of resource condition. In developing the list of indicators and specific measures, the team considered the idealized guidance of Harwell et al. (1999) and particularly Kershner et al. (2011): "Indicators are quantitative biological, chemical, or physical measurements that reflect the structure, composition, or functioning of an ecological system."

For each indicator the team then attempted to define reference conditions against which present conditions could be compared. A reference condition may be a historical condition (e.g., pre-settlement land cover), an established ecological threshold (e.g., EPA standards for air quality), or a targeted management goal or objective (e.g., 90% control of an invasive species for at least ten years). In this project, the team mostly used the period of settlement (i.e. generally the early to mid-1800s) as best as could be determined or surmised. In this case, due to the absence of quantitative data for several resources, qualitative or observational indicators were incorporated.

3.2.3. Ecological Framework

The team reviewed and considered several frameworks for organizing this NRCA, ultimately deciding to generally follow the National Park Service Inventory and Monitoring Framework (Fancy et al. 2009; Table 3.1).

Table 3.1. Focal natural resources of EBLA selected for assessment, presented within the NPS Ecological Framework (Fancy et al. 2009).

Level 1 Category	EBLA Focal Resources	Indicators
Air and Climate	Air Quality and Air Quality Related Values (Section 4.1)	• Visibility • Nitrogen and Sulfur Deposition • Ozone
	Regional and Local Climate (4.2)	• Temperature • Precipitation
Geology and Soils	–	• –
Water	Water Resources (4.3)	• Surface Water Extent • Surface Water Quality • Groundwater Quality • Groundwater Quantity
Biological Integrity	Wetland and Nearshore Vegetation (4.4)	• Distribution/Extent
	Upland Vegetation (4.5)	• Distribution/Extent • Absence of Invasive Species
	Birds (4.6)	• Species Diversity • Presence of Key/Rare species
	Vertebrates (4.7)	• Species/Diversity
Ecosystem Pattern and Processes	Natural Night Skies and Natural Quiet (4.8)	• Nighttime Light • Noise Levels
	Habitat Connectivity and Land Use (4.9)	• Habitat Connectivity • Land Cover

3.2.4. Data and Methods

To identify relevant documents for review, the Phase I team began with a search and retrieval of reports and information from the NPS bibliographic database (IRMA, Integrated Resource Management Applications). The team augmented that database using online search engines (Web of Science, Google Scholar) to identify newer publications as well as locating relevant documents pertaining to the region surrounding the Reserve, searching with phrases such as "Whidbey Island," "Island County" and "Salish Sea." The team obtained complete digital copies (PDFs) of many publications that reported relevant research results from the Reserve and surrounding region. The team then indexed all digital documents in an Excel spreadsheet so they could be sorted by topic and year and prioritized them for review.

In Phases II and III additional literature searches were conducted and new information, both published and unpublished, obtained when possible. For example, in the period between Phase I and II, the vegetation mapping effort for the Reserve was completed (Copass and Ramm-Granberg 2016), as well as several analyses of impacts of current and proposed Navy operations related to groundwater quality and natural quiet.

3.2.5. Reporting Areas

Because EBLA comprises multiple landowners and actual NPS-owned lands are a small portion of the Reserve, it was determined that assessments for most focal resources would be reported Reserve-wide rather than by watershed or management designation.

3.2.6. Condition Assessments

In order to determine an appropriate condition for each resource, the team consulted published reports and analyzed existing data. However, because in many instances data were generally insufficient to provide measured conditions, the team also relied on their own expertise and the expertise of others with prior experience studying natural resources in EBLA. Each assessment was also described in terms of confidence in the conclusions based on available data and expertise.

The described condition was then represented graphically using the symbols presented in Tables 3.2 and 3.3 and according to NPS NRCA guidelines (https://www.nps.gov/orgs/1439/nrca-guidance.htm). A brief descriptive summary of condition is provided at the beginning of each Section in Chapter 4, and a summary for all resources discussed and presented graphically in Chapter 5 and Table 5.1.

Table 3.2. Indicator symbols used to indicate condition, trend, and confidence in the assessment.

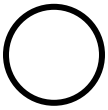
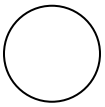
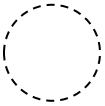
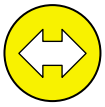
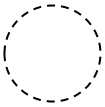
Condition Status		Trend in Condition		Confidence in Assessment	
	Resource is in Good Condition		Condition is Improving		High
	Resource warrants Moderate Concern		Condition is Unchanging		Medium
	Resource warrants Significant Concern		Condition is Deteriorating		Low

Table 3.3. Example indicator symbols and descriptions of how to interpret them.

Symbol Example	Description of Symbol
	Resource is in good condition; its condition is improving; high confidence in the assessment.
	Condition of resource warrants moderate concern; condition is unchanging; medium confidence in the assessment.
	Condition of resource warrants significant concern; trend in condition is unknown or not applicable; low confidence in the assessment.
	Current condition is unknown or indeterminate due to inadequate data, lack of reference value(s) for comparative purposes, and/or insufficient expert knowledge to reach a more specific condition determination; trend in condition is unknown or not applicable; low confidence in the assessment.

3.2.7. Report Format

Per the NPS NRCA guidelines (https://www.nps.gov/orgs/1439/nrca-guidance.htm), each individual resource assessment in Chapter 4 adheres to the following elements:

Assessed Resource

Condition Summary

A brief descriptive summary of condition findings, including graphical symbol, prefaces the discussion of each assessed resource in Chapter 4.

Background

This section describes the resource and generally why it was selected for inclusion in the project. This section also includes threatened or endangered status if appropriate, biological and ecological

descriptions and contexts, and relevance to the NPS mission. If known, threats to the resource or process are included in this section.

Reference Conditions

The measures used to evaluate the condition of the resource are defined here. If no clear science-based measures appear to exist and alternate evaluation methods were utilized, those are also included. The absence of any valid reference is noted here if necessary.

Data and Methods

This section includes references to both existing data and methodologies as well as specific assessment methods incorporated for the NRCA. Though NRCAs generally do not include data collection and are based largely on compilations, syntheses, and new analyses of pre-existing data, this report includes some LiDAR analyses, which are included in the appendix.

Resource Condition and Trend

This section summarizes what is known about the resource in relation to described reference conditions and is based on available literature, data, and expert opinions.

Level of Confidence

In some cases very little is known about the status of the resource and/or the conditions that should be used to make the assessment, or both. This section evaluates the level of confidence the team had in making the assessment.

Data Gaps and Research Recommendations

This section varies in length and scope. In some cases there are clear recommendations for further research or data that would be needed to have a high confidence in making an assessment. For some resources acquiring additional data is either not relevant or far outside the mandate of NPS managers and scientists, and in those situations the section is omitted.

Sources of Expertise

If there were subject matter experts who provided information for the assessment but who are not authors, they are identified here.

Literature Cited

Each section is followed by a complete cited reference list.

3.3. Literature Cited

Copass, C., and T. Ramm-Granberg. 2016. Ebey's Landing National Historical Reserve vegetation inventory and mapping project. Natural Resource Report NPS/NCCN/NRR—2016/1127. National Park Service, Fort Collins, Colorado.

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Kershner, J., J.F. Samhouri, C.A. James, and P.S. Levin. 2011. Selecting indicator portfolios for marine species and food webs: a Puget Sound case study. PLoS One, 6(10), p.e25248.

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Chapter 4. Natural Resource Conditions

4.1. Air Quality and Air Quality Related Values

By Tonnie Cummings

Air quality is not monitored at EBLA, but data from regional sites indicates air quality is generally good though visibility is of concern. No trends are apparent, and confidence is low.



4.1.1. Background

Visitor enjoyment, the health of Reserve ecosystems and the integrity of cultural resources depend upon clean air. To foster clean air in parks, the National Park Service (NPS) monitors air quality, assesses effects on resources, communicates information about air quality issues; advises and consults with regulatory agencies; partners with stakeholders to develop air pollution management strategies; and promotes pollution prevention practices.

The 1977 Clean Air Act amendments identified 48 national parks as Class I areas, affording them special air quality protection. All other NPS areas, including Ebey's Landing National Historical Reserve (EBLA), are designated as Class II air quality areas. The NPS Organic Act, the Wilderness Act and NPS 2006 Management Policies provide the basis for protection of air quality and air quality related values (AQRVs) in Class II areas. Air quality related values are resources sensitive to air quality, including visibility, lakes, streams, vegetation, soils, and wildlife.

Air Pollutants and Sources

Most human activities, including manufacturing and industrial processes, agricultural practices, land disturbance and fossil fuel combustion, produce air pollution. Ebey's Landing National Historical Reserve can be affected by pollution sources on Vancouver Island, British Columbia; by sources along the urban I-5 corridor in Washington and British Columbia; and by agricultural and livestock operations north and east of the Reserve (Figure 4.1-1).

Based on Washington Department of Ecology's (WDOE) most recent (2005) comprehensive emissions inventory, large point sources of air pollution within approximately 100 km of EBLA included refineries, aluminum smelters, cement plants and industrial facilities (WDOE 2012). Significant sources of area emissions near the Reserve were on-road vehicles, marine vessels and woodstoves/fireplaces (WDOE 2012). The air pollutants of concern in NPS areas are sulfur (S) and nitrogen (N) compounds, ground-level ozone and persistent bioaccumulative toxics.

The main source of S pollution is coal combustion at power plants and industrial facilities. Oxidized N compounds (i.e., nitrogen oxides) result from fuel combustion by vehicles, power plants and industry. Reduced N compounds (e.g., ammonia and ammonium) are the result of agricultural activities, fire and other sources. Ozone forms when nitrogen oxides and volatile organic compounds emitted from vehicles, solvents, industry and vegetation react in the atmosphere in the presence of

sunlight, usually during the warm summer months. Persistent bioaccumulative toxics include heavy metals like mercury (Hg) and organic compounds such as pesticides. Coal combustion, incinerators, mining processes and other industries emit Hg.

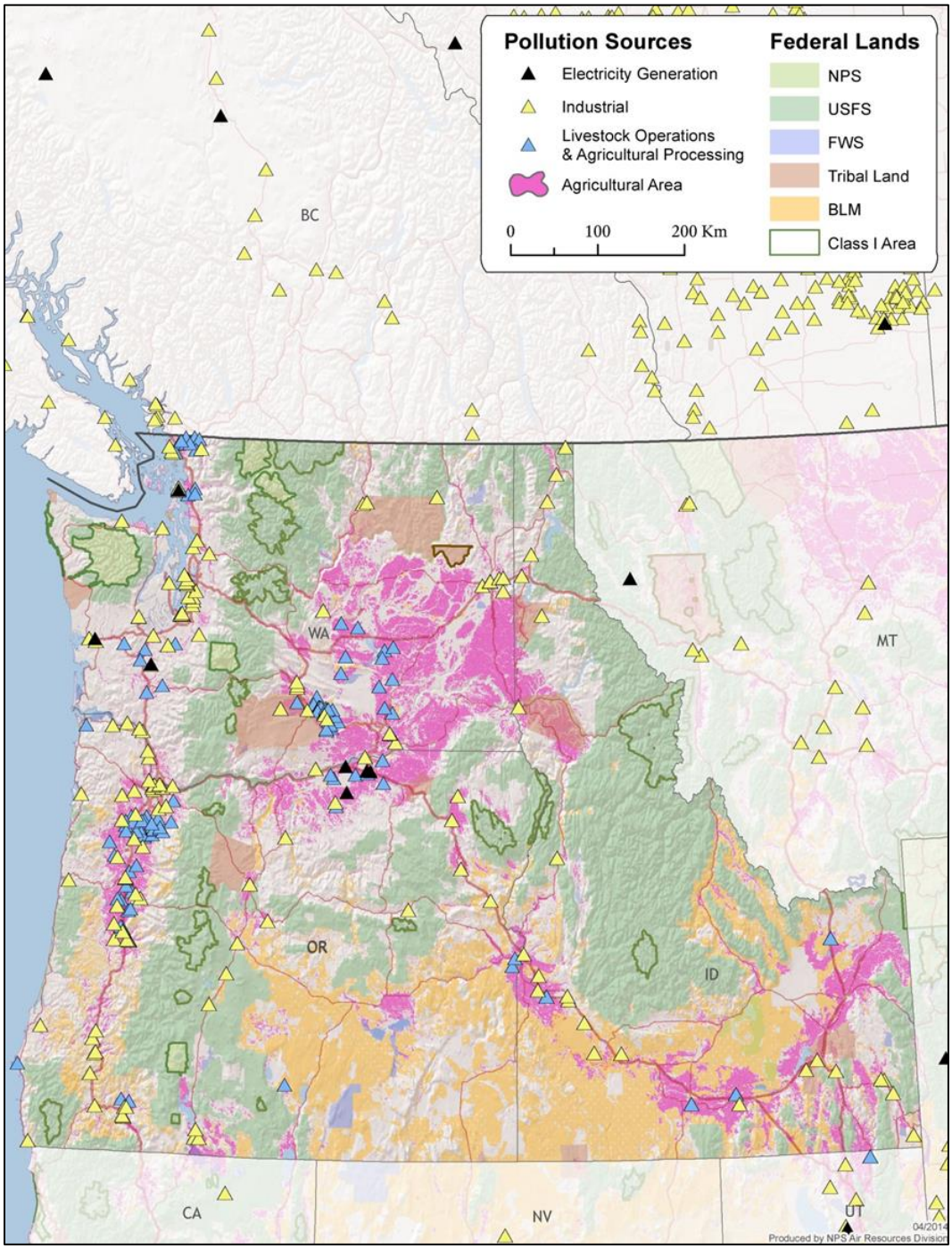


Figure 4.1-1. Public lands and air pollution sources in the Pacific Northwest. Triangles designate point sources that emit greater than 100 tons per year of nitrogen oxides (from Cummings et al. 2014).

Air Pollution Effects

Fine particles of S and N compounds, and other pollutants in the atmosphere, absorb or scatter light, causing haze and reducing visibility (Hand et al. 2011). Sulfur and N pollutants eventually fall out of the atmosphere and are transferred to the Earth's surface by either wet deposition (e.g., rain, snow, clouds and fog) or dry deposition (e.g., gases and particles). These pollutants change water and soil chemistry, which in turn, affects algae, aquatic invertebrates and soil microorganisms, and can lead to impacts higher in the food chain (Sullivan et al. 2011a; Sullivan et al. 2011b; Greaver et al. 2012). Deposition can acidify lakes and streams that have low buffering capacity. Also, because N is an essential plant nutrient, N compounds may cause unwanted fertilization or eutrophication, with subsequent changes in soil nutrient cycling and plant community structure and composition.

Ozone is a respiratory irritant and can trigger a variety of health problems including chest pain, coughing, throat irritation and congestion. Ozone also affects vegetation, causing significant harm to sensitive plant species (USEPA 2013). Ozone enters plants through leaf openings called stomata and oxidizes plant tissue, causing visible injury (e.g., stipple and chlorosis) and growth effects (e.g., premature leaf loss; reduced photosynthesis; and reduced leaf, root and total size).

After Hg is deposited, it can be transformed by ecosystem processes into a very toxic form, methylmercury, which biomagnifies in the food chain and can reach harmful levels in fish and wildlife. Biological effects of Hg and other persistent bioaccumulative toxics include impacts on reproductive success, growth, behavior, disease susceptibility and survival (Landers et al. 2008).

Visibility

Among the experiences that visitors to national parks treasure is enjoying the breathtaking scenery—majestic mountains contrasted against a pure blue sky or a spectacular array of stars at night. Fine particles in the atmosphere absorb or scatter light, causing haze, reducing visibility, and degrading scenic views (Hand et al. 2011). Visibility-impairing particles include anthropogenic pollutants as well as natural compounds like soil and sea salt aerosols. Fine particles are also a significant concern for human health because they lodge deep in the lungs and can cause respiratory problems (Dockery 2009).

Ozone

Ozone is a respiratory irritant that can trigger a variety of human health problems including chest pain, coughing, throat irritation, and congestion. Ozone also affects vegetation, causing significant harm to sensitive plant species (U.S. EPA 2014). Ozone enters plants through leaf openings called stomata and oxidizes plant tissue, causing visible injury (e.g., stipple and chlorosis) and growth effects (e.g., premature leaf loss; reduced photosynthesis; and reduced leaf, root, and total size).

Nitrogen and Sulfur Deposition

Airborne pollutants are eventually deposited through either wet deposition (i.e., rain, snow, clouds, and fog) or dry deposition (i.e., particles and gases) onto vegetation, soils, streams, and lakes. Sulfur and nitrogen deposition can have a significant effect on natural systems, and nitrogen is of particular concern in the western U.S. where many ecosystems are nitrogen limited. Over time, excess nitrogen deposition alters biodiversity and plant and soil chemistry, with cascading effects through ecosystems

(Cummings et al. 2014). Excess nitrogen deposition also leads to increased nitrate leaching to water bodies, where it can cause eutrophication, acidification, or dead zones.

The NPS, other land managers, and the U.S. Environmental Protection Agency (U.S. EPA) use critical loads to determine the threshold for ecosystem sensitivity to nitrogen deposition. A critical load is technically defined as "the quantitative estimate of an exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment are not expected to occur according to present knowledge" (Nilsson and Grennfelt 1988). Critical loads are typically expressed in terms of kilograms per hectare per year (kg ha-1 yr-1) of wet or total (wet plus dry) deposition. Critical loads can be developed for a variety of ecosystem responses, including shifts in aquatic plankton or terrestrial lichen and plant species, changes in soil chemistry, and lake and stream acidification. In general, as nitrogen deposition increases, additional resources are affected, and ecological effects become more pronounced (Cummings et al. 2014; Figure 4.1-2). The goal of the NPS is to limit nitrogen deposition to levels that do not exceed the minimum critical load for a park's most sensitive resources.

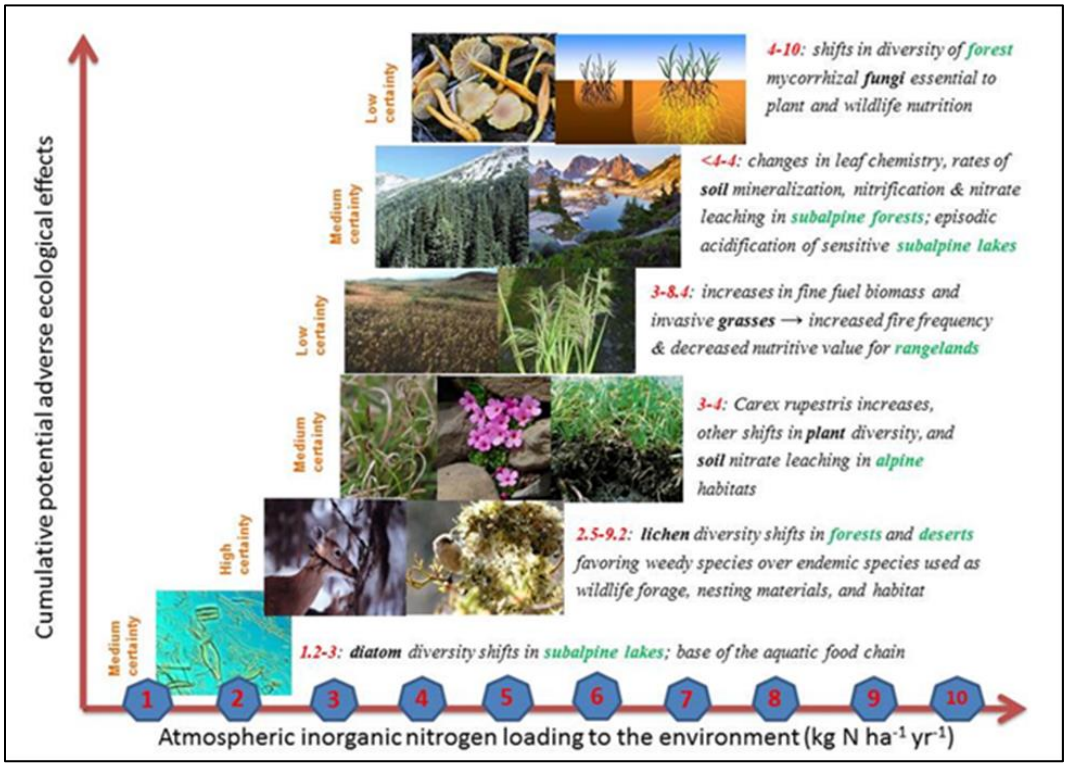


Figure 4.1-2. Cumulative potential adverse ecological effects associated with atmospheric nitrogen deposition in the Pacific Northwest. The reliability assessments are as follows: High Certainty when a number of published papers of various studies show comparable results, Medium Certainty when the results of some studies are comparable, and Low Certainty when very few or no data are available in the Pacific Northwest so the applicability is based on expert judgment (from Cummings et al. 2014).

Persistent Bioaccumulative Toxins

Persistent bioaccumulative toxins consist of heavy metals such as mercury, current and historic use pesticides, industrial chemicals, and by-products of fuel combustion. Concerns mainly pertain to impacts on humans and wildlife. Effects vary with the type of pollutant, but include declines in reproductive success, growth, and neurological function, and increased disease susceptibility (Landers et al. 2008). Though persistent toxins in the air are of great concern, this element will not be included as an indicator for air quality in this assessment.

4.1.2. Reference Conditions

Benchmarks were established based on regulatory standards, natural visibility goals, and ecological thresholds. Values estimated for each park were compared to ARD benchmarks for specific measures of ozone, visibility, and atmospheric deposition (Table 4.1-1).

Table 4.1-1. Indicators and specific measures for air quality condition assessments (from NPS 2015).

Indicator	Specific Measure
Visibility	Visibility on mid-range days minus natural visibility condition on mid-range days
Ozone	Human health: 4th-highest daily maximum 8-hour concentration
	Vegetation health: 3-month maximum 12-hour W126*
Nitrogen and Sulfur	Nitrogen wet deposition
	Sulfur wet deposition

* The W126 is based on a cumulative sum of hourly ozone concentrations during a rolling 3-month period, where the hourly values are weighted according to their magnitude.

Visibility

Visibility conditions and trends are expressed in terms of a haze index which correlates incremental changes in haziness to corresponding changes in perceived visibility. The haze index is reported in deciviews (dv). The dv scale is near zero for a pristine atmosphere and increases as visibility degrades.

The NPS visibility goal for parks is no human-caused impairment. Condition assessments are based on monitored or interpolated average visibility minus estimated average natural background visibility. Parks with average visibility less than 2 dv above natural conditions are considered in "Good Condition." Parks with visibility ranging from 2 to 8 dv above natural conditions are considered to be in the "Warrants Moderate Concern" category, and parks with visibility greater than 8 dv above natural conditions are placed in the "Warrants Significant Concern" category (considered to be equivalent to the terms used in this report). The NPS chose the dv ranges of these categories to reflect the variation in monitored visibility conditions (NPS 2013b). Specifically, these criteria are based on the deviation of the current Group 50 visibility conditions from estimated Group 50 natural visibility conditions, where Group 50 is defined as the mean of the visibility observations falling within the range from the 40th through the 60th percentiles. Visibility is estimated from the interpolation of the five-year averages of the Group 50 visibility.

Visibility monitoring has not been conducted at the Reserve. Interpolated 2005–2009 visibility at the Reserve was 6.6 dv on the 20 percent best days and 17.5 dv on the 20 percent worst days (NPS 2013a). The difference between average interpolated visibility and estimated average natural background visibility was 6.8 dv, i.e., current visibility is 68 percent worse than natural conditions. Visibility was in the Warrants Moderate Concern category (NPS 2013b).

The ARD's condition assessments are based on estimated average visibility on mid-range days (40th to 60th percentile) minus the estimated natural visibility on mid-range days (NPS 2015). The estimated value is compared to ARD benchmarks (Table 4.1-2). The difference between estimated current conditions and estimated natural visibility represents the human contribution to visibility impairment.

Table 4.1-2. Benchmarks for visibility condition (from NPS 2015).

Category	Visibility (dv)
Warrants significant concern	>8
Warrants moderate concern	2–8
Resource is in good condition	<2

Ozone

The ARD's condition assessments for human health risk from ozone are directly related to U.S. EPA's primary National Ambient Air Quality Standard of a 4th-highest daily maximum 8-hour ozone concentration of 75 parts per billion (ppb; NPS 2015). Note that U.S. EPA lowered the primary standard to 70 ppb in late 2015, but ARD had not yet revised its condition assessment to reflect the lower number. The maximum estimated ozone concentration at a park is compared against ARD benchmarks (Table 4.1-3).

Table 4.1-3. Benchmarks for human health condition for ozone (from NPS 2015).

Category	Ozone concentration* (ppb)
Warrants significant concern	≥76
Warrants moderate concern	61–75
Resource is in good condition	≤60

* Estimated or measured 5-year average of annual 4th-highest daily maximum 8-hour concentration

Although the primary National Ambient Air Quality Standard is not a good predictor of vegetation response to ozone, U.S. EPA has not set a secondary standard that focuses on vegetation. However, in its recent policy assessment of the ozone standards, U.S. EPA discussed use of the W126 to assess plant response (U.S. EPA 2014). The W126 preferentially weights the higher ozone concentrations most likely to affect plants and sums all the weighted concentrations during daylight hours. The highest 3-month period that occurs during the growing season is reported in parts per million-hours (ppm-hrs). Based on the information from U.S. EPA, research indicates for a W126 value of:

- ≤ 7 ppm-hrs, tree seedling biomass loss is ≤ 2 % per year in sensitive species; and

- ≥13 ppm-hrs, tree seedling biomass loss is 4–10 % per year in sensitive species.

The ARD compares maximum calculated W126 values at a park to benchmarks tied to the research results to assess vegetation condition related to ozone (NPS 2015, Table 4.1-4).

Table 4.1-4. Benchmarks for vegetation condition for ozone (from NPS 2015).

Category	Ozone concentration* (ppm-hrs)
Warrants significant concern	>13
Warrants moderate concern	7–13
Resource is in good condition	<7

* Estimated or measured 5-year average of the maximum 3-month 12-hour W126 concentration

Nitrogen and Sulfur Deposition

The ARD's condition assessments for nitrogen and sulfur deposition are based on wet deposition only, rather than total deposition, because the evaluation relies on data collected through the 250-plus National Atmospheric Deposition Program-National Trends Network (NADP-NTN) monitoring sites in the United States. Wet deposition is calculated by multiplying nitrogen or sulfur concentrations in precipitation by normalized precipitation amounts (NPS 2015). A park's maximum calculated deposition is then compared to benchmarks based on the results of studies that related the amount of atmospheric deposition to aquatic ecosystem health (Table 4.1-5). If a park is considered very highly sensitive to acidification or nitrogen nutrient enrichment relative to other Inventory and Monitoring parks, the condition is adjusted to the next worse condition category.

Table 4.1-5. Benchmarks for nitrogen and sulfur deposition condition (data from NPS 2015).

Category	Deposition (kilograms hectare-1 year-1)
Warrants significant concern	>3
Warrants moderate concern	1–3
Resource is in good condition	<1

4.1.3. Data and Methods

This air quality assessment used the methods developed by the NPS Air Resources Division (ARD) for a consistent Service-wide approach to evaluating conditions and trends in visibility, ozone, and deposition at NPS units throughout the continental U.S. (NPS 2015). In brief, data collected by federal, state, and local monitoring networks were evaluated with an Inverse Distance Weighted interpolation method to estimate air quality conditions for parks. Even though the data were derived from all available monitors, data from the closest stations to a park "outweighed" the rest. The estimates were based on the most recent 5-year averages.

The ARD calculates short-term trends from data collected over a 10-year period at on-site or nearby representative monitors, where available. Because these data are not available for SAJH, visibility, ozone, and deposition trends were not calculated for the Reserve.

The evaluation of nitrogen critical loads for **SAJH** used the results from ARD's Critical Loads and Estimated Exceedances website (NPS 2016a). The methods followed the approach described in Pardo et al. (2011), which recommended a range of critical load values for each of the Level 1 ecoregions identified in the ecosystem classification system developed through the Commission for Environmental Cooperation for North America (Commission for Environmental Cooperation 1997).

The NPS Air Resources Division (ARD) estimated visibility, deposition and ozone values for all Inventory and Monitoring (I&M) parks in the contiguous United States (NPS 2013a). They used all available data from NPS, U.S. Environmental Protection Agency (USEPA), state, tribal and local monitors to generate interpolations of air pollutant concentrations. The ARD also evaluated air quality trends and assessed air quality conditions in parks (NPS 2013b).

4.1.4. Resource Condition and Trend

The ARD's Air Quality Condition and Trends website (NPS 2016b) provides information on visibility, ozone, and deposition for EBLA based on 2009–2013 data.

Visibility

Visibility impairment is reported in deciviews (dv). Lower dv values correspond with better visibility conditions. Because NPS's visibility goal is no human-caused impairment in parks, condition assessments were based on monitored or interpolated average visibility minus estimated average natural background visibility. Parks with average visibility less than 2 dv above natural conditions were considered in Good Condition. Parks with visibility ranging from 2 to 8 dv above natural conditions were considered to be in the Warrants Moderate Concern category, and parks with visibility greater than 8 dv above natural conditions were placed in the Warrants Significant Concern category. The dv ranges of these categories were chosen to reflect the variation in monitored visibility conditions (NPS 2013b).

Visibility monitoring has not been conducted at EBLA. Interpolated 2005–2009 visibility at the Reserve was 6.6 dv on the 20 percent best days and 17.5 dv on the 20 percent worst days (NPS 2013a). The difference between average interpolated visibility and estimated average natural background visibility was 6.8 dv, i.e., current visibility is 68 percent worse than natural conditions. San Juan Island National Historical Park's visibility was in the Warrants Moderate Concern category (NPS 2013b).

Ozone

The USEPA's ozone National Ambient Air Quality Standards were used as a benchmark for rating ozone condition in parks (NPS 2013b). The primary standard, designed to protect human health, and the secondary standard, intended to protect ecosystems, are identical. To attain these standards, the 3-year average annual 4th-highest daily maximum 8-hour ozone concentrations must not exceed 75 parts per billion (ppb).

Parks with ozone concentrations less than 61 ppb (concentrations less than 80 percent of the standard), were considered in Good Condition. Ozone concentrations that ranged from 61–75 ppb (concentrations greater than 80 percent of the standard) placed parks in the Warrants Moderate

Concern category. Concentrations greater than or equal to 76 ppb exceeded the standards and resulted in the Warrants Significant Concern category.

Washington Department of Ecology monitored ozone at EBLA for one month during the summer of 2009; concentrations were consistently low (Donovan Rafferty, WDOE Air Quality Program, pers. comm. 2013). The 2005–2009 interpolated data indicated a 3-year average annual 4th-highest daily maximum 8-hour ozone concentration of 52.5 ppb at EBLA (NPS 2013a), placing the Reserve in the Good Condition category.

Recognizing that the current form of the secondary standard does not adequately reflect risk to vegetation, USEPA and federal land managers, including the NPS, are considering alternative metrics for a secondary standard. One alternative is the W126, which is a cumulative sum of hourly ozone concentrations over a three-month period, with hourly values weighted according to their magnitude. Another alternative is the SUM06, a measure of cumulative three-month ozone exposure that includes only hourly concentrations over 60 ppb. Ozone concentrations below 7 ppm-hours for the W126, and below 8 ppm-hours for the SUM06, are not considered to be a threat to vegetation. Sullivan (in preparation) reported the relative ozone risk to vegetation for all NPS I&M parks. Ebey's Landing National Historical Reserve was considered at low risk for ozone injury based on both the W126 value of 1.2 ppm-hours and the SUM06 value of 1.4 ppm-hours. Kohut (2004) assessed the risk of ozone-induced foliar injury at all I&M parks based on species sensitivity, ozone concentrations, and soil moisture (which influences ozone uptake). He concluded there was low risk of ozone injury at EBLA.

Deposition

Because dry deposition data are not available for most parks, conditions and trends of atmospheric deposition are based solely on wet deposition data (rain and snow) collected through the National Atmospheric Deposition Program (NADP 2013). There is no indication, at present, that wet deposition amounts less than 1 kilogram per hectare per year (kg/ha/yr) harm AQRVs. Therefore, parks with wet deposition less than 1 kg/ha/yr were considered to be in Good Condition, parks with wet deposition of 1–3 kg/ha/yr were assigned to Warrants Moderate Concern; and parks with wet deposition greater than 3 kg/ha/yr were placed in the Warrants Significant Concern category (NPS 2013b).

Deposition monitoring has not been conducted at EBLA. Interpolated 2005–2009 wet N and S deposition at the Reserve were both 0.4 kg/ha/yr indicating EBLA is in the Good Condition category for deposition.

Sullivan (2016) reported the relative risk from acidification and nutrient N enrichment for all NPS I&M networks and parks. While modeled deposition of N and S at SAJH was considered moderate relative to other I&M parks, estimated ecosystem sensitivity to acidification ranked very low and estimated sensitivity to N enrichment ranked low.

The USEPA has not established air quality standards or thresholds for S and N deposition. In lieu of regulatory standards, the NPS and other federal land managers are increasingly using critical loads to

assess the threat of air pollutants to AQRVs. A critical load is the amount of pollution below which significant harmful effects are not expected to occur. At this time, information about acceptable pollution levels and resource sensitivity is limited. As more studies are completed, critical loads will be developed for more pollutants and more ecosystem components.

Pardo et al. (2011) identified the critical loads that would protect sensitive resources in Level I ecoregions across the conterminous United States against effects caused by atmospheric N deposition. Sullivan (in preparation) compared modeled total N deposition at NPS I&M parks to the critical loads' values identified by Pardo et al. (2011). He determined modeled total N deposition of 2.2 kg/ha/yr at EBLA did not exceed the lowest critical load identified for the Marine West Coast Forests Level I ecoregion, i.e., 2.7–9.2 kg/ha/yr, which is intended to protect N-sensitive lichen species.

4.1.5. Level of Confidence

Moderate

4.1.6. Data Gaps and Research Recommendations

It is not clear how climate change will affect air pollution levels and effects on AQRVs at EBLA. Changes in precipitation amount and timing could affect deposition of S, N and persistent bioaccumulative toxics. Changes in agricultural practices in response to weather patterns or pests could result in additional pesticide deposition at EBLA. A recent comparison of 1993–2001 and 2003–2009 plot surveys indicates increasing temperature and lower relative humidity have already altered Pacific Northwest lichen communities (Linda Geiser, U.S. Forest Service Pacific Northwest Region Air Program, unpublished data). Increased temperatures might change the rate of Hg methylation, resulting in increased bioaccumulation in fish and other species. Increased summertime temperatures may also lead to higher ozone levels (USEPA 2009).

4.1.7. Sources of Expertise

- For current air quality data and information for this park, please visit the NPS Air Resources Division website at www.nps.gov/subjects/air/index.htm

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4.2. Regional and Local Climate

By Catherin Schwemm, Paul Adamus and Anna Packenham

Given that the climate is changing from conditions to which organisms and biological systems have adapted, the condition of this resource is poor. The trend is increased diversion from natural conditions. Confidence in the assessment that climate conditions are changing is high, while confidence of the direction of change of individual climate elements (e.g., seasonal rainfall) is moderate.



4.2.1. Background

Climate change is affecting natural resources and processes in national parks across the country at an increasing rate. Data show that changes in temperature and precipitation are accelerating, and all models predict future increases in the rates of change if CO_2 emissions are not significantly and rapidly reduced (Weaver et al. 2007, Ashfaq et al. 2013, IPCC 2014). At present there is no credible scientific disagreement that climate warming is driven primarily by human activities (Abatzoglou et al. 2014, Wuebbles et al. 2017).

Climate change is a strong force that will require species, populations, and physical processes to respond rapidly to environmental conditions to which they are largely unadapted (Corlett and Westcott 2013), and to protect and preserve resources in this scenario will require immense effort (e.g. van Riper et al. 2014). The National Park Service (NPS) recognizes that climate change presents an immense challenge for protecting resources (Saunders et al. 2007, NPS 2010, Whittington et al. 2013).

PDO and ENSO

The Pacific Decadal Oscillation (PDO) is a pattern of inter-decadal climate variability characterized by large-scale changes in sea surface temperatures, sea level pressure and wind patterns in the Pacific Ocean (Newman et al. 2016). The PDO has warm (positive) and cool (negative) phases, each of which are currently thought to last for up to a few decades before transitioning from one to the other. (Though very relevant to an assessment of climate in the PNW, PDO is a complex process that will not be described further in this assessment; for more information the reader is referred to such sources as Mantua and Hare (2002) and Newman et al. (2016).

The El Nino Southern Oscillation (ENSO) is a much shorter-term process that is measured on an annual time scale. ENSO transitions between three phases: warm (positive; El Nino), cold (negative; La Nina) and neutral. In general, during El Nino years, winter sea surface temperatures in Puget Sound are higher than average (Moore et al. 2008, PSEMP 2016) leading to warmer and dryer average weather conditions (Mote et al. 2014). Though ENSO has been identified as one of the primary drivers of climate in the PNW (Mote et al. 2003, Abatzoglou et al. 2014), its direct impact on precipitation in the PNW is less clear (Cook et al. 2018).

4.2.2. Reference Conditions

Given the realities of climate change it is not possible to determine reference conditions for climate variables at EBLA. (The general climate of EBLA and the Puget Sound region is described in Chapter 2). An assessment could be made of the extent of change compared to historic climate conditions or to modeled change, but such efforts are beyond the scope of this report. This assessment will present general observations of current climate conditions as reported by other sources and modeled change predictions.

Properties of weather that will be particularly affected by climate change and that have strong influences on natural resources and ecological processes in EBLA are average annual and seasonal temperatures and total precipitation, and these two climate elements will be used as indicators for assessing climate. Because the requirements of the Reserve's resources for specific regimes of temperature and precipitation are unknown, average measures prior to the industrial period will be the reference conditions for climate.

4.2.3. Data and Methods

Trends in precipitation and temperature were determined from data obtained at the National Weather Service (NWS) Coupeville weather station within the Reserve. Data from the additional stations were analyzed because there were minor gaps in coverage for the Coupeville station. The full time series for the Coupeville station is 1895–2013 with some data gaps from 1910 to 1924 (88% coverage). Temperature and precipitation data for the Coupeville station were plotted and summarized through water year 2010 by Baccus and Huff (2012).

4.2.4. Resource Condition and Trend

Temperature (All temperature values are presented in °F/°C)

During the twentieth century, from 1895–2011, average temperatures across the PNW increased by approximately 1.3°/0.7°, with most of the increase occurring since approximately 1970 (Mote et al. 2014, IPCC 2014). Since 1880, the ten warmest years globally have occurred since 1998 (https://www.ncdc.noaa.gov/sotc/global/201613). Winter months warmed 2.7°/1.5° on average since 1950 (Hamlet et al. 2007), while average spring and summer temperatures for 1987 to 2003 were 1.6°/0.9° higher than those for 1970 to 1986. Spring and summer temperatures for 1987 to 2003 were the warmest since the beginning of the record in 1895 (Westerling et al. 2006), and the largest warming trends for the western portion of the country occurred during January–March (Hamlet and Lettenmaier 2007).

Specifically, for the Puget Sound region, there was approximately a 2.3°/1.3° warming during the last century (Mote et al. 2005, Melillo et al. 2014). Recently, the 2015 calendar year was the warmest year recorded for the Puget Sound region since records began in 1895 (PSEMP 2016, www.ncdc.noaa.gov). Locally the Olga station on Orcas Island recorded a statistically significant average annual temperature increase of 0.11°F/decade from 1892–2018 (https://climate.washington.edu/climate-data/trendanalysisapp/). Of note, however, a non-significant but noticeable cooling trend was observed during spring from 1980 to 2012 (Abatzoglou et al. 2014).

Future Temperatures

Nearly all climate models predict that average temperatures in the PNW will increase in coming decades, though likely not as much as will occur in the western and southwestern portions of the country (IPCC 2014, Moore et al. 2015). The average warming rate in the Pacific Northwest during the next ~50 years is expected to be in the range of 0.2–1.1°/0.1–0.6° per decade, with a best estimate of 0.5°/0.3° per decade (IPCC 2014). For comparison, warming in the second half of the last century was approximately 0.4°/0.2° per decade (Mote et al. 2008, 2014). Models incorporating scenarios with continued high CO_2 emissions generally converge on a 5–11°/3–6° increase in average annual temperatures by the end of this century (Bachelet et al. 2011, IPCC 2014)

Precipitation

Less confidence is associated with projected changes in regional precipitation than for temperature (Abatzoglou et al. 2014). From 1895–2011, the National Climate Assessment found no significant increases in precipitation, but in general modeling predicts increased likelihood of summer droughts countered by increased precipitation in the winter (Tohver et al. 2014). Cumulatively annual precipitation is expected to increase in the region by anywhere from 5–50% (Bachelet et al. 2011). Average summer precipitation may decline by 6% to 8% or more by 2050 (relative to 1950–1999; Snover et al. 2013, IPCC 2014), while average winter precipitation may increase by 2 to 7% (Snover et al. 2013, Dalton et al. 2013).

Shoreline resources in the Reserve may be particularly vulnerable to changes occurring in the ocean as a result of global climate change. In particular, climate scientists in recent years have focused on the frequency and severity of extreme storm/runoff events (Allan and Komar 2002, IPCC 2014). Heavy rainfall events are projected to become more severe with a predicted 8–20% increase in the number of days when more than 1 inch of rain falls by 2050 (relative to 1971–2000; Snover et al. 2013, Kunkel et al. 2013). Models also indicate that the number of 24-hour rain events in the PNW will increase over the next 50–70 years (TNC and CIG 2016). Overall storm intensity is predicted to result in higher average rainfall amount per storm with resulting increases in flooding and erosional events (Mauger et al. 2015).

4.2.5. Level of Confidence

Confidence is high for recent and historical trends, and moderate to high for future conditions.

4.2.6. Data Gaps and Research Recommendations

- While climate models are converging on predictions for environmental conditions, almost nothing is yet known regarding the impacts of the anticipated changes on biological organisms and ecosystems. Thus, the tolerance, resilience, and adaptability of the Reserve's flora and fauna to long-term changes in temperature and precipitation remain unknown.
- The Reserve lacks a long-term climate monitoring station, but in 2006, Washington State University installed a weather station in Coupeville as part of their statewide AgWeatherNet (weather.wsu.edu). Further analysis should include interpretation of temperature and precipitation data with an emphasis on seasonal or monthly trends to evaluate how seasons are

changing and to ascertain if the local data correlates well with modeled or regional interpretations of climate change.

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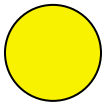
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4.3. Water Resources

By Paul Adamus and Catherin Schwemm

The extent of wetlands has declined substantially from historical conditions but appears stable. Surface water quality is of concern but is well-monitored. Groundwater quality is of serious concern, though water management programs are ongoing and actively working to improve conditions. Groundwater quantities appear sufficient for now, though supplies are limited and climate change (reductions in rainfall), and increased demands are concerns. Confidence in the assessment of the current extent of surface water is high; confidence in the quality of surface waters is low to moderate; confidence in groundwater quantity and quality across the island is moderate to high. Trends for any resource are not detectable with available data.



4.3.1. Background

Surface Freshwater

The San Juan Islands are located in the rain shadow of the Olympic Mountains and receive relatively less rainfall than much of the northwest (Section 4.2). The absence of snow as a source of freshwater also means that without sufficient rainfall in some years freshwater resources may be scarce. Perennial streams are absent from EBLA, and surface runoff is an insignificant portion of the island's water budget (Spivak et al. 1988). No salmonid-supporting streams are present in EBLA (though juvenile salmon are found in some estuaries). The only freshwater lake is Lake Pondilla, a small (< 4 ac/2 ha) glacial kettle pond located in forested habitat in Fort Ebey State Park.

Brackish Wetlands/Lagoons

Crockett Lake

Crockett Lake was historically a tidal lagoon, surrounded by mudflats and marshlands with shoreline plants adapted to tidal processes (Copass and Ramm-Granberg 2016). In the late 1940s tidal gates were constructed to prevent saltwater input and increase available farmland, and as a result the lagoon shrank from over 600 ac (240 ha) to about 10 ac (4 ha). Tidal processes were restored in 1974 when the decision was made to keep the tidal gates open and the lagoon has since increased in size. At present the tidal gates are still in place but water levels are managed such that natural water flow is still partially inhibited (Copass and Ramm-Granberg 2016).

Perego's Lake (Lagoon)

Perego's Lagoon is primarily a brackish site as it rarely receives freshwater input (Klinger et al. 2007). The lake is susceptible to large algal blooms (Van Alstyne 2016) that may be caused by small algal flagellates (M. Dethier, University of Washington, pers. comm. 2015). The aquatic invertebrate fauna is depauperate, though stickleback fish (*Gasterosteus* spp.) are present and may be feeding on insect larvae.

Grasser's and Kennedy's Lagoons

These two lagoons have functioning tidal processes though they are both relatively small. Kennedy's Lagoon is open to Penn Cove; however, the overall hydrology is impacted by Madrona Way, a major road that traverses its barrier spit, and by a tidal gate. Significant development along the shores has generally unknown impacts. Freshwater input comes from upland runoff and rainfall. Both areas are fairly productive and may support juvenile salmonids (Klinger et al. 2007).



Grasser's Lagoon in the northwest corner of Penn Cove (Photo by Steve Olson).

Groundwater

Quantity

Islands in the Puget Sound are characterized by isolated and limited aquifers. On Whidbey Island 60–70% of island residents depend upon one primary aquifer for domestic water and irrigation; the remainder utilize water piped from the mainland (WICD 2016). The depth of the main aquifer ranges from a few feet above sea level to nearly 200 ft (61 m) below sea level (Spivak et al. 1988; Figure 4.3-1). Private wells connected to the aquifer provide water for domestic uses, while the town of Coupeville operates a separate water system drawing from wells largely located northeast of Crockett Lake. The town also maintains a reservoir with a capacity of roughly 500,000 gallons, though only 160,000 gallons can be utilized as an effective water supply (Sumioka and Bauer 2004). Well yields on the island range between 50–350 gal/min, with most yielding less than 100 gal/min.

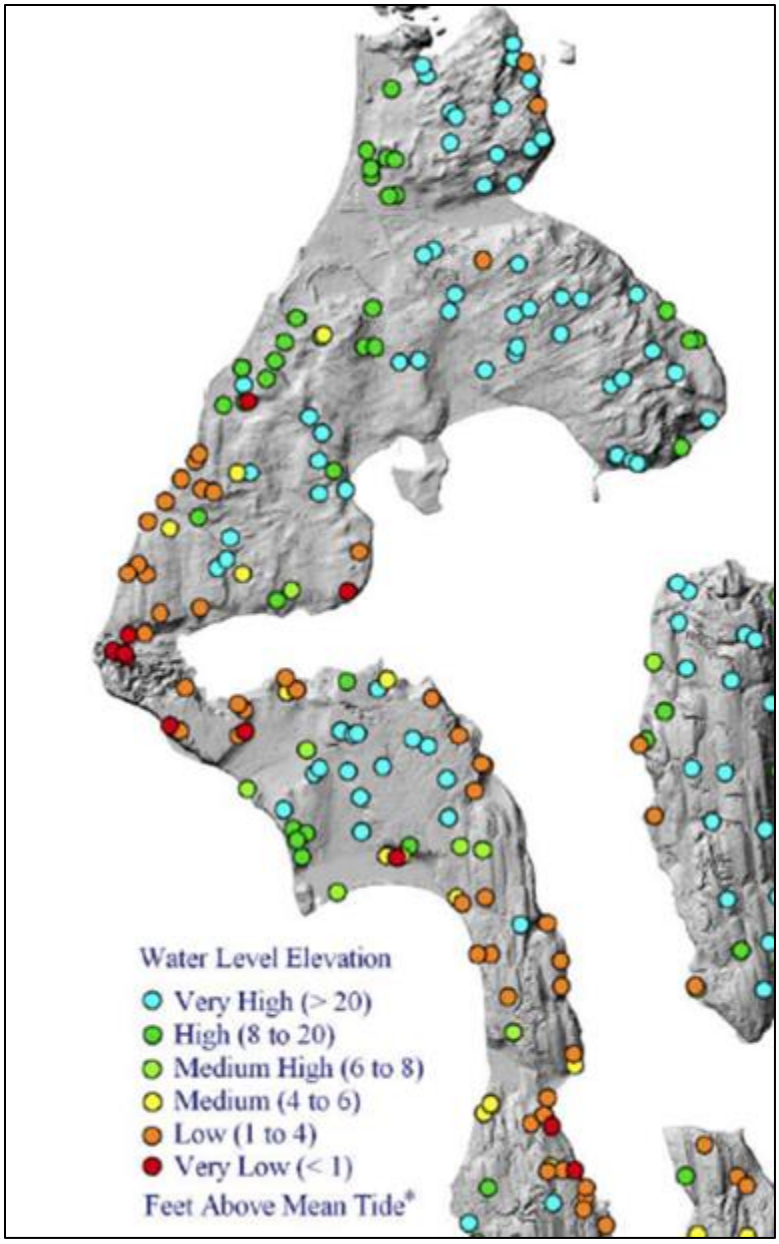


Figure 4.3-1. Groundwater level in central Whidbey wells (source: Island County Water Resource Management Plan 2004).

Groundwater must be recharged by infiltration from precipitation at a faster rate than it is withdrawn. Infiltration rates generally increase with vegetated areas and more porous soils and are greatly reduced where areas of impervious surfaces direct water instead into drainage systems and eventually to the ocean (WICD 2016). Thus, groundwater levels (a proxy measure for the quantity of water in the ground), fluctuate in response to input (precipitation), recharge processes, and withdrawal (pumping from wells; Spivak et al. 1988). Average annual recharge rates on Whidbey Island were estimated by Sumioka and Bauer (2004) to be 5.71 in (14.5 cm)/yr. The entire island has been

designated as a Critical Aquifer Recharge Area (IC 2016; Figure 4.3-2), meaning that all surface areas on the island are theoretically connected to the aquifer (WDOE 2005).

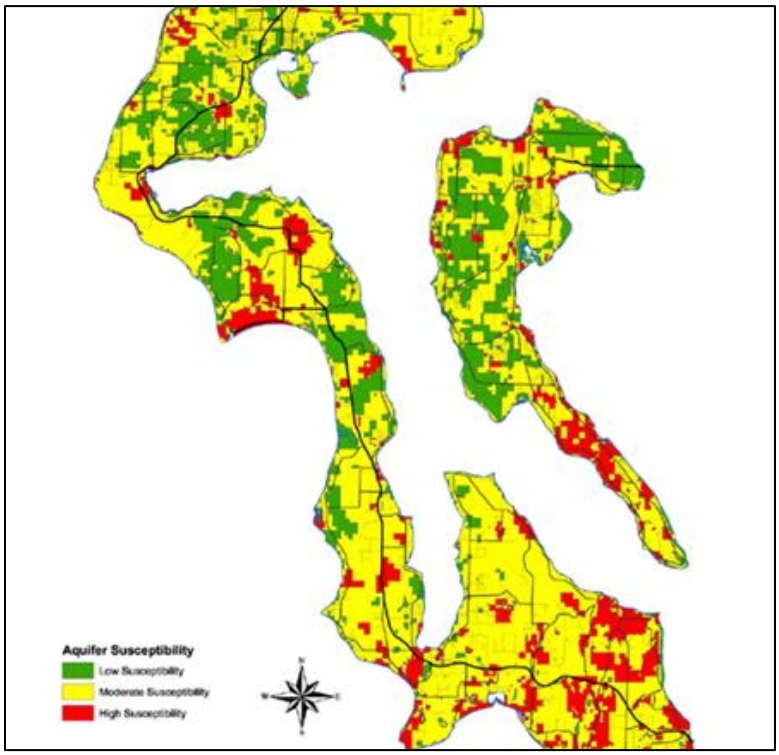


Figure 4.3-2. Critical aquifer recharge areas of central Whidbey Island, including the Reserve (source: Island County Water Resource Management Plan 2004).

Groundwater Quality

Nitrates

Nitrates are an identified concern for Whidbey Island groundwater resources (Hallbauer 1997). Though nitrates can be naturally filtered by microbial processes in the soil, excessive amounts result in contaminated groundwater (Hallbauer 1997). When ingested by humans, nitrates convert to nitrites and react with human hemoglobin, reducing the ability of the blood to carry oxygen, particularly in newborns (Boink and Speijers 1999). The presence of elevated nitrates may also increase the prevalence of diseases in wildlife (Johnson et al. 2010, Jones et al. 2013). Excessive and dangerous levels of nitrates around the world have been definitively and strongly linked to agricultural land use, particularly grazing operations and farming practices that utilize nitrogen-based fertilizers (Spalding and Exner 1993, Di and Cameron 2002, Tegtmeier and Duffy 2004).

Saltwater Intrusion

Where aquafers are located near the ocean, groundwater are subject to saltwater intrusion. Saltwater can enter previously fresh aquifers either because the water table is lowered due to withdrawals that exceed recharge, or because sea level rises (ICWRAC 2005, Ketabchi et al. 2016). Saltwater

intrusion is of particular concern where groundwater is the primary source of drinking water as it is on Whidbey Island (ICWRAC 2005).

PFOS

An emerging and serious threat to groundwater quality on Whidbey Island (and globally) is the introduction of a group of compounds known as PFOS (perfluoroctane sulfonate) and PFOA (perfluorooctanoate; Xiao et al. 2015). In late 2016 the town of Coupeville was notified by the Navy (USN) that these compounds had been detected in island groundwater, most likely (almost certainly) originating from materials used to practice fighting fires (firefighting "foam"). Many of these substances have been identified as carcinogens (particularly in firefighters themselves; Laitinen et al. 2014) and have since been banned by the state of Washington for civilian use.

Water Management

The EPA, upon the request of Island County government, designated the county a Sole Source Aquifer in 1982, providing resources for additional reviews of Federally funded projects that affect groundwater to assure waters are protected. Because water resources on Whidbey Island are limited and water use is increasing, in 1985 Island County (Whidbey and Camano islands) was identified by the state as a Critical Water Supply Service Area (CWSSA), which supports state guidance and assistance in managing water resources (ICWRAC 2005). In addition, in 1986 the Washington Department of Ecology designated the entire County a Ground Water Management Area (GWMA) and the County subsequently developed a Ground Water Management Plan. In general, all groundwater resources in EBLA are managed by Island County in association with local jurisdictions such as the City of Coupeville (Town of Coupeville 2017).

4.3.2. Reference Conditions

Surface Water

Any measurable reduction in wetland area would be cause for concern. Ecologically, surface water quality should support healthy communities of wetland-dependent species, particularly amphibians, birds, and bats (Liang et al. 2016, Noguera-Oviedo and Aga 2016, Reeves et al. 2016, Straka et al. 2016, Li and Kalcounis-Rueppell 2018). Algal blooms are often indications of unhealthy levels of nutrients and should be uncommon.

Groundwater

Quantity

Groundwater levels fluctuate, but over time should not show decreasing trends. Historic levels for three wells from 1980–1983, one of which is in the Reserve near Fort Casey State Park at a depth of 175 ft/53 m (Figure 4, Spivak et al. 1988) provide data from a period when groundwater levels were considered to be in a "steady-state" without evidence of a declining trend (Spivak et al. 1988). At that time depth to the water level in that well was approximately 50–55 ft (15–18 m; Spivak et al. 1988).

Quality

Conditions of salinity (an indicator of saltwater intrusion) should be stable, and levels of nitrates and PFAS substances should be declining. (Table 4.3-1). (There are many other substances that are measured to assess groundwater quality but those will not be considered here.

Table 4.3-1. Water quality standards for groundwater, Washington State (WAC 173-201A-200 (1) (e)), Island County.

Indicator	Measure	Description
Chloride	100 mg/l	Threshold for describing well water as having high chloride concentration (Culhane 1993).
Seawater Intrusion	Low risk: groundwater level elevation > 8.4 ft; any chloride concentration; Medium risk: level elevation ≤ 8.4 ft; chloride concentration < 100 mg/l; High risk: level elevation ≤ 8.4 ft; chloride concentration between 100 and 250 mg/l; Very high risk: level elevation ≤ 8.4 ft; chloride concentration > 250 mg/l	–
Nitrate	Ideally there should be no nitrates in groundwater; 1–3 mg/L indicate a developing problem and 5 mg/L is a serious concern.	Most of the area around the Reserve has moderate susceptibility to nitrate contamination; Coupeville has high susceptibility (Island County Water Resources WRAC 2005).

4.3.3. Data and Methods

Surface Water

Extent

In the 1980s The National Wetlands Inventory (NWI) mapped wetlands in the Reserve at a relatively coarse resolution using available aerial imagery, though none of the maps were ground-truthed. These maps have been referenced over time, and until at least 2009 were reposited in the Island County Department of Planning and Community Development (ICDPCD 1998). A study sponsored by Island County (Adamus et al. 2006) presented a detailed analysis of wetland losses throughout the county during the periods 1985–1998 and 1998–2005. (As part of the current NRCA, an Excel database created from the Adamus et al. study (2006) was provided to NPS that describes all recorded characteristics of wetland sampled). As far as is known there have been no wetland surveys since Adamus et al. (2006).

Water Quality

Island County is one of only a very few counties in the Pacific Northwest that maintains an extensive surface water monitoring program. Designed in 2005, the program (Adamus 2006) is implemented through an ordinance adopted by the Board of Island County Commissioners in 2006. The program collects baseline data from multiple locations throughout the county (Island County Environmental Health 2018). Klinger et al. (2007) conducted a thorough review of water quality for EBLA.

In response to concerns about the water quality conditions within the Reserve, in 2013 the Whidbey Island Conservation District (WICD) initiated an Ebey's Prairie Watershed Stormwater Remediation Project ("EPWSRP," WICD 2016). The purpose was to better understand the hydrology of the area, trace pollutant sources, and recommend measures to alleviate these water quality problems. Seven sites were monitored every other week during the rainy seasons from April–June 2013 and

November–June 2014, except where water was not present, or present but not flowing. Source identification occurred throughout those months, and storm sampling at source identification locations continued into October 2014. In all, seven discrete storm events were sampled. All baseline sites were sampled during two storms (February 24 and May 23, 2014), all but two sites were sampled February 18, 2014, and source identification work occurred during the remaining four storm events.

Groundwater

Quantity

A groundwater management program has been active since 1992. Under this program, new wells must be metered, water levels must be monitored in April and August of each year in domestic wells in high and medium risk areas, and there is a network of monitoring wells for both water level and water quality.

Quality

Under the State Environmental Policy Act (SEPA) and the Planning Enabling Act (Chapter 36.70 RCW) the County is required to control development to protect groundwater sources. Chloride and conductivity measurements are required in April and August in public water system wells in high and medium risk areas. Public wells are routinely tested for nitrates; new private wells must be tested but many older wells have been "grandfathered" in and do not require testing.

The Washington State Department of Ecology has an extensive and accessible groundwater database (WDOE groundwater database), however, there do not appear to be data more recent than 1996 for the two wells nearest the Reserve (AAF270 and AAF252). Island County also maintains an extensive groundwater database that includes public information on test well results (IC groundwater database). Though the IC data were not examined for this assessment, several summary analyses from the County utilized these data.

As far as is known, no permanent sampling points exist to monitor groundwater that supports some of the Reserve's wetlands and streams. Data collected by USN as part of their testing for PFOS are generally not publicly available, though some information is available on their websites. Data provided to entities such as the City of Coupeville are generally communicated to the public through various media (e.g. https://townofcoupeville.org/wp-content/uploads/2017/08/limited-update-water-system-plan-2017.pdf).

4.3.4. Resource Condition and Trends

Surface Water

Extent

County maps indicate there are 3,062 ac in 54 freshwater wetlands that fall partially or wholly within the Reserve (22% of the Reserve's non-marine area), whereas the NWI map shows only 690 ac (5% of the Reserve's non-marine area). The large proportion of soils within the Reserve that are classified as hydric suggests that there may have been areas of surface water present in the past that have since been lost to drainage, diversions, or other impacts (Larrabee 2011, Adamus et al. 2006). As far as is known no further loss of wetlands has occurred in recent years, and ongoing groundwater

withdrawals are not likely to strongly influence the duration of flow in the island's few streams or the persistence of saturated conditions in the island's wetlands (Doug Kelly, County Hydrogeologist).

Quality

As far as is known there are no water quality data for Lake Pondilla, though there appear to be few source point locations that would impair water quality (Klinger et al. 2007). Periodic monitoring just above tidewater on the Reserve's west side (Site 58a, ICPH 2018) as part of the EPWSRP has repeatedly found concentrations of nitrate, phosphorus, turbidity, and fecal coliform bacteria that were higher than anywhere else in Island County and are often far above thresholds considered to be ecologically safe (Adamus 2006, ICPH 2013, ICPH 2018). Another sampling point within the Reserve (SP7) had nitrate levels exceeding 100 mg/L on several occasions in 2014. At sample point 58a, turbidity was found to exceed the County-specified threshold of 14 NTU during 48% of the visits in 2007 and 16% of the visits during 2010.

Because the Reserve encompasses the small town of Coupeville, urban as well as agricultural sources of pollution are a potential concern. Currently, most of Coupeville's storm water flows directly into Penn Cove without any treatment. Some storm water also enters Admiralty Strait at Ebey's Landing. Tests have found contamination with metals (concentrations of up to 0.005 mg/L total copper and 0.004 mg/L dissolved copper), oil products, excessive nutrients, and fecal coliform bacteria.

The EPWSRP determined that the high nitrate concentrations at sample points SP7 and 58a are most likely the result of subsurface tile drains that drain agricultural fields underlain by organic soils—probably a former wetland or prairie. At various times when the fields were cropped over the past century, manure was applied and on other occasions dairy cattle were herded. The nitrate is likely the accumulated legacy of those historical conditions, inasmuch as livestock are no longer present there and use of fertilizer (mainly manure) has been reduced considerably. In 2018 the 58a (Ebey's Landing) site was given a fecal coliform grade of "F," and water quality overall was poor (ICPH 2018).

High levels of fecal coliform in surface waters at a different location (SP4) in the Reserve appeared to be associated with a farm there. The high fecal coliform levels at two locations (SP1a, SP1b) within the Reserve closer to town were tentatively attributed to pets and/or deer.

NPS is a partner in a pilot project to divert storm water runoff into a bioswale on the edge of town. The bioswale percolates this runoff through a mass of roots and soil, which could remove pollutants at least temporarily before the water reaches Puget Sound (Anderson et al. 2016). Consideration is being given to expanding this experiment to include treated wastewater currently being discharged from the town's sewage processing facility into Penn Cove. After being treated again in the bioswale, the water would be used to help irrigate local crops and recharge groundwater. However, caution is advised given the problems currently being encountered with excessive nutrients discharging from some of the area's drained agricultural lands.

Groundwater

Quantity

In the early 1990s the town of Coupeville issued a moratorium on new water hookups, due to well and distribution system limitations, and since 1993 has issued new water hookups within the town limits and continues to improve its supply and distribution system. Drier spring and summer climates are resulting in water use that exceeds availability across the island (WICD 2016). Water rights are presently over-appropriated in certain areas of the County, particularly northwest and southwest of Penn Cove. If these water rights are fully exercised, water will be removed from the groundwater system at a rate greater than the rate of replenishment (ICDPCD 1998), endangering the availability and quality of groundwater within the Reserve especially if droughts occur more often in coming years. However, according to the town of Coupeville (2017), population growth has been less than anticipated in recent years and water supplies are adequate for the foreseeable future.

Quality

Nitrates

Most of the area around the Reserve is rated as having moderate susceptibility to nitrate contamination, while Coupeville is considered to have high susceptibility (Hallbauer 1997, ICWRAC 2005). Elevated levels of nitrates in groundwater have been a concern for some wells especially in the unincorporated areas of Central/South Whidbey (Keeler and Kearsley 2003).

Saltwater Intrusion

Within the Reserve, saltwater intrusion has been documented in wells in the vicinity of West Beach, Coupeville, and Ebey's Prairie (Figure 4.3-3). There is currently is insufficient information to report on trends; conditions may be stable though it is unlikely they are improving (WRAC 2005). The most recent analysis of potential sea level rise for the coasts around EBLA predicts a 0.8 ft (0.3 m) increase on average by 2050 under a low- and high-emissions scenario, and 1.9 ft (0.6 m) and 2.4 ft (0.7 m, respectively) by 2100 (Miller et al. 2018 with methods described therein).

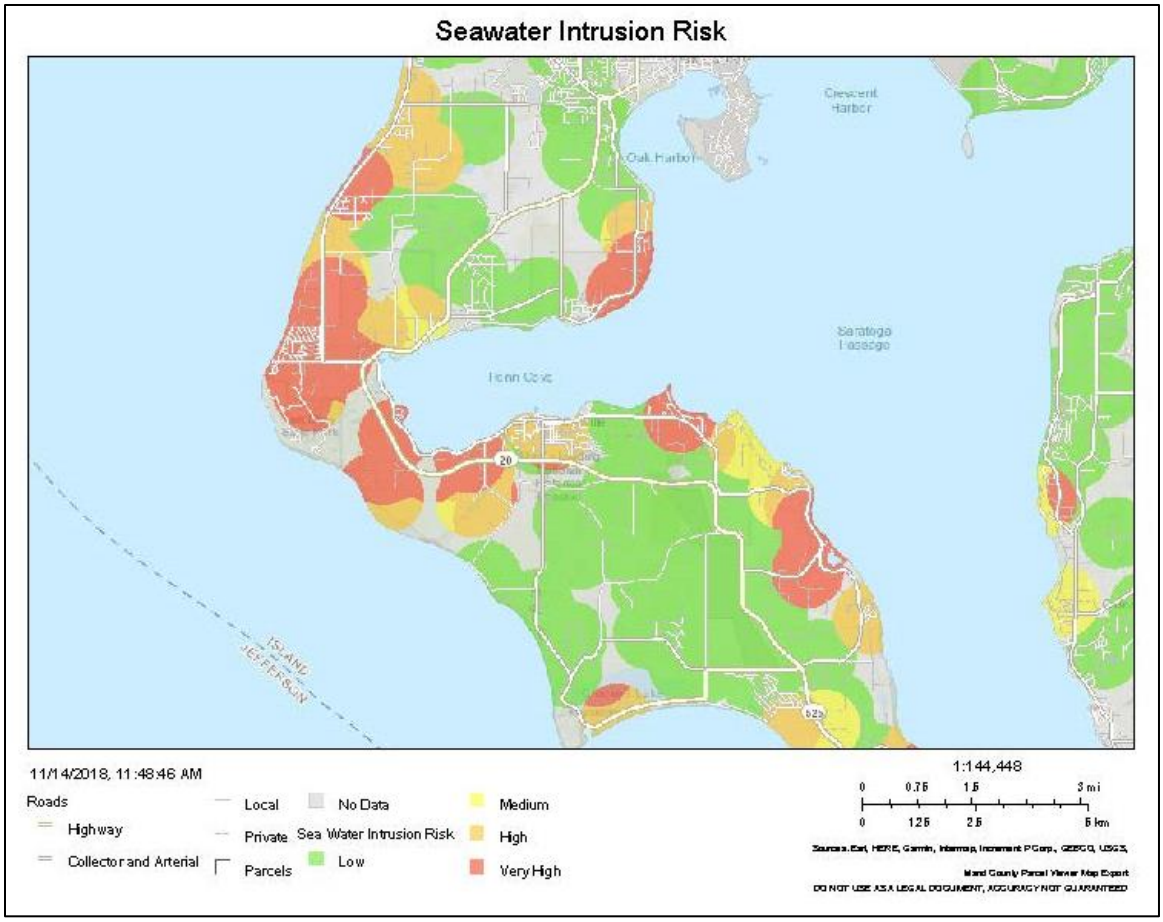


Figure 4.3-3. Risk of saltwater intrusion into aquifers in the area of EBLA. Source is Island County Groundwater Database Mapping Portal (https://islandcountygis.maps.arcgis.com) accessed November, 2018. Data sources and risk analysis methods are available at (https://www.islandcountywa.gov/Health/EH/Hydrogeology/Pages/Seawater.aspx).

PFOS

Since 2016 USN, island residents and city managers have worked to address the problem of PFOS in groundwater. (The topic has become quite contentious in some cases; primary websites for information from USN and Island County are provided in Literature Cited). As of October 2018, groundwater testing by USN is ongoing and island residents with contaminated wells are being provided alternative water sources. The most recent data available from USN indicates that several tested drinking water wells did have levels of PFOS substances higher than the "action level." The town of Coupeville found that it's highest producing well tested positive for PFOS and eight private wells are over the EPA Lifetime Health Advisory (LHA) limit (https://www.epa.gov/ground-water-and-drinking-water/drinking-water-health-advisories-pfoa-and-pfos).

4.3.5. Level of Confidence

Confidence in the assessment of the current extent of surface water is high, though there are some questions as to historical extent. Recent data on surface water quality are scarce and confidence is low to moderate.

Confidence in groundwater quantity and quality across the island is generally high, though specific hydrological relationships between island aquifers and Reserve freshwater resources is largely unknown.

4.3.6. Data Gaps and Research Recommendations

- Very little is known about the natural hydrologic regimes of the Reserve's few ephemeral streams. Specifically, the amount of groundwater recharge needed to sustain the Reserve's wetlands and maintain good water quality is unknown, making the implementation of a well-monitoring program within the Reserve an ongoing need (Flora and Fradkin 2004, NPS 2006, Graham 2014).
- Very little to no surface water quality sampling is conducted within the Reserve, but such a program would be extremely beneficial.
- Little to nothing is known regarding any ecological component of wetlands other than plants and in some cases birds. Small vertebrate and bat studies should be pursued.
- Lake Crockett appears to be highly dependent on groundwater influx but neither its hydrological nor its biological environment has been fully studied.
- As mentioned in Klinger et al. (2007), the development of a Water Resources Management Plan would provide meaningful guidance to the Reserve Board for managing natural resources in coming decades. The description by Klinger et al. (2007) of the elements of such a plan remains relevant:

    "…1) outline the goals and objectives of water resource management within EBLA and, 2) define levels of acceptable water resource condition. This planning effort requires the participation of multiple partners who have varied management jurisdiction. In reviewing available information, we have formed concerns that relate to 1) lack of direct knowledge of current conditions and 2) lack of established threshold values for future conditions."

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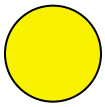
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4.4. Wetland and Nearshore Vegetation

By Paul Adamus and Catherin Schwemm

The condition of wetland vegetation communities is of moderate to significant concern due to the presence of non-native species and limited habitat. No trends for freshwater wetlands, brackish lagoons or dune communities are apparent from the limited data. Seagrass appears to be stable or increasing around Whidbey Island; kelp populations appear stable. Confidence is moderate.



4.4.1. Background

This section addresses vegetation associated with wetland and coastal sites, including fresh, brackish, and marine waters. The overall hydrology and wetland site descriptions are well-detailed in Adamus (2006) and Klinger et al. (2007) and are described in this report in Section 4.3. Vegetation descriptions are presented and mapped in detail in Copass and Ramm-Granberg (2016), and information provided here is primarily summarized from that report unless otherwise referenced.

Freshwater Wetlands

The only freshwater wetland vegetation present in the Reserve is found at Lake Pondilla, a glacial kettle pond located in forested habitat in Fort Ebey State Park. The site supports small areas of several imperiled vegetation types with characteristic species such as Oregon crabapple (*Malus fusca)*, willow (*Salix* spp.), and slough sedge (*Carex obnupta*). Additional unique though less-threatened communities include a water lily (*Nuphar polysepala*)-dominated herbaceous community, and rhododendron (*Ledum groenlandicum*) – bog laurel (*Kalmia microphylla*) associations (Table 4.4-1).

Table 4.4-1. Wetland terrestrial plant assemblages of conservation concern in EBLA (from Copass and Ramm-Granberg 2016). Rankings are from NatureServe (http://www.natureserve.org/conservation-tools/conservation-status-assessment).

Assemblage	Common Names of dominant species	Designation Global/State*	Type	Area (ac/ha)
Salix lucida var. *lasiandra* / *Urtica dioica* spp. *gracilis*	Pacific willow stinging nettle	G2/ S1S2	Wet woodland	1.4/0.6
Salix hookeriana – (*Salix sitchensis*)	coastal/dune willow, Sitka willow	G2 /S2	Wet shrubland	8.1/3/3
Malus fusca – (*Salix hookeriana*) / *Carex obnupta*	Oregon crabapple, coastal/dune willow, slough sedge	G3 /S2	Wet shrubland	0.2/0.1
Argentina egedii – Juncus balticus	Pacific silverweed, Baltic rush	G3G4 /SNR	Salt Marsh	10.1/4.1
Distichlis spicata – *(Salicornia virginica*)	saltgrass pickleweed	G4 /S2	Salt Marsh	65.0/26.3

* G2: Imperiled; G3: Vulnerable; G4: Apparently Secure; S1: Critically Imperiled; S2: Imperiled; SNR: Unranked.



Lake Pondilla (Photo by Marsha Davis).

Brackish Wetlands/Lagoons

Crockett Lake

The shores of Crockett Lake support willow (*Salix* spp.) shrublands, and a saltgrass (*Distichlis spicate*) salt marsh type identified as Imperiled in Washington, though the site is primarily dominated by non-native species (Copass and Ramm-Granberg 2016; discussed below). Willows are small trees that often provide habitat for riparian-associated birds, particularly in semi-urban landscapes (Luther et al. 2008). Relevant to ecological functioning at Crockett Lake is the absence of tidal processes. In 1989 or 1990, mosquitoes (species unknown) became a problem at the lake and several local citizens began operating the tide gates to lower lake levels in an effort to reduce mosquito habitat. With State approval these citizens also initiated a program of biological and chemical control for the mosquitoes. Indications are that the productivity of Crockett Lake has been greatly reduced by manipulation of water levels (though mosquitoes are not as problematic as they once were). Currently, the tide gates are still in place but are not completely effective in excluding marine waters from the lagoon.

Perego's Lake (Lagoon)

Perego's Lagoon is primarily a brackish site as it only occasionally receives freshwater input (Klinger et al. 2007). Adjacent to the lagoon is an area supporting native grasses (red fescue [*Festuca rubra*] – Camas [*Camassia leichtlinii*], Gumweed [*Grindelia stricta* var. *stricta*]) that is globally critically imperiled though non-native species are also present. Also adjacent are areas of red fescue (*Festuca rubra*) – ragweed (*Ambrosia chamissonis*) and dune grass (*Leymus mollis* ssp. *mollis*)-sand verbena (*Abronia latifolia*), two associations that are regionally and globally rare, and other species adapted to highly saline conditions (Copass and Ramm-Granberg 2016). The lake is susceptible to large algal blooms (Van Alstyne 2016).



Autumn sunset on Perego's Lagoon (Photo by Marsha Davis).

Grasser's and Kennedy's Lagoons

Grasser's and Kennedy's Lagoons are both connected to Penn Cove. The lagoons support some remnant salt marsh vegetation and eelgrass in deeper portions. Some of the adjacent lands have been largely converted to lawns and landscaping.



Grassers Lagoon and Hill (Photo by Steve Olson).

Dunes and Bluffs

Herbaceous coastal bluffs are patchily distributed along the western perimeter of the Reserve, confined to the steep slopes immediate above Puget Sound. In some locations there are patches of woody vegetation, but generally the vegetation is a mix of native and non-native herbaceous species. There are also some small patches dominated by sedge (*Carex macrocephala*) that are rare in

Washington and subject to active dune processes and storms (Rocchio et al. 2015). Relatively large patches (~20 ac/8 ha) of red fescue-ragweed and dune grass-sand verbena associations are also found here.



West coast bluff and dunes at Fort Ebey (Photo by Marsha Davis).

Marine/Submerged

Eelgrass

Marine eelgrasses are a common group of seagrasses in the genus *Zostera*. Eelgrass beds usually occur as patches or narrow bands near the shore, or as solid meadows in the subtidal zone (Nelson and Waaland 1997). Eelgrass extent and abundance are determined by many factors including nutrient levels, substrate composition, water quality, depth, and light (Mumford 2007, Kaldy 2014). Eelgrass beds increase in extent in spring and summer in response to warming water temperatures then retreat during fall and winter (Kaldy 2014). Eelgrass (*Zostera marina*) provides important habitat for invertebrates and fish, particularly juvenile salmon and forage fish such as Pacific herring (*Clupea pallasi*), Pacific sand lance (*Ammodytes hexapterus*), and surf smelt (*Hypmesus pretiosus*: Murphy et al. 2000, Boström et al. 2006, Ferraro and Cole 2007, Mumford 2007).

The extent of native eelgrass beds apparently declined substantially in the San Juan Archipelago up until the mid-2000s, but the decline appears to have halted and in many areas eelgrass has increased (Gaeckle et al. 2008, Dethier and Barry 2008, Shelton et al. 2016, Christiaen et al. 2016). The causes of the declines of seagrasses in many of the world's oceans have not been determined conclusively (Short et al. 2011), though recent studies suggest that disease may be an important driver (Groner et al. 2016). Dethier and Barry (2008) generally ruled out temperature, salinity, and sediment changes as causes of eelgrass declines in Washington. According to the Washington Marine Vegetation Atlas, eelgrass beds occur along all the Reserve's shoreline except in a small segment in the innermost (western) part of Penn Cove, along the Crockett Lake barrier beach, and in a small segment just south

of Perego's Lagoon. The Island County Beachwatchers data show dense eelgrass beds occurring in the northeast end of Penn Cove along Scenic Highlights Road.

Kelp and Other Seaweeds

Underwater stands of kelp, (a generic term for several species of large alga), provide food and refuge for fish, sea urchins, herring, crabs, mollusks, and a variety of marine mammals including sea otters (Mumford 2007). Most kelp forests occur in the shallow subtidal zone from MLLW to about 65 ft (20 m) below mean low water (Mumford 2007). Kelp do not absorb nutrients from the substrate to which they are attached but from the waters that flow around them. Ocean conditions supportive of kelp include waters which are highly saline and relatively cold, and seafloor depths shallow enough to receive relatively high levels of ambient light (Mumford 2007).

Bull kelp (*Nereocystis leutkeana*) beds occur along all the Reserve's shoreline except in Penn Cove (NOAA 2014). The Washington Coastal Atlas (NOAA 2014) indicates that kelp is sparser at Fort Casey and northward to about Hill Road, however, surveys by the volunteer group Island County Beachwatchers show a continuous line of kelp along the entire western shoreline, including Crockett Lake. Much less is known about the species composition and richness of other macroalgae within the Reserve.

Conservation Concerns

Invasive/Non-native Species

Invasive species are potential threats to all vegetation communities with the Reserve. Non-native hairy willow-herb (*Epilobium hirsutum*), a Class B noxious weed, is a dominant competitor at Crockett Lake covering over 100 ac (40 ha). European searocket (*Cakile maritima*), scotch broom (*Cystisus scoparius*), gorse (*Ulex europaeus*), and Himalayan blackberry (*Rubus armeniacus*) and *Bromus* spp. are species that can establish on dune and spit habitats. The most abundant wetland-associated invasive, both countywide and within the Reserve, is reed canarygrass (*Phalaris arundinacea*; Adamus et al. 2006). Other aggressive species associated with wetland sites include creeping thistle (*Circium arvense*), and cordgrass (*Spartina anglica*). The potentially invasive *Phragmites australis* is also present at Crockett Lake, and poison hemlock (*Conium maculatum*) has become well-established around the bluffs at Ebey's Landing (Adamus et al. 2006).

The invasive salt marsh cordgrass *Spartina anglica* ("cordgrass") was introduced to nearby Port Susan in the early 1960s and spread to Penn Cove by the 1980s. This species traps sediments which degrade eelgrass beds and bird, fish, and marine invertebrate habitats (Hacker and Dethier 2006). Cordgrass has also occurred in Kennedy's Lagoon and a few other locations near Coupeville, and new and hybrid species appear to be increasing in many coastal areas of the Pacific Northwest (Dethier and Hacker 2004, Saarela 2012). Other competitors of eelgrass in Puget Sound include the non-native brown seaweed, *Sargassum muticum* (Britton-Simmons 2004) and non-native seagrass *Zostera japonica* (Christiaen et al. 2016).

Physical Impacts and Water Quality

Primary stressors on plant communities in nearshore systems appear to be sea level rise, overwater structures, dredging/filling, and sea surface temperature rise (Sobocinski et al. 2010, Thom et al.

2011). Excessive nutrients, often from agricultural runoff, can spur the growth of algae that cause harmful algal blooms. Artificial structures such as bulkheads, docks, and other types of shoreline infrastructure have the potential to alter drift current direction and speed, and thus the amount, type, and location of sediment that is transported and deposited. This in turn influences the subsurface penetration of light that is crucial to underwater productivity.

Climate Change

Numerous impacts of climate change that affect ocean conditions will have variable effects on nearshore systems (Mote et al. 2003, Canning 2005, Mote et al. 2008, Doney et al. 2012). Upland systems will be affected by climate change if precipitation patterns change in ways that reduce annual rainfall (Section 4.2).

Recreational Kelp Harvest

The commercial harvest of kelp is not allowed in Washington, but recreational take is common in areas including Fort Ebey State Beach and may perhaps be increasing. Ten pounds (4.5 kg; wet weight) of kelp/day is allowed per person, licenses are required, and 12–24 in (30–60 cm) of the plant, depending on species, must be left remaining (https://www.dnr.wa.gov/seaweed). The impacts of recreational harvest on kelp species have recently become of interest; results suggest that impacts may not only include the population extent at sea but also the abundance of "wrack" (an accumulation of kelp on beaches, often after storms, that is an important ecological contribution to intertidal communities (Mumford 2007, Kilgo et al. 2018).

4.4.2. Reference Conditions

The extent of native freshwater, brackish, and submerged vegetation communities should not decrease. Optimally, invasive species should be absent. The diversity of native species should not decline, and rare species should persist. Any measurable increase in the relative abundance of non-native species would be cause for concern.

4.4.3. Data and Methods

Copass and Ramm-Granberg (2016) provide a summary of previous non-marine vegetation studies conducted in the Reserve and other locations on Whidbey Island with survey and mapping methods described therein. The Reserve is currently not included in the prairie monitoring protocol for NCCN.

Five freshwater wetlands within the Reserve were visited as part of the Adamus et al. (2006) study; plants found in these wetlands in 2005 are listed in Appendix 1. The Washington State Department of Natural Resources (WDNR) monitors eelgrass (Christiaen et al. 2016), and there is a monitoring site just north of Fort Ebey State Park (WDNR Seagrass Monitoring website). The volunteer group Island County Beachwatchers, in collaboration with the Island County Marine Resources Committee and Washington State University, has been mapping eelgrass throughout Island County for many years. As part of monitoring of eelgrass throughout Puget Sound, the Washington DNR monitors eelgrass at four locations within the Reserve and several more around the island (https://www.dnr.wa.gov/programs-and-services/aquatics/aquatic-science/nearshore-habitat-eelgrass-

monitoring). Bull kelp is monitored in waters adjacent to Ebey's Landing outside the entrance to Admiralty Inlet in partnership with the Island County Marine Resources Committee (ICMRC 2017).

4.4.4. Resource Condition

Freshwater Wetlands

Though all the Reserve's wetlands have been invaded to some degree by non-native plants, the current extent of invasive species populations and whether these populations are increasing in distribution is not known. A survey of 102 Island County wetlands in 2005 determined that 55% supported non-native plant species, representing 1–24% of the cover in any single wetland (Adamus et al. 2006). However, many restoration and invasive plant eradication efforts, particularly by the Whidbey Camano Land Trust, have had significant success.

Brackish Wetlands/Lagoon

Perego's Lagoon was described in 1984 as being in good to excellent condition, dominated by native species, with natural processes intact and operating (Kunze 1984). Recent visits to Perego's Lagoon indicate no significant changes (Chappell and Dunwiddie, pers. obs. 2015). The current conditions at Crockett Lake are mixed; hairy willow herb at Crockett Lake is apparently spreading, while Spartina appears to be reduced in extent due to persistent control efforts.

The Keystone Spit is highly modified by the presence of a paved highway on the spit itself, other development, recreation, historic hydrologic alterations in the vicinity, dredging in the vicinity of the Coupeville (formerly Keystone) ferry and perhaps other physical alterations. The vegetation is in poor to fair condition, being a mix of native (largely dune grass [*Leymus mollis* ssp. *mollis*] and gumweed [*Grindelia stricta*]) and non-native species, especially grasses (del Moral and Hanson 1980, Chappell, pers. obs. 2015). In some years, the site has supported a very large population of seablush (*Plectritis congesta*), a native coastal species that is relatively uncommon elsewhere on Whidbey Island.

Dunes and Bluffs

The current condition of the coastal bluff communities is unknown. Large woody debris, which accumulate on the beaches and help armor the sand berms and facilitate plant recruitment, are present. The bluffs at Fort Ebey State Park are generally in poor condition, with relatively more recreational impacts and dominance of non-natives than at Ebey's Landing and Perego's Lagoon (del Moral and Hanson 1980, Chappell, pers. obs. 2015). Many bluffs have been seriously degraded by the invasion and spread of non-native poison hemlock (*Conium maculatum*) and Scotch broom (*Cytisus scoparius*).

Marine/Submerged

Eelgrass

Seagrass area is increasing slightly in some areas of Puget Sound (Christiaen et al. 2016). Between 2003–2014 only one long-term monitoring site for seagrass (<5.0%) had a decline in native seagrass area (Christiaen et al. 2016), and WDNR estimates the total amount of seagrass in the Sound is relatively stable (Christiaen et al. 2016). No change in eelgrass area was detected by WDNR at three locations along the southeast shore of Penn Cove between the 2006 and 2011. Likewise, no change in

area was detected between the 2001 and the 2010 survey near Partridge Point on the west side of the Reserve. However, other sites have experienced decreases and investigations have detected correlations between declines in seagrass and the presence of shoreline modifications and development (Nahirnick et al. 2018).

Kelp

Kelp monitoring in the region indicates non-significant changes in bull kelp bed extent unrelated to water temperature (Kilgo et al.). Kilgo et al. (2018) also found that recreational harvest of winged kelp (*Alaria marginata*) correlated with differences in blade length of surviving individuals. Direct correlations between floating kelp abundance and climate is lacking (Berry et al. 2017).

4.4.5. Level of Confidence

Moderate

4.4.6. Data Gaps and Research Recommendations

- There is a need for current, detailed information on wetland species composition.
- Detailed mapping of the extent of vegetation and supra-tidal sand at Perego's Lagoon berm would potentially be useful information in the event of future sea level rise. Potential recreational impacts at Perego's Lagoon should also be periodically monitored.
- A survey of Keystone Spit to assess its value, or lack thereof, for native flora should be considered.

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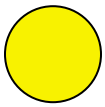
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4.5. Upland Vegetation

By Peter Dunwiddie and Catherin Schwemm

Native prairie communities are at risk, though recent restoration efforts have improved prairie condition. Forest condition is somewhat concerning given fire suppression and the impacts that climate change may have on survival and health of several tree species. The overall trend for the condition of endangered golden paintbrush populations is good; little is known about other rare species and concern is warranted. Confidence is moderate.



4.5.1. Background

This section assesses the condition of the extant upland natural vegetation communities including rare plant species. Wetland and nearshore vegetation are assessed in Section 4.4.

Prairies and Grasslands

For this assessment "prairies" refers to vegetation communities in EBLA that are dominated by native herbaceous species. Garry oak savannas and woodlands are also discussed in this section because the two communities often include similar understory species, occur in proximity to each other, and were historically maintained by similar ecological processes (Peter and Shebitz 2006). In general prairies have few shrubs or conifers, and if oaks or other trees are present there is a relatively open understory (Peterson and Reich 2008). Prairie/oak woodland plant communities are critical resources for many animals but particularly pollinators and birds (Altman 2011, Neame et al. 2013).

Prairies in the Pacific Northwest were historically created and maintained when native people burned forested areas to convert them to sites dominated by herbaceous species for food and medicinal uses (Boyd 1999, Weiser and Lepofsky 2009, Matthews and Turner 2017). The arrival of Europeans essentially ended the practice of prairie burning when livestock were introduced to the landscape (Weiser and Lepofsky 2009). Now Puget Lowland prairies are some of the most endangered habitats in Washington (Noss et al. 1995, Chappell et al. 2001, Chappell 2006a&b, Dunwiddie and Bakker 2011, WDFW 2015), and presently there are only two remaining prairie patches with EBLA; approximately 2.6 ac (1 ha) exists at Smith Prairie, and 1.5 ac (0.6 ha) at the Naas Unit of the Admiralty Inlet Natural Area Preserve located on the bluffs above Perego's Lake. The *Festuca rubra* – (*Camassia leichtlinii*, *Grindelia stricta* var. *stricta*) association at the Nass Unit is represented by fewer than ten occurrences in Washington (Copass and Ramm-Granberg 2016). Other prairie remnants of more degraded quality (*Festuca idahoensis* ssp. *roemeri* – *Camassia quamash* – *Cerastium arvense*) can be found on the bluffs at Fort Ebey.

Prairies and oak woodlands of the northwest have been studied at length, and while a general ecological description is provided below, a thorough description is beyond the scope of this assessment. For additional information the reader is directed to sources such as Chapelle et al. (2001), Burton (2002), and Dunwiddie and Bakker 2011).

Forests

Forests dominate at low elevations across western Washington, and approximately one-third of the Reserve is currently forested, dominated primarily by Douglas fir (*Pseudotsuga menziesii*) and western hemlock (*Tsuga heterophylla*). The total forested area of the Reserve is approximately 4,500–4,800 ac (1,821–1,942 ha; Copass and Ramm-Granberg 2016). Despite the long history of disturbance and land conversion, the Reserve contains several rare forest types that are found only within the rain shadow of the Olympic Mountains. Forest stands of note include occurrences of the following associations classified by the Washington NHP as imperiled statewide:

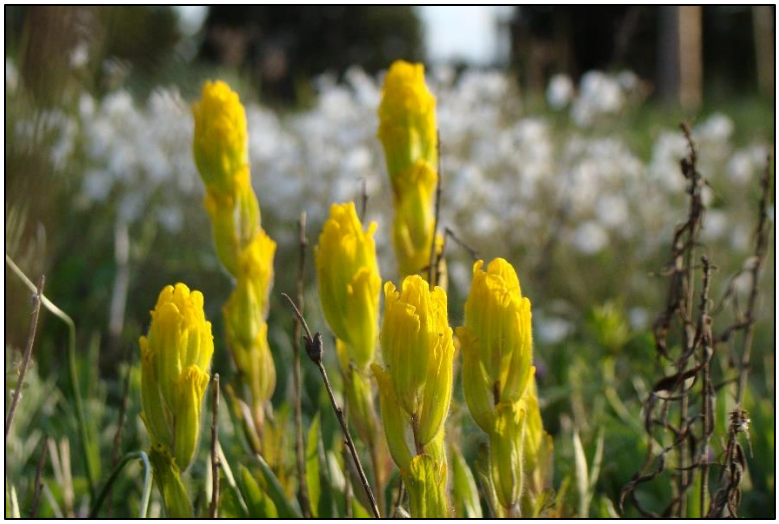
- *Pseudotsuga menziesii – Tsuga heterophylla / Gaultheria shallon* (Fort Ebey State Park)
- *Pseudotsuga menziesii – Tsuga heterophylla / Holodiscus discolor / Polystichum munitum* (Heritage Forest of Whidbey-Camano Land Trust and one other mature stand)
- *Pseudotsuga menziesii – Tsuga heterophylla / Rhododendron macrophyllum – Vaccinium ovatum – Gaultheria shallon* (Rhododendron County Park)



Forested cove at Fort Ebey State Park (Photo by Marsha Davis).

Species of Concern

Only one plant species occurring in the Reserve—golden paintbrush (*Castilleja levisecta*)—is federally listed as Threatened and state listed as Endangered. Twelve naturally-occurring populations of this species exist, four of which occur within the Reserve (one each at Ft. Casey State Park, Heritage Forest bluff, Naas/Admiralty Inlet NAP, and Ebey's Landing – Hill Road; Gamon 1993).



Golden paintbrush, *Castilleja levisecta* (Photo courtesy of Pacific Rim Institute).

In addition to golden paintbrush, several other species considered to be rare in Washington currently occur in Island County or have been recorded there historically. Three of these, shortspur seablush (*Plectritis congesta* ssp. *brachystemon*), Columbian white-top aster (*Sericocarpus rigidus*), and Scouler's catchfly (*Silene scouleri* ssp. s*couleri*) are currently known to occur within the Reserve and all are of significant concern:

- Shortspur seablush (pink plectritis): This species was first found in the Reserve in 2012 and is known from a single population in Smith Prairie. It appears to be largely confined to an area of several tens of square meters and may consist of several thousand individuals.
- Columbian white-top aster: A single occurrence of this species was first found in an unprotected native prairie remnant on privately-owned property in 1984 and was rediscovered about 2001. It was last observed to occupy about a 100 square meter area in 2002. The population is threatened by shrub invasion (much of remnant already shrub covered) and road work.
- Scouler's catchfly: Very little is known regarding the status of the one known population of this species within the Reserve. The population occurs near the top of the bluff at TNC's Ebey's Landing Reserve and was last documented in 2004.

Several other species of conservation concern may occur within the Reserve in small numbers or could potentially occur and may be candidates for restoration (Table 4.5-1).

Table 4.5-1. Rare plant species recorded from Island County, Washington. From: http://www1.dnr.wa.gov/nhp/refdesk/lists/plantsxco/island.html.

Scientific Name	Common Name	State	Federal	County listed	Historical Only
Agoseris elata	tall agoseris	S	–	X	H
Balsamorhiza deltoidea	Puget balsamroot	R2	–	–	H
*Castilleja levisecta**	golden paintbrush	E	LT	X	–
Ceratophyllum echinatum	smooth hornwort	R1	–	–	H
Cicuta bulbifera	bulb-bearing water-hemlock	S	–	X	H
Erythronium revolutum	pink fawn-lily	S	–	–	H
Fritillaria camschatcensis	black lily	S	–	X	H
Leptosiphon minimus	true babystars	R1	–	–	–
Meconella oregano	white meconella	T	SC	X	–
*Plectritis brachystemon**	shortspur white plectritis	R1	–	–	–
Ranunculus californicus var. *californicus*	California buttercup	T	–	–	H
*Puccinellia nutkaensis**	Alaska alkaligrass	–	–	X	–
*Sericocarpus rigidus**	white-top aster	S	SC	X	H
Silene scouleri ssp. *scouleri**	Scouler's catchfly	S	–	–	H
Solidago missouriensis	Tolmie's goldenrod	R2	–	–	H

* Indicates species with current records in the Reserve. State status abbreviations are as follows: E=Endangered, S=Sensitive, T=Threatened, R1 and R2=Review groups of potential concern, H=Historic, recorded only prior to 1977. Federal Status: LT=Listed Threatened, SC=Species of Concern.

Threats

Development

Within the past 50 years, rural development has increased within or near the Reserve and across Whidbey Island. The relatively small size of this Reserve, its mixed-use mission, and its location on an island potentially concentrate the factors associated with development which could impact the Reserve's vegetation. Currently approximately 60% of the Reserve (8,549 ac/3,460 ha) is either developed, in cultivation, or dominated by non-native species (Copass and Ramm-Granberg 2016).

Browsing

Populations of Columbia black-tail deer (*Odocoileus hemionus columbianus*) on Whidbey Island are exceptionally high due to the relatively mild marine climate, extensive intermixing of open areas and woodland, abundant edge habitat, lack of significant predators, and restrictions on hunting within semi-developed areas of the Reserve (Ruth Milner, WDFW, pers. comm. 2015; MacDougall 2008). When deer and other herbivore populations remain high for long periods, tree regeneration may suffer, eventually altering the composition and structure of the maturing forest (MacDougall 2008, Martin et al. 2011).

Non-native Species

Non-native species have become a major component of the island's flora and of the vegetation composition of the Reserve. Non-native species within the Reserve comprise between 25% (Rochefort 2010) and 33% (this report) of the Reserve's flora. The vast majority of these species occur in open habitats such as agricultural fields, dunes, or residential yards in developed zones. Invasive shrubs like Scotch broom (*Cytisus scoparius*) and Himalayan blackberry (*Rubus armeniacus*), while less frequent in the prairies than grasses and herbs, can be extremely deleterious if they become established (Jordan et al. 2008). At least 23 plant species classified as noxious have been found within the Reserve, representing 5%–7% of the Reserve's known flora. Some of the most abundant of the non-native grasses and invasive forbs in the prairies are listed in Table 4.5-2.

Table 4.5-2. Species designated as Class A, B, or C weeds by the Washington State Noxious Weed Board reported from the Reserve. Sources: Rochefort 2010, Dunwiddie et al. 2013.

Vegetation Type	Scientific Name	Common Name
Grasses	*Agrostis capillaris*	colonial bentgrass
	Arrhenatherum elatius	tall oatgrass
	Anthoxanthum odoratum	sweet vernalgrass
	Bromus hordeaceus	soft brome
	Bromus rigidus	ripgut brome
	Bromus sterilis	poverty brome
	Dactylis glomerata	orchardgrass
	Elymus repens	quackgrass
	Vulpia bromoides	brome fescue
	Holcus lanatus	common velvetgrass
	Poa pratensis	Kentucky bluegrass
	Schedonorus phoenix	tall fescue
Forbs	*Anthriscus caucalis*	bur chervil
	Cirsium arvense	Canada thistle
	Cirsium vulgare	bull thistle
	Conium maculatum	poison hemlock
	Crepis capillaris	smooth hawksbeard
	Hypochaeris radicata	hairy cat's ear
	Leucanthemum vulgare	oxeye daisy
	Rumex acetosella	sheep sorrel
	Vicia sativa	common vetch
	Vicia villosa	winter vetch

Disease

Sudden oak death, caused by a non-native fungal blight (*Phytophthora ramorum*), was first recorded in Washington state in 2003 and can occur on many native species including Oregon white oak (Garry oak; *Quercus garryana*), Douglas-fir (*Pseudotsuga menziesii*), and bigleaf maple (*Acer*

macrophyllum). This pathogen can result in significant mortality in some species such as oaks, presenting a major threat to this vegetation type (http://www.hungrypests.com/the-threat/sudden-oak-death.php).

A fungus that produces cankers (*Fusicoccum arbuti*) is the major pathogen that is contributing to a regional decline in Pacific madrone (*Arbutus menziesii*; Elliott et al. 2002, Farr et al. 2005). The fungi's increase since the 1970s is hypothesized to be related to the absence of fire, which was previously the agent probably most responsible for mortality of mature trees (Elliott et al. 2002). Fungal mortality leaves a root burl that is depauperate in resources available for resprouting, in contrast to burn mortality which results in resprouting and renewal of stands (Elliott et al. 2002).

4.5.2. Reference Conditions

Because this is an historical Reserve whose primary mission is to preserve the appearance of the landscape similar to post European contact (~1792) through the late 1880s (NPS 2006), reference conditions for vegetation are less ecological than cultural. Consequently, there are areas of agricultural lands and other sites reminiscent of the period that do not include native vegetation but that will be managed and maintained. Determining the appropriate locations and successional processes for native vegetation within the historical landscape is beyond the scope of this assessment, but, where such stands remain, they should be protected and enhanced as much as possible. Specifically, existing stands of prairie and forest vegetation should be managed so that native species increase in abundance and overall extent does not decline. Recruitment of key species, particularly tree species, at relevant successional stages should be occurring, and rare species should be preserved.

Prairies

Soil analysis indicates many sites where prairies likely existed prior to the arrival of European settlers (Sheehan 2007), and ideally this extent would be the ecological state (Figure 4.5-1). However, many of these sites were converted to agriculture when livestock and ranching practices were introduced, and such land use is valued as part of the cultural landscape. Increasing the extent of prairie cover could likely be achieved by restoration and management and would improve the overall ecological condition of the landscape. For this assessment overall prairie extent should be stable or increasing, and in all prairie areas native species should be dominant.



Figure 4.5-1. Extent of historical prairies and oak woodlands on Whidbey Island based on soil development (based on Sheehan 2007).

Forests

Extent and Age Structure

Soil surveys indicate that forests once covered approximately 8,495 ac (3,438 ha) of the Reserve. White (1980) argued that the vast majority of pre-settlement forests on Whidbey Island were primarily dense old-growth, while other sources (Agee 1993, Chappell 2006b) and field experience of several authors, provide evidence that the pre-settlement forested landscape of the Puget Lowland was a dynamic mosaic of differing age classes and stand structures. For example, significant areas of woodland (< 60 percent tree canopy cover) associated with more frequent low- to moderate-severity fires associated with Native American cultural burning practices may have been present alongside old-growth.

Demography/structure and percentage of forest with late-successional stands could be utilized as reference metrics. Douglas-fir, grand fir, western hemlock, western red cedar, red alder, and Pacific madrone should appear relatively frequently as canopy dominants or co-dominants, which would be

similar to the presumed pre-EuroAmerican settlement distribution. The age distribution of each forest type used as reference conditions is presented in Table 4.5-3.

Table 4.5-3. Combinations of vegetation dominance type and stand age expected to occur in EBLA forests.

Forest Associations	Very Young	Young	Mature	Old growth
Pseudotsuga menziesii (Douglas fir)	X	X	X	X
Pseudotsuga menziesii – Abies grandis (Douglas fir – grand fir)	X	X	X	–
Pseudotsuga menziesii – Arbutus menziesii (Douglas fir – Pacific madrone)	–	X	X	–
Pseudotsuga menziesii – Acer macrophyllum (Douglas fir – bigleaf maple)	X	X	X	–
Pseudotsuga menziesii – Thuja plicata – Tsuga heterophylla (Douglas fir – red cedar – western hemlock)	–	X	X	–
Pseudotsuga menziesii – Tsuga heterophylla (Douglas fir – western hemlock)	X	X	X	X
Abies grandis (grand fir)	–	X	X	–
Acer macrophyllum – Alnus rubra (bigleaf maple – red alder)	X	X	–	–
Acer macrophyllum (bigleaf maple)	X	X	–	–
Alnus rubra – Tsuga heterophylla (red alder – western hemlock)	–	X	–	–
Alnus rubra (red alder)	X	X	–	–
Alnus rubra – Pseudotsuga menziesii (red alder – Douglas fir)	X	X	–	–

Old Growth – Late Successional Stage

The US Forest Service (USFS) has developed interim old-growth definitions for all forest series present on National Forest lands in Washington and Oregon (Fierst et al. 1992, 1993). While the national forests include very little of the Puget Lowland, a modification of these definitions could be used in the Reserve.

The vast majority of the reserve's forests fall within the Western Hemlock series with a small minority in the Grand Fir or Douglas-fir series (Copass and Ramm-Granberg 2016). To meet the USFS definition of old-growth, western hemlock series stands should have:

- Minimum of 8 standing live trees/acre at least 21–42 in (53–107 cm) dbh and >200 years old (varying by site class)
- Decadent trees present
- Minimum of two tree canopy layers
- Four snags per acre, at least 20 in (51 cm) dbh (numbers of snags and logs are typical minimums, but are not required to qualify as old growth)

- 29–69 downed logs at least 8–12 in (20–30 cm) diameter (varying by site class)

For Douglas-fir old-growth series where there is very little to no hemlock or red cedar regenerating there should be:

- Minimum of 8–10 standing live trees/acre at least 24–37 in (61–94 cm) dbh and >190–205 years old (varying by site class)
- Decadent trees present
- Minimum of two tree canopy layers
- One snag per acre, at least 13–17 in (33–43 cm) dbh (varying by site class)
- Four logs at least 24 in (61 cm) diameter

Species of Concern – *Castilleja levisecta*

Three criteria are proposed to evaluate the status of this species within the Reserve, all based on the recovery criteria identified in the federal Recovery Plan (USFWS 2000):

- Number of Populations: The Recovery Plan sets a goal of 20 self-sustaining populations distributed across the extant and historic range of the species. A minimum of four viable populations in the central Whidbey Island area would be appropriate towards meeting this goal.
- Number of flowering individuals within each population: Criteria within the Recovery Plan specify that the 20 self-sustaining populations must be stable, with stability defined as populations maintaining a 5-year running average size of at least 1,000 flowering individuals.
- Population Extent: Ideally, each population should occupy an area of at least several acres.

Additional Rare Species

Criteria to evaluate shortspur seablush, Columbian white-top aster, and Scouler's catchfly would include the number of populations, size of populations, population trend, and population area in relation to pre-settlement, however, the authors are aware of no studies that have reconstructed the number and composition of species that existed in prairies during pre-EuroAmerican settlement times in the Reserve or elsewhere in the region.

4.5.3. Data and Methods

Prairies

Steve Erickson (pers. comm., 2013) conducted a detailed assessment and inventory of prairie remnants within the Reserve in about 2001. Floristic data and GIS layers documenting the areal extent of these remnants are in NPS files (Allen McCoy, pers. comm. 9/12/2013), and provide an excellent baseline for potentially tracking changes in composition and extent of native prairie over time. Copass and Ramm-Granberg (2016) mapped two prairie types: *Festuca idahoensis* ssp. *roemeri* – *Camassia quamash* – *Cerastium arvense* Herbaceous Vegetation located at Smith Prairie, and *Festuca rubra* – (*Camassia leichtlinii, Grindelia stricta* var. *stricta*) Herbaceous Vegetation Association at the Naas Unit.

Forests

Forest extent and canopy height distribution were estimated using LiDAR (Appendix 3). Copass and Ramm-Granberg (2016) mapped 16 Alliances in the Reserve (Table 4.5-4).

Table 4.5-4. Forest alliances mapped by Copass and Ramm-Granberg (2016).

Macrogroup	Group	Alliances
Vancouverian Lowland and Montane Rainforest Macrogroup	*Tsuga heterophylla – Pseudotsuga menziesii / Cornus unalaschkensis* Mesic Forest Alliance	2
	Tsuga heterophylla – Pseudotsuga menziesii / Holodiscus discolor Dry Forest Alliance	3
	Tsuga heterophylla – Picea sitchensis / Rhytidiadelphus loreus Forest Alliance	1
	Pseudotsuga menziesii – Abies grandis – Arbutus menziesii Forest and Woodland Alliance	4
	Total	**10**
Vancouverian Flooded & Swamp Forest Macrogroup	*Salix lucida* Temporarily Flooded Woodland Alliance	1
	(Acer macrophyllum, Alnus rubra) Riparian Forest Alliance	1
	(Picea sitchensis, Tsuga heterophylla) – (Alnus rubra) Riparian Forest Alliance	1
	Total	**3**

Rare Species and Communities

Castilleja

At all sites, direct census counts of flowering individuals are conducted as part of the recovery plan (USFWS 2000), the results of which are associated with high confidence. (Some extrapolations were conducted in the very high-density areas within the large Smith Prairie population in 2012).

Additional Rare Species

The authors are aware of no studies that have reconstructed the number and composition of species that existed in prairies during pre-EuroAmerican settlement times in the Reserve or elsewhere in the region. Likewise, there is no comprehensive floral inventory, either for Whidbey Island as a whole, or for the Reserve, which would provide information on additional rare species.

4.5.4. Resource Conditions and Trends

Prairies and Grasslands

The acreage of native prairie that once comprised Ebey's, Smith, and Crockett Prairies has been reduced to less than 1% of its historical extent, primarily due to the removal of fire from the landscape following settlement. Copass and Ramm-Gramberg (2016) calculated that the extent of native grasslands has been reduced from approximately 4,313 ac (1,746 ha/ ~25% of the Reserve) to 21.2 ac (8.5 ha).

Forests

Extent

The Reserve's forests appear to be in better condition than in many other locations throughout the Puget Lowlands, though the total extant area of old growth forest within the Reserve is probably less than 200 ac (81 ha; Chappell, pers. obs., 2007 Natural Heritage Program surveys). Copass and Ramm-Granberg (2016) estimated approximately 4,708 ac (1,905 ha) of forest within the Reserve. Given that soils surveys mentioned previously indicate there were historically perhaps 8,500 ac, the extent of forests in the Reserve is greatly reduced.

Rhododendron County Park has about 80 ac (32 ha) of mostly old-growth Douglas-fir, which is the largest known area of old-growth in the Reserve. Fort Ebey State Park has about 30 ac (12 ha) of old-growth, and there is a narrow strip of old-growth, dry-site Douglas-fir extending from Fort Ebey State Park south to Ebey's Landing and the Robert Y. Pratt Preserve, located at the top of the coastal bluff. Also, in the Pratt Preserve is a small area dominated by mature Sitka spruce (*Picea sitchensis*) with an understory of salal (*Gaultheria shallon*) and oceanspray (*Holodiscus discolor*). This community is unique in the Puget Lowland, being an upland (as opposed to wetland) site where spruce is likely favored by frequent fog. The Heritage Forest includes a mature (140–150 years) stand of Douglas-fir and grand fir that appear to have regenerated naturally after fire and do not appear to have been logged.

Demography

The current distribution of forest age classes on the Reserve appears to be strongly weighted toward the young age class (50–100 ft/15–31 m), with much less old-growth than would have been present historically, though data are lacking to know the current distribution of stand ages and dominance types. Demographic trends appear to be greater structural complexity and larger tree size, though it is unlikely than human activities will set back stand structures to early successional characteristics. However, Copass and Ramm-Granberg (2016) observed that Reserve forests represent some of the only remaining dry forests in the region.

Rare Species

Castilleja levisecta

Several new populations of golden paintbrush have been restored in the Reserve in recent years and the overall trend for this species is good (Dunwiddie and Bakker 2011; Figure 4.5-2). In the early 2000s, only three populations were known at the Reserve, and none met the 1,000 flowering plant goal for a minimum viable population (Lowe and Sheehan 2010). By the later 2000s habitat management, population augmentation, and establishment of new sites was underway and by 2013 all populations had exceeded restoration goals (Dunwiddie et al. 2013); all sites had stable or increasing populations and population extent at most sites was expanding with active management and naturally occurring population increases. A population status review of *C. levisecta* was initiated by FWS in 2018 (FWS 83 FR 3014).

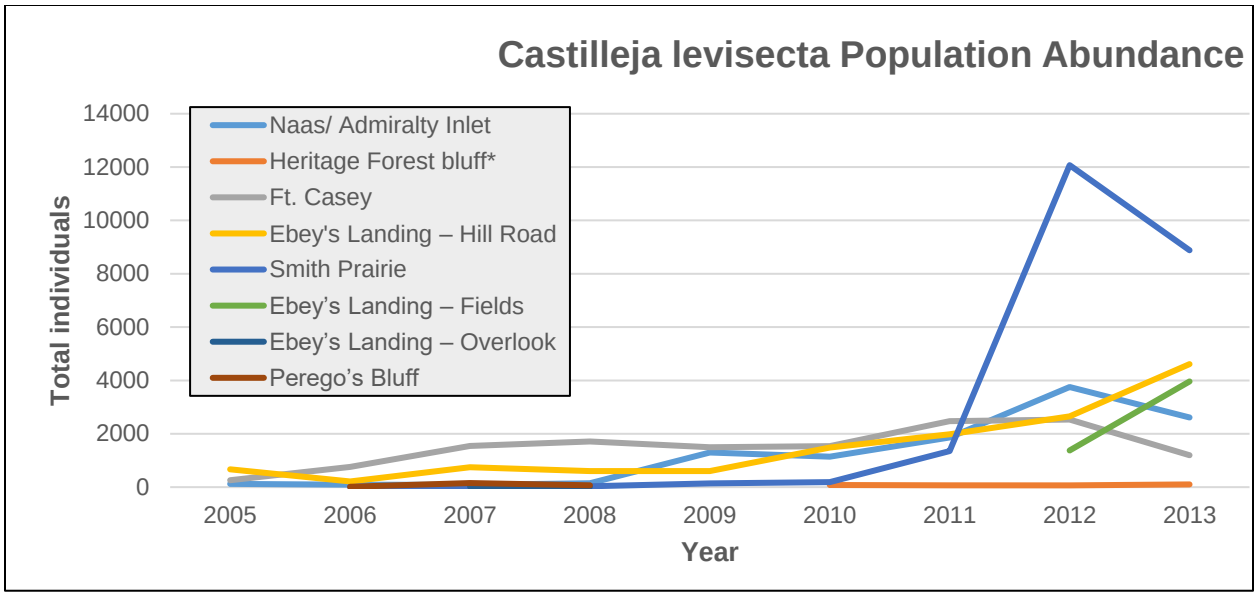


Figure 4.5-2. Number of flowering *C. levisecta* plants in populations within the Reserve since 2005. (Source: graph created for this study using data provided by Joe Arnett and Peter Dunwiddie, shown in Table 4.5-5).

Table 4.5-5. Number of flowering *C. levisecta* plants in populations within the Reserve since 2000. (Source: Joe Arnett, Peter Dunwiddie).

Year	Naas/ Admiralty Inlet	Heritage Forest bluff*	Ft. Casey	Ebey's Landing – Hill Road	Smith Prairie	Ebey's Landing – Fields	Ebey's Landing – Prairie Overlook	Perego's Bluff
2000	97	–	151	7627	–	–	–	–
2001	97	–	166	–	–	–	–	–
2002	98	–	185	–	–	–	–	–
2003	122	–	307	–	–	–	–	–
2004	59	–	235	–	–	–	–	–
2005	120	–	260	669	–	–	–	–
2006	94	–	760	214	4	29	–	15
2007	86	–	1544	747	16	–	20	154
2008	148	–	1713	601	31	–	16	68
2009	1297	–	1497	601	143	–	–	–
2010	1144	80	1538	1487	186	0	19	–
2011	1860	71	2471	1984	1355	–	–	–
2012	3754	67	2534	2656	12071	1375	0	–
2013	2609	103	1196	4612	8883	3962	–	15
2014	2329	109	227	2191	5291	3143	–	4
5-year avg.	2339	86	1593	2586	5557	x	0	x

*The Heritage Forest bluff site was not censused prior to 2010.

Other Rare Species

Plectritis congesta ssp. *brachystemon*: This species was first found in the Reserve in 2012 and is known from a single population in Smith Prairie. It appears to be largely confined to an area of several tens of square meters and may consist of several thousand individuals.

Sericocarpus rigidus: A single occurrence of this species was first found in an unprotected native prairie remnant on privately-owned property in 1984 and was rediscovered about 2001. It was last observed to occupy about a 100 square meter area in 2002. Population is threatened by shrub invasion (much of remnant already shrub covered) and road work.

Silene scouleri spp. *scouleri*: There is only one population of this species and little is known about it. It occurs near the top of the bluff at TNC's Ebey's Landing Reserve and was last documented in 2004.

4.5.5. Level of Confidence

Confidence in the extent of prairies and forest vegetation types (and the amount of change in those measures over time) is relatively high given available information such as soil surveys. Confidence in species composition and ecological function is lower given the general absence of historic information.

4.5.6. Data Gaps and Research Recommendations

Prairies

Management goals and challenges for prairie restoration are specifically discussed in detail in Chapter 5.

Forests

- Specific information on the ecology and demography of dominant tree species would be helpful including: 1) the distribution of stand age classes and dominance types; 2) the abundance of late-successional forest structures within significant areas of forest, and 3) further examinations of old-growth assessment criteria.
- Additional research investigating best management responses to the presence and impacts of disease (e.g. the relative benefits and outcomes of burning versus selective cutting to reduce the impacts of disease) would be beneficial.

Rare Species

- Grazing herbivores pose some challenges for restoration of golden paintbrush (Dunwiddie et al. 2013). Some sites have required fencing to protect flowering individuals, and where managers have been able to install and maintain fencing, flowering of paintbrush has increased, and populations have grown rapidly. However, fencing is expensive to erect and maintain and creates some logistical problems, so investigation into alternative solutions for protecting rare plants from grazers would be helpful.
- Additional research toward understanding the ecology of several rare species would greatly assist prairie restoration efforts. For example, due to the limited amount of native prairie habitat on the

Reserve, there is little likelihood that other populations of *Plectritis brachystemon* and *Sericocarpus rigidus* will be found. Still, efforts could be made to collect and propagate seed of both species from their extant populations to try and generate new populations in prairie restoration efforts undertaken elsewhere in the Reserve and gain basic information on the reproductive biology of these species.

- Additional research and monitoring of *Silene scouleri* ssp. *scouleri* populations would also be useful.

4.5.7. Sources of Expertise

Christopher Chappell, Vegetation Ecologist, Natural Heritage Program, Washington Department of Natural Resources, Olympia, WA 98504

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4.6. Birds

By Paul Adamus and Catherin Schwemm

Bird diversity in the Reserve is high, with several areas such as Crockett Lake providing important resources especially during seasonal migration. Little is known regarding population trends for the majority of species, though most species of concern appear to be stable. Caution is warranted for forest and prairie-dependent species and seabirds. Threats include non-native species, disease, and ocean-related effects of climate change. Confidence is moderate to high given the presence of many bird enthusiasts on the island that maintain sighting records.



4.6.1. Background

This assessment focuses on landbirds (all species not otherwise strongly associated with marine or wetland habitats), waterbirds (species that require shallow but permanent sources of either fresh [waterfowl] or saline [shorebirds] water), and seabirds (species that forage at sea and nest generally on offshore rocks and islands and occasionally mainland sites). Common names are used in the text; a comprehensive list of all bird species recorded from EBLA is presented in Appendix 2 with associated scientific names.

The availability of abundant marine and terrestrial resources supports high bird diversity in the San Juan Islands (Miller et al. 1935, Altman 2011, Holmgren et al. 2016). Though the Reserve comprises only about 13% of the land area of Whidbey Island, 85% of all bird species know from the island have been recorded from the Reserve including all species known to breed on the island.

Landbirds

Rare Species

Two landbird species that occur regularly in the Reserve—the olive-sided flycatcher and the northern harrier—are federally listed as Species of Concern. In 2013 the US Fish and Wildlife Service designated the streaked horned lark as a Threatened species under the Endangered Species Act. Streaked horned larks bred in the Reserve's prairie habitat until the 1960s or 70s but are now only rare migrants and do not breed on Whidbey Island (MacLaren and Cummins 2000). Regional estimates are that there are less than 2,000 individual streaked horned larks remaining (Altman 2011). Oregon vesper sparrows are a Federal Subspecies of Conservation Concern and a Washington species of Greatest Conservation Need/Candidate Species (Altman 2013, WDFW 2015).

Western bluebirds were reintroduced to San Juan Island from British Columbia and Washington beginning in 2007 following the decline and ultimate extirpation of breeding populations that began in the 1960s and 70s (Slater and Altman 2011, 2013). Because nesting cavities are a critical habitat element for western bluebirds, the introduction of nesting boxes into appropriate habitat has resulted in increased breeding success in many areas (Slater and Altman 2013).

Peregrine falcons and bald eagles were both previously listed as federally Threatened and are designated Threatened by the Washington Department of Fish and Wildlife (WDFW 2015). Both species have recovered considerably following the banning of DDT in the 1970s (Newman et al. 1977, Elliott et al. 2011) and each has been delisted. The San Juan Islands support the highest nesting densities of these two species in the Pacific Northwest (at least 122 bald eagle nesting territories and 20 peregrine falcon territories; WDFW 2015). Although peregrines are an increasingly common nester on the nearby San Juan Islands, they seldom if ever nest on Whidbey Island. At least nine bald eagle nests are occupied annually in the Reserve.

Prairie and Forest-associated Species

Of particular conservation interest are species dependent on or strongly associated with prairie and oak woodland habitats (Altman 2011, Section 4.6). Among 49 bird species that associate strongly with prairie-oak habitat in the Pacific Northwest, a significantly large number (21) have experienced extirpations, range contractions, or regional declines (Altman 2011). Human-initiated fires historically maintained habitat for prairie-associated species by limiting woody species expansion into grassland, and fire suppression during the last century has removed this barrier, thus degrading the habitat upon which many grassland-associated bird species depend on (Cahall and Hayes 2009, Altman 2011). The high densities of deer on Whidbey Island have further reduced the abundance of shrub cover, areas that naturally provide habitat for many smaller landbird species (Martin et al. 2011, Jirinec et al. 2017). Species present in EBLA associated with prairie habitats are noted in Appendix 2.

The historical conversion of forest cover to farmland and prairie has also reduced habitat resources required by forest birds. Features such as nesting cavities in tall trees may become unavailable when forests are cleared, and forest-associated bird species may decline as a result (Altman and Stephens 2012). These same changes in landcover, though, may have created or improved habitat for native open-land species such as the northern harrier and the savannah sparrow that formerly may have been absent or much less common (Altman 2011).

Waterbirds

Black oystercatchers, a federal shorebird species of concern, feed along the Reserve's shoreline and are of interest due to the relatively low global population (~ 11,000 individuals; Golumbia et al. 2009). In addition to being listed federally as a Species of Concern, oystercatchers are identified as a regional species of high concern by the Northern Pacific Coast Regional Shorebird Management Plan. Common loons occur during winter and migration in marine waters of the Reserve, and breeding occurrences are listed as Sensitive.

Seabirds

Seabirds are species that spend most of their lives at sea, returning to land only to breed. Only one seabird species that is regularly present near the island is federally listed. The marbled murrelet is a small seabird that nests in old growth forests (critical habitat that is sparse in the Reserve; USFWS 1997), and feeds regularly, often in large groups, in marine waters adjoining the Reserve. Marbled murrelets continue to exhibit small but consistent declining trends in Washington state waters

(Pearson et al. 2014, Falxa and Raphael 2016). Brown pelicans were listed as federally endangered in the 1970s and were de-listed in 2009 (USFWS 2009), but are still listed by the state as endangered. Only one non-breeding record of brown pelicans exists from Whidbey Island and they have not been recorded in the Reserve. Seabird species considered for the WDFW priority list that occur in the Reserve or adjacent waters include western grebe, Brandt's cormorant, common murre**,** and tufted puffin (WDNR 2010, WDFW 2015).

Pigeon guillemots are the only seabird that nests on Whidbey Island. Approximately 1,000 adult birds are present each year, and cumulatively the breeding pairs construct over 200 shoreline nesting burrows. Twenty-four nesting colonies are known to exist on Whidbey Island, and each year since 2007 between 2–5 of those, including one in the Reserve at Rolling Hills on Penn Cove, have been monitored. A pair of pigeon guillemots has also nested on a structure near the Keystone jetty.

Important Habitat Areas

Crockett Lake and Penn Cove (including Grasser's and Kennedy's Lagoons) were designated Habitats of Local Importance by Island County, and in 2001 were designated Important Bird Areas (IBAs) by the Audubon Society of Washington (Drut and Buchanan 2000). Both Penn Cove and Crockett Lake are listed by WDFW as important winter waterfowl concentration sites. Reserve sites that support high bird diversity, rare species, and/or large seasonal concentrations are listed in Table 4.6-1.

Table 4.6-1. Important Bird Areas in or near EBLA with records from eBird (hotspots – Island County; https://ebird.org/region/US-WA-029/hotspots?yr=all&m=).

Site	Noted bird species present
Crockett Lake	Colonies of nesting great blue herons and purple martins; large concentrations of barn and cliff swallows, large numbers of red-winged and Brewer's blackbirds; many migrating shorebirds and raptors in autumn; winter habitat for bald eagles and ducks; generally quality habitat for swallows, savannah sparrows, auklets, cormorants, and guillemots. 2000 northern pintail, 1000 American widgeon, 400 gadwall, 255 mallard, 250 green-winged teal, 850 lesser scaup, 215 ruddy duck, 150 bufflehead, and 120 hooded mergansers; 20,000* western sandpiper, 11,000 dunlin, 5000 least sandpiper, 444 red-necked phalarope, 380 short-billed dowitcher, 300 black-bellied plover, 200 long-billed dowitcher, 200 sanderling, 180 semipalmated plover, 100 killdeer, 75 greater yellowlegs, 13 lesser yellowlegs, and 40 Baird's sandpipers.
Fort Ebey State Park	Seabirds and waterfowl, kingfisher, crossbill, woodpeckers, other forest birds including nuthatch, creeper, kinglets.
Kennedy Lagoon	Kingfishers, waterfowl including hooded mergansers, goldeneyes, bufflehead, scaup, scoters.
Penn Cove	Kingfishers, herons, loons, goldeneyes, bufflehead, scaup, pigeon guillemots. 2000 western grebes; 475 black turnstone and 50 surfbirds; 7000 surf scoters, 3000 white-winged scoters, 250 common goldeneye, 125 bufflehead, and 20 Barrow's goldeneye.
Ebey's Landing	Loons, grebes, waterfowl, meadowlarks, blackbirds, raptors.

Table 4.6-1 (continued). Important Bird Areas in or near EBLA with records from eBird (hotspots – Island County; https://ebird.org/region/US-WA-029/hotspots?yr=all&m=).

Site	Noted bird species present
Fort Casey	Loons, grebes, auklets, guillemots, mergansers, gulls, great horned owls, passerines including chickadees, nuthatches, creepers, winter wrens, warblers. 200 common murres and 110 marbled murrelets at Fort Casey; 50 red-throated loons and 20 common loons; 30 harlequin duck and 20 Barrow's goldeneye.
Libby Beach	30 horned grebes, 800 rhinoceros auklets

Threats

Oil Spills and Commercial Fishing

Population-level impacts on seabirds occur from oil spills and leaks (Wiese and Robertson 2004, O'Hara and Morandin 2010), anthropogenic lights at night (Krüger et al. 2017, Rodriguez et al. 2017), and commercial fishing operations. Fishing by-catch and "ghost-nets", nets that have been abandoned and remain in the ocean as hazards, account for many seabird deaths (Hamel et al. 2009, Zydelis et al. 2013). For example, since 2002 over 870 unattached gillnets have been removed from the Salish Sea and in one study (Good et al. 2009), 14% of recovered gillnets held dead seabirds. Discarded plastic material and microplastics are likewise attributed to seabird mortality (Vegter et al. 2014).

Non-native Species and Predation

The impacts of non-native bird species on the Reserve's native landbirds are unknown. One exotic species whose North American range is expanding rapidly is the Eurasian collared dove. Collared doves arrived in the Pacific Northwest around 2000, spreading from the southeastern United States and the West Indies (Fujisaki et al. 2010). Numbers of collared doves on Whidbey Island and in the Reserve have increased noticeably since they were first noted in about 2009, and flocks of 20 at Penn Cove in 2013 and 24 at Crockett Lake in 2014 have been reported. Other birds not native to the Pacific Northwest that occur regularly in parts of the Reserve are European starlings, house sparrows, rock pigeons, California quail, and ring-necked pheasants. Although native to North America, brown-headed cowbirds occur throughout the Reserve, parasitizing the nests of many other bird species. Cowbirds tend to be more common where forests have been fragmented by small residential developments, rights-of-way, or agriculture (Abernathy and Peer 2017). Finally, population growth of predatory bird species such as bald eagles and peregrine falcons following successful recovery programs has indirectly led to stronger predation pressures at some seabird nesting colonies (Parrish et al. 2001, Buchanan 2006, Hayward et al. 2010, Hipfner et al. 2012).

Disease

West Nile virus (WNV) was introduced to North America relatively recently but has spread quickly with significant impacts on landbird populations (George et al. 2015). Studies have found increased incidence of WNV with altered climate conditions and predict future scenarios with greater incidences of WNV in both wildlife and humans (Harrigan et al. 2014, Hahn et al. 2015).

Climate Change

Sea level rise associated with climate change could have significant impacts on shorebirds (Glick et al. 2007, Veloz et al. 2013, Galbraith et al. 2014). Additional changes in ocean conditions, particularly increases in sea surface temperatures and multiple impacts to forage fish populations, may have multiple and related impacts on seabird productivity (Cury et al. 2011, Hayward et al. 2014, Vilchis et al. 2014, Grémillet et al. 2015, Alava et al. 2017).

4.6.2. Reference Conditions

The diversity of native breeding bird species should be maintained, indicating habitat integrity. There should be persisting populations of rare species and species of concern, though in almost no cases are there sufficient data to determine historical population numbers of rare and/or endangered species in EBLA. Critical habitats should be maintained at present sizes, including in particular prairies/oak woodlands and intertidal/coastal habitats and resources.

4.6.3. Data and Methods

All Species

A primary source of information on bird presence on Whidbey Island is the Whidbey Audubon Society (www.whidbeyaudubon.org). In particular, the organization conducts an annual Bird-a-thon that collects data on species that are present during the peak migration period in early May.

Though not directly inclusive of Whidbey Island, Crewe et al. (2012) conducted an analysis of survey results from the British Columbia Waterbird Survey from 1999–2012; methods and locations are described therein.

For seabirds, Bower (2009) utilized survey results from several monitoring efforts within the Salish Sea region, including a portion of the Whidbey Island coast, to analyze overall seabird abundance and trends for selected species from 1975–2007. A somewhat more intensive data analysis was conducted by Vilchis et al. (2014) using annual aerial surveys and Christmas Bird Count data from the Salish Sea from 1994 to 2010.

The Washington State Department of Fish and Wildlife maintains a publicly-accessible spatial database of species occurrences from the Priority Habitat and Species list (PHS; http://apps.wdfw.wa.gov/phsontheweb/); descriptions of how map source data were acquired are available at https://apps.wdfw.wa.gov/phsontheweb/faq.htm.

EBLA is not included in the NPS NCCN landbird monitoring program (Siegel et al. 2007).

4.6.4. Resource Condition and Trend

Several bird species (e.g. streaked horned lark) have apparently been extirpated from Reserve lands, and several species are experiencing regional declines (Altman 2011). Multiple factors have likely led to the extirpation of several species, including the conversion of large areas of prairie and fire suppression. No monitoring data have been collected from the Reserve so trends for any species are unknown. General conditions for each group are provided below.

Landbirds

Though EBLA is not included in landbird monitoring, Holmgren et al. (2016) found that in NCCN parks outside of EBLA, overall detections of landbird species remained high from 2013–2015, and no substantial changes in detections were noted either for species of concern or non-native species. In a wider analysis, Saracco et al. (2014) found that from 2005–2012, Cassin's vireos, Swainson's thrush, and Townsend's warblers declined in NCCN parks. Most recently, Ray et al. (2017) analyzed monitoring data from 2005–2014 at Mount Rainier, Olympic, and North Cascades National Parks and found that densities of 39 breeding species were stable or increasing. Conversely, for prairie-associated species, Altman (2011) found that among 49 species that are strongly associated with prairie-oak habitat in the Pacific Northwest, a large number (21) have experienced extirpations, range contractions, or regional declines. Crewe et al. (2012) found that in the Strait of Georgia bald eagles declined by 1.8% per year while peregrine falcons showed no change during the period (1999–2012).

Shorebirds and Waterbirds

Results from the Whidbey Audubon Birdathon from 2013–2018 (http://www.whidbeyaudubon.org/Birdathon_bird_summary_2013-2018.pdf) included the first-time detections of snow geese, Lewis's woodpecker, northern shrike, red-eyed vireo, horned lark, western bluebird, Nashville warbler, white-throated sparrow, western meadowlark, and Bullock's oriole. Birds not observed in 2018 (after being seen in 2013–2017) are identified in Appendix 2.

Seabirds

Many seabird species found in the Puget Sound and greater Salish Sea region have experienced declines over the past several decades (Bower 2009, Vilchis et al. 2014). Suspected contributors to the declines (or shifts in geographic range) include entrapment in fishing gear, oil spills, contaminants, and habitat loss (Gaydos and Pearson 2011, Good et al. 2018). Overall Bower (2009) found 14 of the 37 seabird species he analyzed in the Salish Sea experienced significant declines from 1975–2007, with declines of 11 of those species exceeding 50%. The recent analysis by Vilchis et al. (2014) implicated changes in the availability of low-trophic prey such as forage fish as a major cause of declines for wintering alcids and grebes.

4.6.5. Level of Confidence

Moderate

4.6.6. Data Gaps and Research Recommendations

- No long-term data for bird populations have been collected from within the Reserve that allow valid calculation of trends for any of the Reserve's bird species. This is particularly true of marine birds and nocturnal owls.
- For nearly all species, data on reproductive success have not been collected within the Reserve. Such data are required to assess trends and help define minimum viable population levels.
- Relative sensitivities of different bird species to disturbance from traffic and recreationists have not been determined within the Reserve. In particular human activities in the nearshore area should be monitored for effects on shorebird species.

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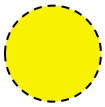
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4.7. Vertebrates

By Catherin Schwemm and Paul Adamus

Almost nothing is known regarding the population status of terrestrial vertebrates in EBLA. Several species are known to be extirpated; native species that may be increasing are those tolerant of human presence (deer, raccoon, coyote). Very little is known regarding several rare amphibians. Confidence is low.



4.7.1. Background

For this assessment the term "vertebrates" includes reptiles, amphibians, land mammals, and bats. (Birds are discussed in Section 4.7). Common names are used in the text; scientific names for all species are provided in the Tables 4.7-1 and 4.7-2.

Amphibians and Reptiles

Amphibians generally require mesic environments with either perennial standing or flowing freshwater, or at least periodically moist conditions during a portion of the year (e.g. ephemeral pools; Green et al. 2014). Critical habitat for most amphibian species includes wetlands where eggs are deposited and larvae mature, and upland habitat adjacent to ponds and streams for adult life stages (Hruby 2013, O'Regan et al. 2014, Grand et al. 2017).

Amphibians are declining globally due to impacts from climate change, habitat loss, disease, and the presence of toxics in their environment (Gardner et al. 2007, Kilpatrick et al. 2010, Li et al. 2013). In the Pacific Northwest the dense, complex rainforests and associated riparian habitats upon which many amphibian species depend have been much degraded or completely lost, leading to reduced amphibian diversity and abundance (DeMaynadier and Hunter 1995, Grialou et al. 2000, Olson et al. 2007, Hodgson 2008).

The relatively dry environment (i.e. limited surface water) of EBLA coupled with island isolation does not support high amphibian diversity, and compared too much of the Pacific Northwest, relatively few species are known to be present on Whidbey Island (Meserve and Jaksic 1991, Blaustein et al. 1995, Samora et al. 2013). Because there are no perennial streams in the Reserve and most ephemeral streams are highly altered, flow-dependent breeding amphibians are mostly absent. The only breeding species are found in a few sites that have standing or seasonal water such as Lake Pondilla and a few small wetlands or in mesic forest habitats (Samora et al. 2013). Five reptile species are apparently present in the Reserve (Table 4.7-1).

Table 4.7-1. Amphibians and reptiles documented from or potentially present in EBLA. From various sources: (C – Confirmed; P – present; PP – probably present).

Common Name	Scientific Name	Samora et al. 2013	NPSpecies
Pacific tree (chorus) frog	*Hyla* (*Pseudacris) regilla*	C	P
Northern red-legged frog	*Rana aurora*	C	P
Western toad*	*Bufo boreas*	–	P
Rough-skinned newt	*Taricha granulosa*	C	P
Ensatina	*Ensatina eschscholtzii*	C	P
Long-toed salamander	*Ambystoma macrodactylum*	C	P
Northwestern salamander	*A. gracile*	C	P
Western terrestrial garter snake	*Thamnophis elegans*	–	P
Northwestern garter snake	*T. ordinoides*	C	P
Common garter snake	*T. sirtalis*	C	P
Northern alligator lizard	*Elgaria coerulea*	–	PP
Rubber boa	*Charina bottae*	–	–

* Species of Concern

Small Mammals

The term “small mammals” commonly refers to insectivores (non-bat species that require some meat in their diets, usually in the form of insects), and small rodents (species that do not require meat though many are omnivores). The only groups of insectivorous small mammals in North America are moles and shrews; moles live almost exclusively underground (“fossorial”) in self-excavated tunnels, while shrews, which are the smallest mammals, do not burrow but live under leaf litter and vegetation. Rodents are a highly diverse group of mammals (Feldhamer 2007), with one family (Muridae, old world rats and mice) that includes over 700 species. In addition to their role as consumers and seed distributors, small mammals are key prey items for many terrestrial and avian predators (Drost and Fellers 1991, Hulme 1998).

Large Mammals

Populations of black-tailed deer have prospered in the Reserve and throughout Whidbey Island, largely as a result of the elimination of large predators from the island during early settlement, and the reverting of prairie to intermediate successional stages in the absence of fire (Chamberlain et al. 2007). Damage to native ecosystems from abnormally high deer density has been documented from many locations including on many of the San Juan Islands (Allombert et al. 2005, Martin et al. 2011). As of 2018 only one elk individual is present on Whidbey Island, a male who apparently swam across from the mainland and remains on North Whidbey. There are no large predators on the island

Bats

Bats are a diverse group of flying mammals found throughout the world, with approximately 47 species in North America (Adams 2003). Bats are extremely important insect predators and pollinators in ecosystems worldwide and the economic and ecologic value of maintaining healthy bat communities is substantial (Agosta 2002, Boyles et al. 2011, Kunz et al. 2011). Common to all bat

species is a nocturnal life history that includes the physiological adaptations of echolocation and flight, but other aspects of bat ecology vary across species. In particular species can differ greatly in their habitat requirements and social behaviors, for example in whether they are colonial or solitary, hibernate or migrate, or require the establishment of maternity colonies for reproduction (Adams 2003). Bats are adapted to specialized habitats for roosting, hibernating, and breeding that almost without exception must be dark, within certain temperature and humidity parameters, and relatively free of human disturbance (Adams 2003).

White-nose syndrome (WNS) is a serious condition caused by the spread of a fungus through hibernating bat colonies, most often in caves (Foley et al. 2011, Maher et al. 2012). While not all bat species hibernate, WNS is nearly 100% fatal to all individuals in affected colonies. WNS was reported in Washington in 2016 (Haman et al. 2016), and the fungal pathogen found on individuals in 2017, however it is not clear whether the disease has infected any bat populations in the state (https://wdfw.wa.gov/species-habitats/diseases/bat-white-nose). Still, the means of contamination and a cure for WNS are not yet identified and many researchers anticipate further spread in coming years (http://whitenosesyndrome.org).

Rare and Endangered Species

Boreal (western) toads are federally listed as a Species of Concern as well as a Candidate for state listing as a Priority Species, due to well-documented declines throughout much of the Pacific Northwest. It was not found during the extensive amphibian surveys of Samora et al. (2013) during 2002–2003, but in 2005 was found at multiple locations elsewhere on Whidbey Island (Adamus et al. 2006).

All mammals present or potentially present in EBLA are presented in Table 4.7-2.

Table 4.7-2. Mammals documented or potentially present in EBLA. From various sources: (C – Confirmed; P – likely, PP – probably present).

Common Name	Scientific Name	NPSpecies
Vagrant shrew	*Sorex vagrans*	PP
Townsend's vole	*Microtus townsendii*	P
Creeping (Oregon) vole	*Microtus oregoni*	P
Deer mouse	*Peromyscus maniculatus*	P
Townsend's chipmunk	*Tamias townsendii*	PP
Eastern gray squirrel	*Sciurus carolinensis*	P
Douglas's squirrel	*Tamiasciurus douglasii*	PP
Norway rat[1]	*Rattus norvegicus*	PP
Vagrant (wandering) shrew	*Sorex vagrans*	PP
Eastern cottontail	*Sylvilagus floridanus*	PP
Columbia black-tailed (mule) deer	*Odocoileus hemionus*	P
Red fox	*Vulpes vulpes*	P

[1] Non-native

[2] Species of concern

Table 4.7-2 (continued). Mammals documented or potentially present in EBLA. From various sources: (C – Confirmed; P – likely, PP – probably present).

Common Name	Scientific Name	NPSpecies
River otter	*Lontra canadensis*	P
American beaver	*Castor canadensis*	P
American mink	*Mustela vison*	PP
Raccoon	*Procyon lotor*	PP
Coyote	*Canis latrans*	P
Bobcat	*Lynx rufus*	PP
Feral cat[1]	*Felis catus*	P
Muskrat	*Ondatra zibethicus*	PP
Steller's sea lion	*Eumetopias jubatus*	P
Big brown bat	*Eptesicus fuscus*	P
Silver-haired bat	*Lasionycteris noctivagans*	P
California myotis	*Myotis californicus*	P
Little brown bat	*M. lucifugus*	P
Long-eared myotis	*M. evotis*	PP
Hoary bat	*Lasiurus cinereus*	P
Keen's myotis	*M. keenii*	PP
Townsend's big-eared bat[2]	*Corynorhinus townsendii*	P

[1] Non-native

[2] Species of concern

Threats to Vertebrate Populations

Habitat Loss and Fragmentation

Habitat integrity includes not only the ability of a particular environment to support a specie's needs but also the connectivity between different areas that species may require throughout their life. The inability of individuals to travel due to incompatible land uses potentially reduces genetic diversity and abundance, and substantial research has demonstrated that the long-term viability of many species is significantly reduced when patchiness and fragmentation increase (Saunders et al. 1991, Fahrig and Merriam 1994, Crooks 2002, Rudnick et al. 2012). Habitat degradation can occur not only when habitat is converted to other uses but also when specific components of habitat are removed. For example, many necessary habitat elements for forest bat species such as roost sites in old-growth trees and undisturbed rock shelters and caves have been lost as a consequence of human activities and development (Hayes and Wiles 2013; Section 4.9).

Non-native Species

Non-native species such as bullfrogs, game fish, and black rats present strong competitive and predatory challenges to native species (Kiesecker et al. 2001). For example, most native amphibians are absent from Lake Pondilla, and based on research elsewhere in the Pacific Northwest (Adamus 2011), it is likely that non-native predatory smallmouth bass, which were introduced into that pond, are degrading the biodiversity of the lake (Schiphouwer et al. 2017).

4.7.2. Reference Conditions

Amphibians/Reptiles

As far as is known there is no information on population abundance or distribution for any amphibian or reptile species in the Reserve. Minimally there should be no reduction in species diversity on Reserve lands. Non-native species should be absent.

Mammals

A decline in small and medium-sized vertebrate abundance, or fundamental changes in diversity, could affect food webs and trophic interactions, but could also indicate alterations to the system from human impacts, for example the absence of native predators (Rowe et al. 2015). Measurable reductions in diversity over time would be cause for concern, but because small mammal species differ greatly in population dynamics and response to changing resource conditions, in the absence of regular monitoring many years would likely pass before ecologically relevant changes were noted (Moritz et al. 2008). Certainly, an increase in the populations of non-native mammals such as black rats or cats would be cause for concern.

Bats

There should be no indication of WNS for any species that hibernates in Washington and bats should continue to use EBLA habitats in patterns observed historically. Diversity should remain high.

4.7.3. Data and Methods

For all species the Washington State Department of Fish and Wildlife maintains a publicly-accessible spatial database of occurrences from the Priority Habitat and Species list (PHS; http://apps.wdfw.wa.gov/phsontheweb/).

Amphibians and Reptiles

Samora et al. (2013) conducted amphibian surveys at EBLA in 2002 at both Reserve sites and details and methods of those surveys are included in that document. Reptiles were not targeted by Samora et al. (2013) but were identified and recorded when found. The report noted that surveys were conducted when conditions may already have been too dry to detect some species (April 2002; Samora et al. 2013). That effort is now nearly 15 years old and as far as is known no follow-up surveys or monitoring have been conducted.

Mammals

As far as is known, no comprehensive surveys for land mammals or bats have been conducted either on Whidbey Island or within EBLA sites. A lack of credible and comprehensive faunal surveys, especially during the early years of island occupation by humans, makes it impossible to confirm the disappearance of many plants and animals formerly reported from the island or suspected to have occurred here based on the types of habitats they are known to associate with.

4.7.4. Resource Condition and Trend

Amphibians and Reptiles

Almost nothing can be stated with confidence regarding the status of amphibians within the Reserve, though western pond turtles and spotted frogs have apparently been extirpated (R. Milner, WDFW,

pers. comm. 2015). Very little is known regarding the status of western toads on the island or locations of critical breeding sites (The Watershed Company 2016) and they were not observed by Samora et al. (2013) though they are listed in NPSpecies. Bullfrogs are present at several locations across the island (Adamus et al. 2006, Samora et al. 2013) though it is not known whether they are present within EBLA specifically. Nearly nothing is known regarding the status of reptiles; alligator lizards are the only lizards on the island.

Terrestrial Mammals

Only three native small mammals are present in EBLA, two rodents (deer mice and Townsend's voles) and one insectivore (vagrant shrews). Voles are often considered pests by agricultural interests, but like gophers play important roles in maintaining healthy soils and supporting raptor populations among other ecosystem functions (Davidson et al. 2012). Mid-size mammal species that are adaptive to human presence such as raccoons and coyotes may be increasing in abundance, particularly where urban (human-based) and rural/agricultural resources are available (Mitchell et al. 2015). Riparian-associated species such as mink and beaver are present, but nothing is known regarding populations status.

Bats

Seven bat species have been confirmed from EBLA, but very little else is known regarding bat diversity or the status of rare species.

4.7.5. Level of Confidence

Confidence in this assessment is low. There are few data that describe the status of any community of vertebrates (other than birds), and nearly nothing is known regarding the population status of any native mammal species other than deer.

4.7.6. Data Gaps and Research Recommendations

- Island invasions by non-native vertebrates, particularly mammals, have resulted in numerous extirpations of native species on islands around the world (Clavero and García-Berthou 2005). More frequent monitoring of vertebrates at EBLA would provide early indications of any new species and allow time for response (Kurle et al. 2013).
- It would be helpful to managers and island-wide conservation efforts to know definitively whether western toads are present in the Reserve and if so to determine whether additional protective efforts should be taken.
- Species that are particularly in need of additional surveys are red-legged frogs, rough-skinned newts, western red-backed salamanders (Guderyahn et al. 2016) and sharp-tailed snakes.
- Surveys and monitoring are also needed for native mammals to assess possible responses to climate change and continued habitat alterations in and near the Reserve. In particular deer and small mammal populations should be monitored.
- Surveys and monitoring of bat species should be increased and supported.
- Additional reptile and amphibian surveys are needed in suitable habitats when detection probabilities are high (periods of the year when conditions facilitate surface activity). Species

that are particularly in need of additional surveys are red-legged frogs, rough-skinned newts, western red-backed salamanders (Guderyahn et al. 2016) and sharp-tailed snakes.

- The effects of prairie and oak woodland habitat restoration (generally, and specific practices such as burning and vegetation thinning) on amphibians and reptiles have not been monitored within the Reserve.

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4.8. Natural Night Skies and Natural Quiet

By Catherin Schwemm and Emma Brown

The condition of natural night skies is generally good in Reserve areas; sources of anthropogenic light are minimal outside of town centers. The condition may be improving given attention to this issue by local advocates; confidence is moderate.



The condition of natural quiet is poor. The presence of the Navy's Whidbey Island Complex and associated military aircraft operations creates an extremely loud environment throughout Reserve areas. The trend is declining, given Navy plans to expand operations; confidence is high.



4.8.1. Background

Natural Night Skies

The importance of maintaining natural cycles of light and dark at night has become a priority issue in national parks, and increasing attention is being paid by NPS and others to measuring as well as minimizing the impacts of anthropomorphic sources of light (Henderson et al. 1985, Schelz and Richman 2003, NPS 2006, Duriscoe et al. 2007). Prior to electricity the moon provided the only source of light at night, and organisms adapted their biology and behaviors to the light patterns of lunar cycles (Dodson 1990, Duriscoe et al. 2007). Now, anthropogenically-derived light at night comes from many sources, including direct light impacts (essentially all electrical sources), vehicles, and polarized light (light from human sources which is reflected back from the atmosphere; Horvath et al. 2009). Recent data indicate that over half of the land surface of the U.S. is affected by light-polluted night skies (Falchi et al. 2016).

Several descriptors are commonly used to describe the measures and effects of anthropomorphic light, and it is helpful to understand the differences between impacts to visitors as part of the Reserve experience, and ecological impacts (Smith and Hallo 2013). The phrase "light pollution" is normally regarded as a cultural concept and refers to the over-abundance of artificial light in human landscapes (Rogers and Sovick 2001, Sovick 2001). More specifically, the term "astronomical light pollution" describes the degree to which light affects humans' ability to see stars and other objects in the night sky (Longcore and Rich 2004).

Ecological light pollution (ELP) refers instead to the effects of unnatural nighttime light on biological communities (Rich and Longcore 2005). Ecological light pollution has been shown to have numerous direct negative effects on many living organisms, including plant populations (Lewanzik and Voigt 2014), insects (Geffen et al. 2014, Perkin et al. 2014), intertidal invertebrates (Luarte et al. 2016), birds (songbirds, owls, shorebirds, seabirds; Kempenaers et al. 2010, Rodriguez et al. 2012, McLaren et al. 2018), amphibians (Perry et al. 2008), rodents, bats (Stone et al. 2009),

snakes, marine organisms, and primates (Le Tallec et al. 2013; see Gaston et al. 2013 and Davies et al. 2013 for reviews). The presence of artificial light at night can result in increased predation, reduced productivity, direct mortality, and reduced time for nocturnal foraging (Longcore and Rich 2004, Duriscoe et al. 2007, Gaston and Bennie 2014). In the Puget Sound, artificial lighting has been shown to increase predation pressures by larger fish on juvenile salmon and forage fish species (PSEMP 2016).

Natural Quiet

Acoustic resources are generally defined as both natural sounds (e.g. wind, water, wildlife, weather), and cultural and historic sounds (e.g. battle reenactments, tribal ceremonies, quiet). The quality of the acoustic environment in an area is measured in terms of frequency and amplitude (decibels; Ambrose and Burson 2004). Because national parks are often (perhaps wistfully) considered "islands" of quiet (Miller 2008, Lynch et al. 2011, Buxton et al. 2017), NPS has been working for several decades to establish baseline conditions and develop measuring and monitoring methods for soundscapes in national parks (Miller et al. 2008). Similar to the topic of light pollution, however, soundscapes have primarily been addressed as a cultural resource in relation to visitor experiences (Rogers and Sovick 2001, Sovick 2001, Miller 2008, Lynch et al. 2011) with relatively little attention given to potential ecological and landscape-scale impacts (Barber et al. 2011, Buxton et al. 2017).

Soundscape ecology is an emerging field of study that attempts to connect ecological processes with human and natural sounds at landscape scales (Dumyahm and Pijanowski 2011b, Pijanowski et al. 2011, Truax and Barrett 2011). When evaluated ecologically, the impacts of anthropogenic sounds are most commonly considered in terms of effects on wildlife and biodiversity (Francis et al. 2017). Not surprisingly impacts have been shown to be greatest on groups and species that most utilize sound in their habits and communication (Francis and Barber 2013). (Marine studies are abundant, but herein only terrestrial systems will be discussed).

For example, studies have demonstrated the negative impacts of noise on birds (Dooling and Popper 2007, Slabbekoorn and Ripmeester 2008, Francis et al. 2011), bats (Schaub et al. 2008, Bunkley et al. 2015), rodents (Shier et al. 2012), frogs (Barber et al. 2010a, Bee and Swanson 2007), invertebrates (Morley et al. 2014) and even plants (Francis et al. 2012). Prey species are particularly sensitive to human noise because sounds can both mimic predator movements and mask them (Landon et al. 2003, Chan et al. 2010, Brown et al. 2012). Some species are able to adapt to long-term additions of noise in their environment, but others are not (Barber et al. 2010b). Impacts at individual and population scales can further translate up to ecosystem and process levels (Slabbekoorn and Halfwerk 2009).

Navy Aircraft Operations

The US Navy's (USN) Outlying Landing Field at Coupeville (OLF-C) and Ault Field (together known as the "Whidbey Island Complex") are both located on Whidbey Island with OLF-C located within the Reserve. These facilities are used by USN primarily to train pilots in simulated aircraft carrier landings. The main aircraft used are known as "Growlers" (https://www.naval-technology.com/projects/ea-18g-growler), highly advanced attack aircraft that, in layman's terms, are

very, very loud (https://www.doh.wa.gov/Portals/1/Documents/4000/DOH_DEIS_Comments.pdf). Take-offs and landings are conducted at night as well as during the day.

Most recently the Navy has incorporated new types of Growlers that are even louder and proposes to add 36 aircraft to the Whidbey Island Complex (USN 2018). The Navy further proposes an enormous increase in the number of annual aircraft operations (each take-off or landing is one operation); Ault Field would support 88,000 total operations/year (an increase of 9,800), and OLF-C would support 24,100 operations/year (an increase of 17,590 operations; http://www.whidbeyeis.com/ProposedAction.aspx).

The impacts of aircraft noise in relation to USN operations on Whidbey Island have been the focus of ongoing controversy for many years, with USN supporters and local island advocates often in strong disagreement (http://www.knkx.org/post/navy-growler-noise-spurring-community-action-beyond-whidbey-island). In 2014 the NPS commented on the impacts of USN operations on National Park sites in the Pacific Northwest (www.citizensofebeysreserve.com/Files/NPS%20EIS%20letter%20Nov%20%202014.pdf), and conducted monitoring (Pipkin 2016), which characterized jet noise as high as 177 dBA, making the Reserve one of the loudest units in the NPS system.

4.8.2. Reference Conditions

Natural Night Skies

The NPS has developed a system for measuring sky brightness to quantify the source and severity of light pollution, however, these measurements relate to human perception only. NPS is in the process of determining what the night sky reference values should be, thus ecologically the reference condition on Reserve lands should be the absence of artificial light at night that negatively affects organisms and natural processes.

Natural Quiet

National Park Service policies direct that the absence of anthropogenic noise ("natural ambient sound level") be the baseline against which impacts are measured (NPS 2006, Lynch et al. 2011). Research on soundscapes has further suggested that due to the complex nature of sounds, conditions for wildlife at multiple spatial and temporal scales must also be considered, for example how often is it quiet or noisy, and how far away can specific sounds be heard or sensed? (Barber et al. 2011, Dumyahn and Pijanowski 2011a and b).

Sound is measured in several ways, though the most common metric is Sound Pressure Level (SPL) as measured in decibels using the A-weighted scale (dBA; https://www.doh.wa.gov/Portals/1/Documents/4000/DOH_DEIS_Comments.pdf. Pipkin (2016) provides a general range of sound levels that humans experience, and a literature review includes numerous citations of documented sound pressure levels that impact wildlife (Shannon et al. 2016; Table 4.8-1). However, wildlife often perceive sound much differently than humans, and impacts may be much greater on animals and require alternative assessment methods (Pater et al. 2009, Barber et al. 2011, Keyel et al. 2017). Given the relative absence of information on the effects of

noise on wildlife, measurements of anything over natural sounds may be considered undesirable (Shannon et al. 2016) (Figure 4.8-1).

Table 4.8-1. Examples of human and wildlife effects at discrete sound levels. From Pipkin (2016) and Shannon et al. (2016); references provided in each.

dB*	Effect
35	• blood pressure and heart rate increase in sleeping humans • desired background sound level in classrooms
45	• WHO recommendation for maximum noise level inside bedrooms • decline in bird species diversity
52	• speech interference for interpretive programs • increase in amplitude of some bird vocalizations
58	• decline in reproductive success of some birds
60	• speech interruption for normal conversation
72–74	• alterations in chorus behavior of male frogs • changes in spatial movement patterns by mammals
80	• shifts in call frequency for bats • increase in psychological stress for mammals from construction noise
95–160	• increase in stress hormones for fish and mammals • changes in spatial movements of fish • changes in vocalization behavior for mammals

* Variable measures of sound pressure.

4.8.3. Data and Methods

Natural Night Skies

The measurement system utilized by NPS, developed with the assistance from professional astronomers and the International Dark-Sky Association, utilizes a research-grade digital camera to capture the entire sky with a series of images (Duriscoe 2013). Sky brightness is measured in astronomical magnitudes in the V-band, abbreviated as “mags.” The V-band measures mostly green light, omitting purple through ultraviolet and orange through infrared. The magnitude scale is a logarithmic scale: a difference of 5 magnitudes corresponds to a 100x difference in brightness. Lower values (smaller or more negative) are brighter.

In cases where on-site measurements have not been collected, NPS uses modeling tools derived from satellite imagery to determine night sky conditions (Duriscoe 2013). In these modeling scenarios, the primary metric used to assess night sky condition is the all-sky light pollution ratio (ALR). The ALR is the average anthropogenic sky luminance presented as a ratio over natural conditions. One limitation of this method is that it generally does not capture horizontal light trespass from adjacent sources of light pollution. Horizontal trespass is light that falls upon a horizontal surface, such as level ground, in areas where light is not wanted. Horizontal trespass is accounted for in this assessment qualitatively by noting the upward radiance (upward traveling light) of nearby potential

light sources under the assumptions that 1) upward radiance at the source correlates to the maximum potential brightness of horizontal trespass, and 2) the brightness of horizontal trespass from a single source diminishes with distance approximately proportionally to the change in upward radiance with distance from that source.

Natural Quiet

Sound levels are measured in two ways. The "deviation from natural ambient" measures the difference between the average sound level (for all sound) and the natural ambient condition (the absence of human sounds). The "maximum sound level" is the loudest sound level generated during a noise event. As far as is known no studies have been conducted on Whidbey Island in relation to noise impacts on wildlife.

Pipkin (2016) conducted site-specific acoustic inventories in EBLA, using methods described in Lynch et al. (2011). Two sites were monitored: site EBLA001 is directly below the flight path at OLF-C, while EBLA002 is somewhat further away and adjacent to Ebey's Landing but might also have impacts from Ault Field to the north; sampling methods are included in that report. Included in the EIS for the Whidbey Complex expansion is an Aircraft Noise Study (Appendix A *in* USN 2018). The methods are complex and are described in that report, but importantly the results were obtained via modelling rather than on-the-ground measurements. Previously USN had commissioned a study which measured A-weighted sound pressure level at five points across southern Whidbey Island (Mann 2013). An excellent description and comparison of all three efforts is provided in "A Summary of the Association Between Noise and Health" published by the state of Washington (https://www.doh.wa.gov/Portals/1/Documents/4000/DOH_DEIS_Comments.pdf).

4.8.4. Resource Condition

Natural Night Skies

No measurements of night sky brightness have been collected in EBLA. In 2003, Island County passed a lighting ordinance to preserve the qualities of the island's night sky resources, and advocates continue to work with local agencies to incorporate lighting systems that are less intrusive (e.g. http://www.southwhidbeyrecord.com/news/dark-sky-advocates-aim-to-dim-whidbeys-lights/). In particular Camp Casey is regionally recognized as an important location for stargazing and celestial study due to the consistent dark night sky conditions at the site.

To assess night sky condition in terms of all-sky light pollution ratio (ALR), anthropogenic light was extracted from calibrated VIIRS (Visible Infrared Imaging Radiometer Suite) data. Natural light was determined by simulation model (Duriscoe 2013). The modeled mean all-sky light pollution ratio in EBLA is 1.62, meaning that existing conditions are 162 % brighter than natural levels (Figure 4.8-1).

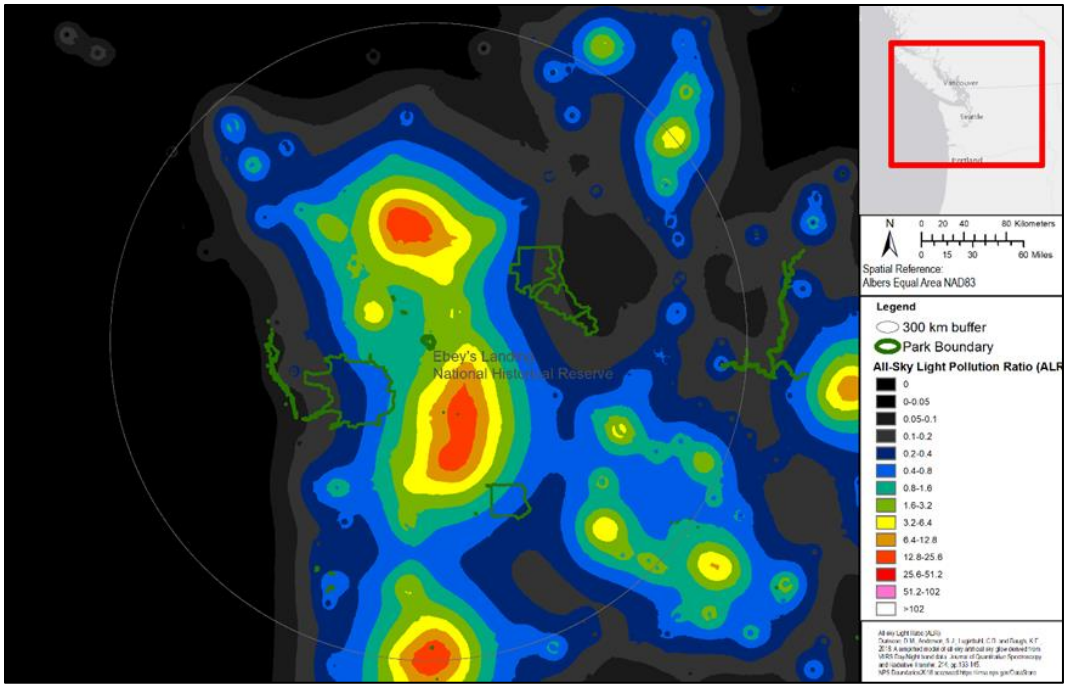


Figure 4.8-1. All-sky average anthropogenic to natural sky brightness ratio at Ebey's Landing National Historical Reserve and surrounding lands, with 300 km buffer, the distance at which stray light from urban environments has been documented in national parks. Mean ALR in the Reserve is about 1.62, meaning existing conditions are about 162% brighter than natural levels (Duriscoe 2013).

Natural Quiet

Though there are sources of anthropogenic noise that are apparent in Reserve areas (e.g. jet skis are occasionally present in Penn Cove, noises emanate from the ferry landing at Fort Casey, and farm and maintenance equipment and vehicle traffic are detectable), by far the greatest negative impact on natural quiet emanates from the OLF-C. Mann (2013) found maximum A-weighted sound pressure levels of 81–119 dB at the five sites sampled. Pipkin (2016) recorded the percent of time at each site that sound levels reached several of the sound levels described in Table 4.8-1 (Table 4.8-2). Pipkin (2016) also recorded several extremely loud "acoustic events" (up to 113 dB, $LA_{max\ event}$) at the site closest to OLF-C (EBLA001). The $LA_{90,\ 12\ hr}$ sound level (which is a reasonable estimate of prevailing background sound level per ANSI/ASA S12.18) at EBLA001 was 32.9 dB for daytime and 30.5 dB for nighttime. The $LA_{90,\ 12\ hr}$ sound level at EBLA002 was 35.5 dB for daytime and 35.7 dB for nighttime. At a larger scale, a prior study estimated that over half of the island was within the 60–65 dBA noise corridor (IC 2016).

Table 4.8-2. Percent time above sound pressure levels from the monitoring period represented in a truncated (T) frequency range and the full measured frequency range. 20–1250 Hz represents sound frequencies produced by transportation, including aircraft, while 12.5–20,000 Hz are all other sounds (From Pipkin 2016).

Site	Frequency (Hz)	Time above sound level (% of daytime hours, 07:00–19:00)				Time above sound level (% of nighttime hours, 19:00–07:00)			
		35 dB*	45 dB*	52 dB*	60 dB*	35 dB*	45 dB*	52 dB*	60 dB*
EBLA001 (max. 113 dBA)	20–1250 (aircraft)	53.79	8.26	1.85	0.37	36.87	3.85	0.71	0.07
	12.5–20,000	73.96	12.2	2.57	0.43	57.32	8.96	1.83	0.13
EBLA002 (max. 117 dBA)	20–1250 (aircraft)	75.51	7.85	1.98	0.38	62.11	2.69	0.32	0.03
	12.5–20,000	90.8	17.99	4.00	0.55	77.52	11.45	2.43	0.34

* dB re 20 μPa

Among other findings, the Navy's modeling study concluded that on average under Alternative 2 (the preferred alternative) an additional 15% of the human population (within the sample area) would be exposed to ≥ 65 dBA, and many locations ("Points of Interest" – POI) would experience increases of 1–2 events per hour when recreational speech would be interfered by aircraft noise (Appendix A, USN 2018). Several direct conclusions from the EIS (USN 2018) are:

1) "The Proposed Action [Alternative 2] … would have a significant impact on the noise environment as it relates to aircraft operations at Ault Field and OLF Coupeville. There would be an increase in population within the 65 dB DNL [day-night average sound level with nighttime sounds weighted higher] noise contour under all alternatives and scenarios. More specifically…Alternative 2 would result in an increase of up to 15.8 percent…of the total population [within in the 65 dB DNL] surrounding the two airfields." (p. 5–17, USN 2018).
2) "In addition, the population that may be vulnerable to permanent hearing loss increased under the Proposed Action, with more of an impact on the populations surrounding Ault Field." (p. 5–17, USN 2018)
3) "Overall, implementation of the Proposed Action at NAS Whidbey Island would result in localized significant impacts to recreation at Ebey's Landing National Historical Reserve, various county and municipal parks and recreational areas, and private recreational facilities under some alternatives and scenarios, as a result of increased noise exposure… Proposed Action would directly affect recreation management in the study area as a result of long-term changes in noise exposure that would affect the recreational experiences of visitors when aircraft are operating in the area." (p. 5–22, USN 2018)

4.8.5. Level of Confidence

Moderate for natural night skies; High for natural quiet

4.8.6. Data Gaps and Research Recommendations

- More monitoring of anthropogenic light is needed to determine trends.

- A lighting plan for the Reserve should be developed, and dark night sky goals incorporated in Reserve planning documents.
- Ongoing noise monitoring at Reserve sites would provide important information on current conditions and trends

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4.9. Habitat Connectivity and Land Use

By Catherin Schwemm and Peter Dunwiddie

Land conservation efforts have the potential to reduce negative impacts on natural resources of adjacent land use. Habitat connectivity is of moderate concern given multiple land uses occurring in the Reserve that hinder animal movement, but trends appear to be stable or improving with ongoing land acquisition and habitat enhancement efforts. Confidence is moderate.



4.9.1. Background

Habitat connectivity is the potential for a landscape to support the movement of individual animals between areas that provide necessary resources (Beier 1993, Crooks 2002, Berger 2004). Connectivity is reduced and habitats are fragmented when human-created barriers exist that limit individual dispersal and migration and hinder propagule (e.g. seed) transport (Beier 1993, Fahrig and Merriam 1994, Crooks 2002, Hanski 2011). A reduction in available habitat eliminates resources necessary for the survival of individuals (e.g. Beier 1993), while the loss (actual or virtual) of connectivity between habitats has additional and often greater long-term negative effects on population sustainability (Saunders et al. 1991, Fahrig and Merriam 1994, Berger 2004, Krauss et al. 2010), even for flying organisms such as insects, birds, and bats (Tremblay and St Clair 2011, Frey-Ehrenbold et al. 2013). Habitat can also be functionally fragmented if physical or virtual obstacles prevent the transfer of genetic material, as when pollinators are extirpated (Hadley and Betts 2012, Rudnick et al. 2012, Newman et al. 2013).

A prevalent impact to ecological connectivity is incompatible land use that eliminates or degrades habitat connections for native species (Hansen and DeFries 2007, Rudnick et al. 2012, Bauer and Swallow 2013, Hansen et al 2014). Though the presence of land uses within EBLA that preserve the cultural landscape are highly valued (NPS 2006, IC 2016), both direct (habitat loss) and indirect (predator control, pesticide use, water diversions, introduction of invasive species) effects of agricultural practices in particular have high potential to reduce habitat and impair connectivity (McLaughlin and Mineau 1995, Duelli and Obrist 2003, Hole et al. 2005, Potts et al. 2010).

Roads

The presence of roads in and near natural areas is a primary contributor to habitat fragmentation and loss of overall ecosystem integrity (Trombulak and Frissell 2000, Rudnick et al. 2012, Dietz et al. 2013, Riley et al. 2014). Roads and associated vehicle traffic affect ecological interactions through direct impacts (animal mortality), and indirectly via increased noise, the introduction of toxic materials and non-native species, and multiple impacts from human disturbance on animal behavior (Mader 1984, Tyser and Worley 1992, Benitez-Lopez et al. 2010, Dietz et al. 2013, Kitzes and Merenlender 2014). Road influence can extend tens to hundreds of meters from the road surface (Riiters and Wickham 2003). At larger scales these impacts accumulate, changing and redefining habitat landscapes (Hawbaker et al. 2006).

4.9.2. Reference Conditions

Given that large mammals are largely absent or extirpated from Whidbey Island (Bennett 1990, Noss 1991, Atobe et al. 2014, Lechner et al. 2015), connectivity concerns for NPS at EBLA are primarily related to birds, small vertebrates, amphibians and plants. Because habitat connectivity and impacts of adjacent land use are species and process specific, there are no common reference conditions for all resources of interest in the EBLA region (Rudnick et al. 2012). Ideally there would be no impacts on resources from outside land uses or barriers to dispersal and genetic transfer for any native species.

4.9.3. Data and Methods

Because very little is known regarding dispersal and habitat needs of any native species in the Reserve, sources such as vegetation maps and remotely sensed data can be utilized to indicate likely movement corridors. For example, inferences for suitable habitat for species of concern can be made from the recent vegetation map produced by Copass and Ramm-Granberg (2016), and the Whidbey-Camano Land Trust (WCLT) has mapped habitat fragmentation and corridors throughout the county (WCLT 2018). Land cover trends were inferred from Rottle (2003) who looked at changes from 1983–2000, and other source data as referenced. An important assessment of existing fish and wildlife habitat areas was prepared for Island County in 2014 (Watershed Company and Parametrix 2014).

4.9.4. Resource Condition

For purposes of reference to many County documents, the area included in EBLA (described in Chapter 2) will generally coincide with “Central Whidbey” terminology.

Land Use

Currently over half of the Reserve is classified as cultural or unvegetated landcover, including areas comprised of nearly equal amounts of housing and agriculture (Copass and Ramm-Granberg 2016; Figure 4.9-1). Copass and Ramm-Granberg (2016) found the Reserve to be nearly 60% cultural or unvegetated (approx. 8,550 ac/3,460 ha), allocated by pastures and agricultural fields (~55%), low density housing (~25%) and high-density housing (~20%).

Visual examination of historic and current aerial photographs indicate that the amount of land used for agriculture has changed little in the last century (Figure 4.9-1), though recent Federal Census of Agriculture data show that the amount of land dedicated to farming in Island County overall decreased by 19 percent between 1992 and 1997. Since 1978, the total number of farms (countywide) has increased slightly from 244 to 262, though the number of full-time farms decreased by eight percent from 122 farms in 1992 to 112 farms in 1997. Since 1978, the average farm size has also continued to decrease from an average of 89 ac per farm to 61 ac. There appears to have been comparatively little additional loss of native herbaceous vegetation within the Reserve in recent years, and lands converted to development have come largely from agriculture and managed forests (USDA 1997).

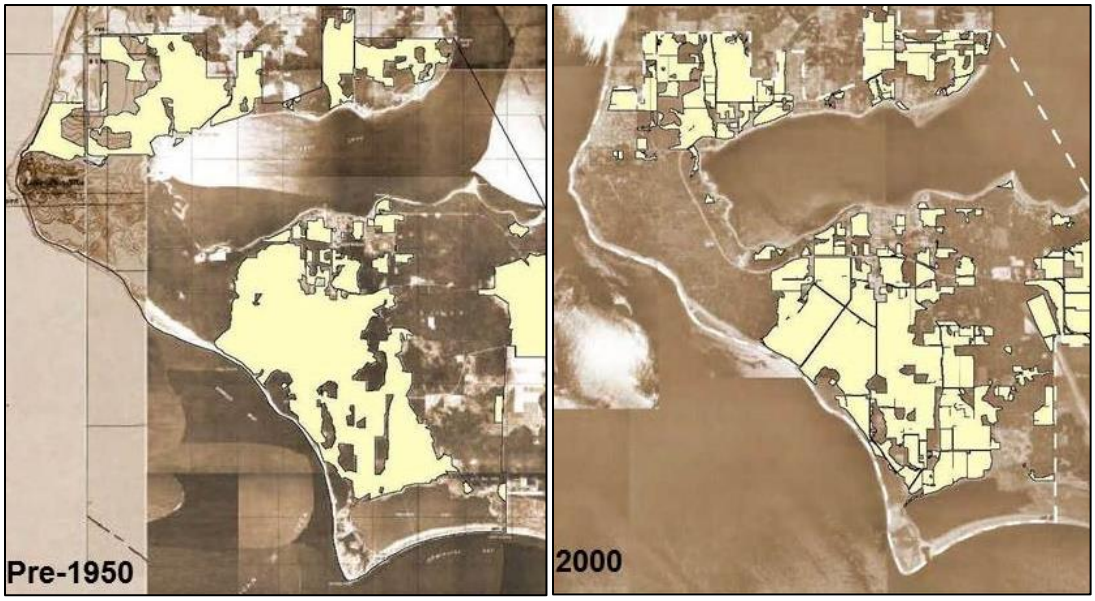


Figure 4.9-1. Land use of "agriculture" as mapped from aerial photography in 1941 (left) and in 2000 (right) (Adapted from Rottle 2003, figure 8a).

In a land cover trend analysis spanning 1983–2000, Rottle (2003) reported several observations including:

- Agricultural lands, especially pastures, were converted to both residential subdivisions (41% increase in urban areas and residential subdivisions) and dispersed rural residential development;
- There was a 44% increase in the number of structures (an indicator of development impact including dispersed rural);
- There was a slight decline in forested area (2%);
- There was an increase (11%) in unmanaged grasslands (former pastures and croplands set aside as conservation lands or abandoned)

Open Space and Natural Areas

Most non-agricultural open space in the Reserve exists along the western and southern shores though some additional development on the island is likely in coming years, Island County planners and citizens appear to be in favor of increased land protection for sensitive areas. The 2016 Comprehensive Plan Update (IC 2016) identifies "wetlands," "areas with a critical recharging effect on aquifers used for potable water," and "fish and wildlife habitat conservation areas" as Critical Areas. Critical Areas are defined as those that "…possess certain development limitations, or that provide important public resources," though the document also states that, "… a property owner cannot be deprived of a reasonable use and the enjoyment of lands on which critical areas and their associated buffers, if any, are located."

Adjacent Land Use

The County stresses a desire to maintain a rural culture (IC 2016), as per its commitment to support the Reserve idea, though this expectation is somewhat in contrast to the planned expansion of the

USN Whidbey Complex and significant increases in military aircraft operations (Section 4.8). As stated in the most recent County planning document (IC 2016), "Island County faces a dual challenge of balancing the demands of population growth while protecting rural character." That said, the same document (IC 2016) states that the protection of natural resources should be a priority in coming decades:

"*Natural resource systems should be conserved and preserved in recognition of the irreplaceable character of such resources, and of their importance to the quality of life of residents, visitors, and the future generations of Island County. Provisions should be made for natural resources to meet human needs throughout the County in order to protect them and enhance enjoyment and appreciation of the environment*."

Habitat Connectivity

Very little is known regarding the quality of habitat and the impacts of movement barriers for terrestrial species that inhabit the Reserve (Section 4.7). The WCLT has identified lands that are of high priority for connecting existing areas that provide habitat (WCLT 2018), though as far as is known no studies have been done that investigate the impacts of land protection alternatives on wildlife species. Private lands identified by the WCLT inside and adjacent to the Reserve that would enhance habitat quality and connectivity if protected from development include existing farmland in Monroe Landing and the Reserve, Smith Prairie and Crockett Lake.

Traffic on State Route 20—the main highway through the Reserve—averages approximately 8,000 daily trips/year, and that number has increased only slightly since 1994 (TranspoGroup 2015). Still, the Washington Department of Transportation (WDOT) reports that this highway has one of the highest rates of deer collisions in the state (https://www.wsdot.wa.gov/environment/protecting/wildlife-collisions#Areas%20of%20the%20state). As far as is known no new primary roads are planned for Central Whidbey (TranspoGroup 2015, IC 2016).

4.9.5. Level of Confidence

Moderate

4.9.6. Data Gaps and Research Recommendations: Connectivity

- Wildlife corridors can lessen fragmentation impacts on wildlife, particularly in urban areas, as can management practices that leave hedgerows or other relicts of the original vegetation structure in agricultural fields. Continued participation by NPS managers with ongoing planning efforts within Island County would help facilitate the protection of areas that connect habitat patches with corridors of vegetation outside of areas already set aside as natural preserves.
- The completion of an Ebey's Landing Land Protection Plan, as was proposed in the Reserve's General Management Plan (NPS 2006), would serve to help the Reserve Trust Board, State and local partners, and non-profit organizations such as the Whidbey-Camano Land Trust protect as much land as possible in perpetuity as habitat and open space.

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Chapter 5. Discussion

By Catherin Schwemm and Paul Adamus

This assessment serves as a review and summary of available data and literature for focal natural resources in Ebey's Landing Reserve, providing a partial baseline against which future conditions may be compared. Table 5.1 summarizes the condition, trend, and level of confidence in the assessment for each resource addressed.

The two resources that were determined to be in poor condition—climate and soundscape—also both appear to be experiencing a downward trend. Unfortunately, these are each resources affected at global and large regional scales and there is little NPS can do in the short term to alter these trends; climate change is a global process that will require attention at the level of national governments, and the impacts of Navy operations on natural quiet are well known and are being debated throughout the San Juan islands. In regard to these resources it is the authors' recommendation that NPS increase efforts to monitor the condition of natural resources of concern and communicate to partners and stakeholders any observed impacts of climate change and intense aircraft noise on natural systems within EBLA.

NPS may wish to pay particular attention to the focal resources assessed in this report—freshwater resources, wetland and nearshore vegetation, upland vegetation, and vertebrates—where the condition has been assessed as moderate but with medium to low confidence and where there is no indication of trends due to the absence of information.

Table 5.1. Summary of Resources, Indicators, and graphic representations of Condition and Trend evaluated for EBLA and placed within the NPS Ecological Monitoring Framework (Fancy et al. 2005). See individual sections of Chapter 4 for discussion of the methods and data used for each determination.

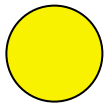
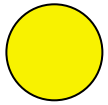
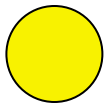
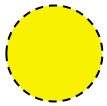
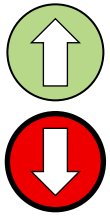
EBLA Resource	Assessment	Rationale
Air Quality (Section 4.1)		Air quality is not monitored at EBLA, but data from regional sites indicates air quality is generally good though visibility is of concern. No trends are apparent, and confidence is low.
Climate (4.2)		Given that the climate is changing rapidly from conditions to which organisms and biological systems have adapted, the condition of this resource is poor. The trend is increased diversion from natural conditions. Confidence in the assessment that climate conditions are changing is high, while confidence of the direction of change of individual climate elements (e.g., seasonal rainfall) is moderate.
Freshwater Resources (4.3)		The extent of wetlands has declined substantially from historical conditions but appears stable. Surface water quality is of concern but is well-monitored. Groundwater quality is of serious concern, though water management programs are ongoing and actively working to improve conditions. Groundwater quantities appear sufficient for now, though supplies are limited and climate change (reductions in rainfall), and increased demands are concerns. Confidence is moderate.
Wetland and Nearshore Vegetation (4.4)		The condition of wetland vegetation communities is of concern due to the presence of non-native species and limited habitat. No trends for freshwater wetlands, brackish lagoons or dune communities are apparent from the limited data. Seagrass appears to be stable or increasing around Whidbey Island; kelp populations appear stable. Confidence is moderate.
Upland Vegetation (4.5)		Native prairie communities are at risk, though recent restoration efforts have improved prairie condition. Forest condition is somewhat concerning given the impacts that climate change may have on survival and health of several tree species. The overall trend for the condition of endangered golden paintbrush populations is good; little is known about other rare species and concern is warranted. Confidence is moderate.
Birds (4.6)		Bird diversity in the Reserve is high, with several areas such as Crockett Lake providing important resources. Little is known regarding population trends for the majority of species, though most species of concern appear to be stable. Caution is warranted for forest and prairie-dependent species and seabirds. Threats include non-native species, disease, and ocean-related effects of climate change. Confidence is moderate to high given the presence of many bird enthusiasts on the island that maintain sighting records.
Vertebrates (4.7)		Almost nothing is known regarding terrestrial vertebrates in EBLA. Several species are known to be extirpated; native species that may be increasing are those tolerant of human presence (deer, raccoon, coyote). Very little is known regarding several rare amphibians. Confidence is low.

Table 5.1 (continued). Summary of Resources, Indicators, and graphic representations of Condition and Trend evaluated for EBLA and placed within the NPS Ecological Monitoring Framework (Fancy et al. 2005). See individual sections of Chapter 4 for discussion of the methods and data used for each determination.

EBLA Resource	Assessment	Rationale
Natural Night Skies and Natural Quiet (4.8)		The conditions of these two resources are quite different and require separate assessments. The condition of natural night skies is generally good in Reserve areas; sources of anthropogenic light are minimal outside of town centers. The condition may be improving given attention to this issue by local advocates; confidence is moderate. The condition of natural quiet is poor. The presence of the Outlying Landing Field Coupeville and associated military aircraft operations creates a loud environment throughout Reserve areas. The trend is declining, given Navy plans to expand operations. Confidence is high.
Land Use (4.9)		Land conservation efforts have the potential to reduce negative impacts on natural resources of adjacent land use. Habitat connectivity is of moderate concern given multiple land uses occurring in the Reserve that hinder animal movement, but trends appear to be stable or improving with ongoing land acquisition and habitat enhancement efforts. Confidence is moderate.

5.1. Water Resources

Surface waters and wetlands were likely more extensive than at present, and restoration of some sites would likely increase biodiversity, particularly for birds, vegetation, and invertebrates. Water quality, particularly in relation to nitrates, saltwater intrusion, and PFOS, has been an ongoing concern on the island; increasing water quality monitoring and determining point sources would allow NPS and partners to better address ways to improve water quality. Groundwater quantity may be a future concern; island-wide partnerships that include NPS will likely be needed to conserve groundwater resources.

5.2. Wetland, Nearshore and Upland Vegetation

Continued work with partners, particularly Washington State Parks, could reduce the impacts of visitors and recreational activities on native plants, particularly in dune and coastal bluff areas that are highly visited. Efforts to remove invasive plants have been successful in several areas, but continued attention to this threat is necessary to protect native species and natural sites. The protection of native prairie communities is a priority throughout the region, and EBLA could provide optimal opportunities to address several outstanding research questions and management needs:

- The development of a fire management plan would encourage NPS and partners to conduct an island-wide assessment of current prairie conditions regarding wildfire and the use of fire as a restoration tool;
- Additional research is needed on the effects of management tools such as fire and herbicides on prairie-dependent invertebrate and vertebrate wildlife species, particularly island marble butterflies;
- The nature of the island landscape, where natural sites mix across the island with developed and agricultural patches, likely benefits some species while limiting habitat for others. Further research on metapopulation dynamics and connectivity, particularly for rare species, should be encouraged.

5.3. Vertebrates

The island potentially has a rich faunal resource, and the protected lands within the Reserve boundary likely support a diversity of species. Unfortunately, very little is known about several important groups, in particular amphibians, bats, and small and medium sized terrestrial mammals. Future impacts from climate change, habitat loss, disease, competition with non-native species, and other factors will likely go mostly undetected without a greater understanding of the current status and condition of vertebrate populations. These efforts will almost certainly be most successful if undertaken in partnership with partner agencies and organizations across the island.

Appendix 1. Wetland plants recorded from EBLA

Table A.1-1. Adamus et al. 2006.

Scientific Name	Common Name	No. of Occurrences[1]	% of Occurrence[1]	X/5 wetlands where found 2005[2]
Agrostis stolonifera (alba)	Creeping bentgrass	46	7.8	2
Alnus rubra	Red alder	–	–	2
Anthoxanthum odoratum	Sweet vernal grass	–	–	1
Atriplex patula	Spear saltbush	–	–	1
Cirsium arvense	Canada thistle	3	0.5	3
C. vulgare	Bull thistle	–	–	4
Conioselinum pacificum	Pacific Hemlock Parsley	72	12.2	2
Cornus sericea	Redstem dogwood	15	2.5	–
Distichlis spicata (stricta)	Saltgrass	–	–	2
Eleocharis pachycarpa	Black sand spikerush	82	13.9	2
E. palustris	Common spikerush	–	–	2
Epilobium ciliatum (watsonii)	Fringed willowherb	–	–	2
Equisetum arvense	Horsetail	–	–	2
Festuca rubra	Red fescue	–	–	2
Galium trifidum (cymosum)	Pacific bedstraw	2	0.3	1
Geum macrophyllum	Large-leaf avens	–	–	1
Grindelia integrifolia	Puget Sound gumweed	–	–	1
Holcus lanatus	Common velvetgrass	–	–	4
Ilex aquifolium	English holly	–	–	1
Juncus balticus (arcticus)	Baltic rush	–	–	2
J. effusus	Soft Rush	97	16.4	1
Lonicera involucrata	Twin berry honeysuckle	–	–	1
Malus (Pyrus) fusca	Oregon crabapple	–	–	1
Mentha arvensis (canadensis)	Corn (wild, field) mint	–	–	1
Nuphar lutea (polysepala)	Yellow pond lily	–	–	1
Oenanthe sarmentosa	Water parsley	–	–	1
Phalaris arundinacea	Reed canary grass	13	2.2	1
Plantago lanceolata	Narrowleaf plantain	–	–	2
P. maritima	Seaside plantain	–	–	1
Potentilla anserina	Silverweed	37	6.3	4
Ricciocarpus natans	Purple-fringed riccia (liverwort)	–	–	1

[1] One-day surveys during one of the years, 2007–2013 in four wetlands in EBLA conducted by Island County staff; total survey included 15 transects with 590 sample points.

[2] These data do not necessarily represent a comprehensive inventory within each wetland. See shapefiles provided with this report for locations of these wetlands.

Table A.1-1 (continued). Adamus et al. 2006.

Scientific Name	Common Name	No. of Occurrences[1]	% of Occurrence[1]	X/5 wetlands where found 2005[2]
Rosa nutkana	Nootka rose	–	–	**1**
Rubus discolor	Himalayan blackberry	2	0.3	–
R. leucodermis	Blackcap	22	3.7	–
R. spectabilis	Salmonberry	–	–	2
R. ursinus	Blackberry	–	–	2
Rumex crispus	Curley dock	5	0.9	3
R. obtusifolius	Bitter dock	–	–	2
Salix scouleriana	Scouler willow	18	3.1	1
S. sitchensis	Sitka willow	–	–	1
Salicornia depressa (virginica)	Virginia glasswort	–	–	2
Sambucus racemosa	Red elderberry	–	–	2
Schoenoplectus acutus	Hard-stem bullrush	–	–	2
Scirpus tabernaemontanii	Softstem bulrush	66	11.2	–
Solanum dulcamara	Bitter nightshade	46	7.8	1
Sparganium eurycarpum	Giant burreed	56	9.5	–
Symphoricarpos albus	Common snowberry	–	–	1
Trifolium repens	White clover	–	–	1
Triglochin maritima	Seaside arrowgrass	–	–	1
Typha latifolia	Cattail	–	–	3
Urtica dioica	Stinging nettle	4	0.7	1
Veronica americana	American speedwell	–	–	1

[1] One-day surveys during one of the years, 2007–2013 in four wetlands in EBLA conducted by Island County staff; total survey included 15 transects with 590 sample points.

[2] These data do not necessarily represent a comprehensive inventory within each wetland. See shapefiles provided with this report for locations of these wetlands.

Appendix 2. Birds Known or Likely Present in EBLA.

Tables A2-1 through A2-4 include NPSpecies, eBird to 3/4/18 for "Ebey's Landing NHP-Pacific Rim Institute", "Fort Ebey State Park", "Ebey's Landing NHP – Fort Ebey – Gun Battery" and "Fort Casey State Park." The Reserve bird checklist (2008) for includes 230 species. All references are provided in Section 4.7 of this report.

Table A.2-1. Birds known or likely present in EBLA: Landbirds.

Common Name	*Scientific Name*	NPSpecies	Abundance[1]; eBird	Conservation Status[2]	Trend[3] (if known)	Prairie Associate[4]
American Crow*	*Corvus brachyrhynchos*	Yes	Common	–	–	–
American Goldfinch*	*Carduelis tristis*	Yes	Common	–	–	X
American Pipit	*Anthus rubescens*	Yes	Rare	–	–	–
American Robin*	*Turdus migratorius caurinus*	Yes	Abundant	–	–	–
Anna's Hummingbird*	*Calypte anna*	Yes	Unconfirmed	–	–	X
Audubon's Warbler	*Dendroica coronata auduboni*	Yes	Uncommon	–	–	–
Band-tailed Pigeon*	*Patagioenas fasciata*	Yes	Uncommon	CC/	–	–
Bank Swallow*	*Riparia*	Probably Present	–	–	–	–
Barn Swallow*	*Hirundo rustica erythrogaster*	Yes	Common	–	W	–
Belted Kingfisher*	*Megaceryle alcyon*	Yes	Common	–	–	–
Bewick's Wren*	*Thryomanes bewickii*	Yes	Uncommon	–	–	X
Black Swift	*Cypseloides niger*	Yes	Probably Present	–	–	–

[1] Abundance: Information from eBird database (www.ebird.org, accessed December 15, 2014) and landbird survey reports by Siegel et al. (2006, 2007, 2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2016, 2017);

[2] Conservation Status: CC – Climate Change Vulnerable (wa.audubon.org/climate-change); C – Candidate; T – Threatened; S – Sensitive; G – suggested by Cassidy and Grue (2007) as being of conservation concern; 1-WDFW cavity nesting waterfowl; 2-alcid concentrations; 3-loon and grebe concentrations; 4-waterfowl concentrations; 5-shorebird concentrations; A-Audubon Society of Washington "Immediate Concern";

[3] Trends: Only trends that have been published for species that occur within the Reserve or nearby waters are shown (V- Vilchis et al. 2014; C – Crewe et al. 2012; A-Altman 2011; B-Bower 2009; W – Whidbey Audubon Birdathon first absence in 2018)

[4] Prairie associate: X – obligate or associated with prairie habitats (Altman 2011).

Table A.2-1 (continued). Birds known or likely present in EBLA: Landbirds.

Common Name	*Scientific Name*	NPSpecies	Abundance[1]; eBird	Conservation Status[2]	Trend[3] (if known)	Prairie Associate[4]
Black-capped chickadee	–	–	–	–	–	X
Black-headed Grosbeak*	*Pheucticus melanocephalus*	Yes	Uncommon	–	–	–
Black-throated Gray Warbler*	*Dendroica nigrescens*	Yes	Uncommon	–	Declining (A)	X
Bohemian Waxwing	*Bombycilla garrulus*	Yes	Probably Present	–	–	–
Brewer's Blackbird*	*Euphagus cyanocephalus*	Yes	Common	–	W	–
Brown Creeper*	*Certhia americana*	Yes	Uncommon	CC/	–	–
Brown-headed Cowbird*	*Molothrus ater artemisiae*	Yes	Common	–	–	–
Bushtit*	*Psaltriparus minimus*	Yes	Uncommon	–	Declining (A)	X
California Quail*	*Callipepla californica*	Yes	Common	–	–	X
Calliope Hummingbird	*Stellula calliope*	Unconfirmed	eBird record 2013 Pacific Rim	–	–	–
Cassin's Vireo*	*Vireo cassinii*	Yes	Rare	–	–	X
Cedar Waxwing*	*Bombycilla cedrorum*	Yes	Common	–	–	–
Chestnut-backed Chickadee*	–	Yes	Common	–	–	–
Chipping Sparrow	*Spizella passerina*	Yes	Occasional	–	Declining (A)	X
Clay-colored Sparrow	–	No	–	–	–	–
Cliff Swallow*	*Petrochelidon pyrrhonota*	Yes	Common	CC/	–	–
Common Nighthawk	*Chordeiles minor minor*	Unconfirmed	–	–	Declining (A)	X

[1] Abundance: Information from eBird database (www.ebird.org, accessed December 15, 2014) and landbird survey reports by Siegel et al. (2006, 2007, 2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2016, 2017);

[2] Conservation Status: CC – Climate Change Vulnerable (wa.audubon.org/climate-change); C – Candidate; T – Threatened; S – Sensitive; G – suggested by Cassidy and Grue (2007) as being of conservation concern; 1-WDFW cavity nesting waterfowl; 2-alcid concentrations; 3-loon and grebe concentrations; 4-waterfowl concentrations; 5-shorebird concentrations; A-Audubon Society of Washington "Immediate Concern";

[3] Trends: Only trends that have been published for species that occur within the Reserve or nearby waters are shown (V- Vilchis et al. 2014; C – Crewe et al. 2012; A-Altman 2011; B-Bower 2009; W – Whidbey Audubon Birdathon first absence in 2018)

[4] Prairie associate: X – obligate or associated with prairie habitats (Altman 2011).

Table A.2-1 (continued). Birds known or likely present in EBLA: Landbirds.

Common Name	*Scientific Name*	NPSpecies	Abundance[1]; eBird	Conservation Status[2]	Trend[3] (if known)	Prairie Associate[4]
Common Raven*	*Corvus corax*	Yes	Uncommon	CC/	–	–
Common Yellowthroat*	*Geothlypis trichas*	Yes	Common	–	W	–
Crow	*Corvus caurinus*	Yes	Common	–	–	–
Dark-eyed Junco*	*Junco hyemalis*	Yes	Common	–	W	–
Downy Woodpecker	*Picoides pubescens*	Yes	Uncommon	–	Decreasing (A)	X
Dusky Flycatcher	*Empidonax oberholseri*	No	–	–	–	–
Eurasian Collared-Dove*	*Streptopelia decaocto*	No	–	–	–	–
European Starling*	*Sturnus vulgaris vulgaris*	Yes	Abundant	–	–	–
Evening Grosbeak*	*Coccothraustes vespertinus*	Yes	Rare	–	–	–
Fox Sparrow	*Passerella iliaca*	Yes	Occasional	–	–	–
Golden-crowned Kinglet*	*Regulus satrapa olivaceus*	Yes	Common	CC/	–	–
Golden-crowned Sparrow	*Zonotrichia atricapilla*	Yes	Common	–	–	–
Hairy Woodpecker*	*Picoides villosus*	Yes	Common	CC/	–	–
Hammond's Flycatcher	*Empidonax hammondii*	Yes	Rare	–	–	–
Hermit Thrush	*Catharus guttatus*	Yes	Rare	–	–	–
Hermit Warbler	*Dendroica occidentalis*	Unconfirmed	–	–	–	–
Horned Lark	*Eremophila alpestris*	Unconfirmed	–	–	–	X
House Finch*	*Carpodacus mexicanus frontalis*	Yes	Common	CC/	W	–
House Sparrow*	*Passer domesticus*	Yes	Uncommon	–	W	–
House Wren*	*Troglodytes aedon*	Yes	Uncommon	–	Declining (A)	X

[1] Abundance: Information from eBird database (www.ebird.org, accessed December 15, 2014) and landbird survey reports by Siegel et al. (2006, 2007, 2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2016, 2017);

[2] Conservation Status: CC – Climate Change Vulnerable (wa.audubon.org/climate-change); C – Candidate; T – Threatened; S – Sensitive; G – suggested by Cassidy and Grue (2007) as being of conservation concern; 1-WDFW cavity nesting waterfowl; 2-alcid concentrations; 3-loon and grebe concentrations; 4-waterfowl concentrations; 5-shorebird concentrations; A-Audubon Society of Washington "Immediate Concern";

[3] Trends: Only trends that have been published for species that occur within the Reserve or nearby waters are shown (V- Vilchis et al. 2014; C – Crewe et al. 2012; A-Altman 2011; B-Bower 2009; W – Whidbey Audubon Birdathon first absence in 2018)

[4] Prairie associate: X – obligate or associated with prairie habitats (Altman 2011).

Table A.2-1 (continued). Birds known or likely present in EBLA: Landbirds.

Common Name	*Scientific Name*	NPSpecies	Abundance[1]; eBird	Conservation Status[2]	Trend[3] (if known)	Prairie Associate[4]
Hutton's Vireo*	*Vireo huttoni huttoni*	Yes	Uncommon	–	W	X
Killdeer*	*Charadrius vociferus*	Yes	Common	–	–	X
Lapland Longspur	*Calcarius lapponicus*	Probably Present	–	–	–	–
Lazuli Bunting	*Passerina amoena*	Unconfirmed	–	–	–	–
Lincoln's Sparrow	*Melospiza lincolnii*	Yes	Rare	–	–	–
MacGillivray's Warbler	*Oporornis tolmiei tolmiei*	Yes	Rare	–	–	–
Marsh Wren*	*Cistothorus palustris*	Yes	Uncommon	CC/	–	–
Mountain Bluebird	*Sialia currucoides*	Probably Present	eBird record 2017 Pacific Rim	–	–	–
Mourning Dove*	*Zenaida macroura*	Yes	Common	–	Declining (A)	X
N. Rough-winged Swallow*	*Stelgidopteryx serripennis*	Yes	Uncommon	–	W	–
Nashville Warbler	*Vermivora ruficapilla*	Unconfirmed	–	–	Declining (A)	–
Northern Flicker*	*Colaptes auratus cafer*	Yes	Uncommon	–	–	–
Northern Shrike	*Lanius excubitor*	Yes	Rare	–	–	–
Olive-sided Flycatcher*	*Contopus cooperi*	Yes	Uncommon	A	–	–
Orange-crowned Warbler*	*Vermivora celata lutescens*	Yes	Uncommon	–	W	–
Pacific (Winter) Wren*	*Troglodytes pacificus*	Yes	Common	–	–	–
Pacific-slope Flycatcher*	*Empidonax difficilis*	Yes	Common	CC/	W	–

[1] Abundance: Information from eBird database (www.ebird.org, accessed December 15, 2014) and landbird survey reports by Siegel et al. (2006, 2007, 2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2016, 2017);

[2] Conservation Status: CC – Climate Change Vulnerable (wa.audubon.org/climate-change); C – Candidate; T – Threatened; S – Sensitive; G – suggested by Cassidy and Grue (2007) as being of conservation concern; 1-WDFW cavity nesting waterfowl; 2-alcid concentrations; 3-loon and grebe concentrations; 4-waterfowl concentrations; 5-shorebird concentrations; A-Audubon Society of Washington "Immediate Concern";

[3] Trends: Only trends that have been published for species that occur within the Reserve or nearby waters are shown (V- Vilchis et al. 2014; C – Crewe et al. 2012; A-Altman 2011; B-Bower 2009; W – Whidbey Audubon Birdathon first absence in 2018)

[4] Prairie associate: X – obligate or associated with prairie habitats (Altman 2011).

Table A.2-1 (continued). Birds known or likely present in EBLA: Landbirds.

Common Name	*Scientific Name*	NPSpecies	Abundance[1]; eBird	Conservation Status[2]	Trend[3] (if known)	Prairie Associate[4]
Pileated Woodpecker*	*Dryocopus pileatus abieticola*	Yes	Rare	C	–	–
Pine Siskin*	*Carduelis pinus*	Yes	Uncommon	CC/	–	–
Purple Finch*	*Carpodacus purpureus californicus*	Yes	Uncommon	CC/	Declining (A)	X
Red Crossbill*	*Loxia curvirostra*	Yes	Uncommon	CC/	–	–
Red Knot	*Calidris canutus*	Yes	Occasional	–	–	–
Red-breasted Nuthatch*	*Sitta canadensis*	Yes	Common	CC/	–	–
Red-breasted Sapsucker*	*Sphyrapicus ruber*	Yes	Common	–	–	–
Red-eyed Vireo	*Vireo olivaceus*	Unconfirmed	–	–	–	–
Red-winged Blackbird*	*Agelaius phoeniceus*	Yes	Common	–	–	–
Ring-necked Pheasant*	*Phasianus colchicus*	Yes	Rare	–	–	–
Rock Pigeon (Feral Pigeon) *	*Columba livia*	Yes	Common	–	–	–
Ruby-crowned Kinglet	*Regulus calendula*	No	eBird record 2018, Ft. Ebey SP	–	–	–
Ruff	*Philomachus pugnax*	Probably Present	–	–	–	–
Ruffed Grouse	*Bonasa umbellus*	Unconfirmed	–	–	–	–
Rufous Hummingbird*	*Selasphorus rufus*	Yes	Common	CC/	–	–
Savannah Sparrow*	*Passerculus sandwichensis*	Yes	Common	–	W	X

[1] Abundance: Information from eBird database (www.ebird.org, accessed December 15, 2014) and landbird survey reports by Siegel et al. (2006, 2007, 2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2016, 2017);

[2] Conservation Status: CC – Climate Change Vulnerable (wa.audubon.org/climate-change); C – Candidate; T – Threatened; S – Sensitive; G – suggested by Cassidy and Grue (2007) as being of conservation concern; 1-WDFW cavity nesting waterfowl; 2-alcid concentrations; 3-loon and grebe concentrations; 4-waterfowl concentrations; 5-shorebird concentrations; A-Audubon Society of Washington “Immediate Concern”;

[3] Trends: Only trends that have been published for species that occur within the Reserve or nearby waters are shown (V- Vilchis et al. 2014; C – Crewe et al. 2012; A-Altman 2011; B-Bower 2009; W – Whidbey Audubon Birdathon first absence in 2018)

[4] Prairie associate: X – obligate or associated with prairie habitats (Altman 2011).

Table A.2-1 (continued). Birds known or likely present in EBLA: Landbirds.

Common Name	*Scientific Name*	NPSpecies	Abundance[1]; eBird	Conservation Status[2]	Trend[3] (if known)	Prairie Associate[4]
Short-billed Dowitcher	*Limnodromus griseus*	Yes	Uncommon	–	–	–
Snow Bunting	*Plectrophenax nivalis*	Probably Present	–	–	–	–
Song Sparrow*	*Melospiza melodia*	Yes	Common	–	–	–
Sora*	*Porzana carolina*	Yes	Rare	–	–	–
Spotted Sandpiper	*Actitis macularia*	Yes	Uncommon	–	–	–
Spotted Towhee*	*Pipilo maculatus*	Yes	Common	–	W	X
Steller's Jay	*Cyanocitta stelleri*	Yes	Uncommon	–	W	–
Surfbird	*Aphriza virgata*	Yes	Uncommon	CC/	–	–
Swainson's Thrush*	*Catharus ustulatus*	Yes	Uncommon	–	–	–
Tennessee Warbler	*Oreothlypis peregrina*	Yes	Occasional/ Migratory	–	–	–
Townsend's Solitaire	*Myadestes townsendi*	Unconfirmed	eBird record 2017 Pacific Rim	–	–	–
Townsend's Warbler*	*Dendroica townsendi*	Yes	Common	–	–	–
Tree Swallow*	*Tachycineta bicolor*	Yes	Common	CC/	–	–
Varied Thrush	*Ixoreus naevius naevius*	Yes	Uncommon	CC/	–	–

[1] Abundance: Information from eBird database (www.ebird.org, accessed December 15, 2014) and landbird survey reports by Siegel et al. (2006, 2007, 2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2016, 2017);

[2] Conservation Status: CC – Climate Change Vulnerable (wa.audubon.org/climate-change); C – Candidate; T – Threatened; S – Sensitive; G – suggested by Cassidy and Grue (2007) as being of conservation concern; 1-WDFW cavity nesting waterfowl; 2-alcid concentrations; 3-loon and grebe concentrations; 4-waterfowl concentrations; 5-shorebird concentrations; A-Audubon Society of Washington "Immediate Concern";

[3] Trends: Only trends that have been published for species that occur within the Reserve or nearby waters are shown (V- Vilchis et al. 2014; C – Crewe et al. 2012; A-Altman 2011; B-Bower 2009; W – Whidbey Audubon Birdathon first absence in 2018)

[4] Prairie associate: X – obligate or associated with prairie habitats (Altman 2011).

Table A.2-1 (continued). Birds known or likely present in EBLA: Landbirds.

Common Name	*Scientific Name*	NPSpecies	Abundance[1]; eBird	Conservation Status[2]	Trend[3] (if known)	Prairie Associate[4]
Vaux's Swift	*Chaetura vauxi*	Probably Present	eBird record 2003 Pacific Rim, 2015 Ft. Ebey SP, 2016 Ft. Casey SP	C	–	–
Vesper Sparrow	*Pooecetes gramineus*	Yes	Uncommon/ Breeder	C/A	–	X
Violet-green Swallow*	*Tachycineta thalassina thalassina*	Yes	Common	CC/	–	–
Virginia Rail*	*Rallus limicola*	Yes	Uncommon	–	–	–
Warbling Vireo*	*Vireo gilvus swainsoni*	Yes	Uncommon	–	–	–
Western Bluebird*	*Sialia mexicana*	Unconfirmed	eBird record 2013 Pacific Rim	–	–	X
Western Kingbird	*Tyrannus verticalis*	Yes	Occasional	–	–	X
Western Meadowlark	*Sturnella neglecta confluenta*	Yes	Rare	–	Declining (A)	X
Western Tanager*	*Piranga ludoviciana*	Yes	Uncommon	CC/	–	–
Western Wood-Pewee	*Contopus sordidulus saturatus*	Yes	Rare	–	–	X
White-breasted Nuthatch	*Sitta carolinensis*	Unconfirmed	–	–	–	–
White-crowned Sparrow*	*Zonotrichia leucophrys pugetensis*	Yes	Common	–	–	–

[1] Abundance: Information from eBird database (www.ebird.org, accessed December 15, 2014) and landbird survey reports by Siegel et al. (2006, 2007, 2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2016, 2017);

[2] Conservation Status: CC – Climate Change Vulnerable (wa.audubon.org/climate-change); C – Candidate; T – Threatened; S – Sensitive; G – suggested by Cassidy and Grue (2007) as being of conservation concern; 1-WDFW cavity nesting waterfowl; 2-alcid concentrations; 3-loon and grebe concentrations; 4-waterfowl concentrations; 5-shorebird concentrations; A-Audubon Society of Washington "Immediate Concern";

[3] Trends: Only trends that have been published for species that occur within the Reserve or nearby waters are shown (V- Vilchis et al. 2014; C – Crewe et al. 2012; A-Altman 2011; B-Bower 2009; W – Whidbey Audubon Birdathon first absence in 2018)

[4] Prairie associate: X – obligate or associated with prairie habitats (Altman 2011).

Table A.2-1 (continued). Birds known or likely present in EBLA: Landbirds.

Common Name	*Scientific Name*	NPSpecies	Abundance[1]; eBird	Conservation Status[2]	Trend[3] (if known)	Prairie Associate[4]
White-throated Sparrow	*Zonotrichia albicollis*	Probably Present	eBird record 2007 Ft. Casey SP	–	–	–
Wild Turkey	*Meleagris gallopavo*	Yes	Uncommon/ Resident	–	–	–
Willow Flycatcher*	*Empidonax traillii brewsteri*	Yes	Uncommon	CC/	–	–
Wilson's Snipe*	*Gallinago delicata*	Yes	Uncommon	–	–	–
Wilson's Warbler*	*Cardellina pusilla chryseola*	Yes	Common	–	–	–
Yellow Warbler*	*Dendroica petechia*	Yes	Uncommon	–	–	–
Yellow-headed Blackbird*	*Xanthocephalus xanthocephalus*	Probably Present	–	–	–	–
Yellow-rumped Warbler*	*Septophaga coronata*	Yes	Common	–	–	–

[1] Abundance: Information from eBird database (www.ebird.org, accessed December 15, 2014) and landbird survey reports by Siegel et al. (2006, 2007, 2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2016, 2017);

[2] Conservation Status: CC – Climate Change Vulnerable (wa.audubon.org/climate-change); C – Candidate; T – Threatened; S – Sensitive; G – suggested by Cassidy and Grue (2007) as being of conservation concern; 1-WDFW cavity nesting waterfowl; 2-alcid concentrations; 3-loon and grebe concentrations; 4-waterfowl concentrations; 5-shorebird concentrations; A-Audubon Society of Washington "Immediate Concern";

[3] Trends: Only trends that have been published for species that occur within the Reserve or nearby waters are shown (V- Vilchis et al. 2014; C – Crewe et al. 2012; A-Altman 2011; B-Bower 2009; W – Whidbey Audubon Birdathon first absence in 2018)

[4] Prairie associate: X – obligate or associated with prairie habitats (Altman 2011).

Table A.2-2. Birds known or likely present in EBLA: Landbirds (raptors and owls).

Common Name	*Scientific Name*	NPSpecies	Abundance[1]; eBird	Conservation Status[2]	Trend[3] (if known)	Prairie Associate[4]
American Kestrel*	*Falco sparverius*	Yes	Uncommon	CC/	Declining (A)	X
Bald Eagle*	*Haliaeetus leucocephalus washingtoniensis*	Yes	Uncommon	CC/S	Increasing (V)	–
Barn Owl*	*Tyto alba*	Probably Present	eBird record 2012, Ft. Casey SP, 2017 Pacific Rim, 2014 Fort Ebey SP	–	–	–
Barred Owl*	*Strix varia varia*	Yes	Uncommon	–	–	–
Cooper's Hawk*	*Accipiter cooperii*	Yes	Rare	–	Increasing (A)	X
Golden Eagle	*Aquila chrysaetos*	Probably Present	–	C	–	–
Golden-crowned Kinglet	*Regulus satrapa olivaceus*	Yes	Common	CC/	–	–
Great Horned Owl*	*Bubo virginianus*	Yes	Uncommon	–	–	–
Gyrfalcon	*Falco rusticolus*	Unconfirmed	–	–	–	–
Long-eared Owl	*Asio otus*	Unconfirmed	–	–	–	–
Merlin	*Falco columbarius*	Yes	Rare	–	–	–
Northern Goshawk	*Accipiter gentilis*	Unconfirmed	–	–	–	–
Northern Harrier*	*Circus cyaneus*	Yes	Common	CC/	–	X
Northern Pygmy-Owl	*Glaucidium gnoma*	Unconfirmed	–	–	–	–

[1] Abundance: Information from eBird database (www.ebird.org, accessed December 15, 2014) and landbird survey reports by Siegel et al. (2006, 2007, 2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2016, 2017);

[2] Conservation Status: CC – Climate Change Vulnerable (wa.audubon.org/climate-change); C – Candidate; T – Threatened; S – Sensitive; G – suggested by Cassidy and Grue (2007) as being of conservation concern; 1-WDFW cavity nesting waterfowl; 2-alcid concentrations; 3-loon and grebe concentrations; 4-waterfowl concentrations; 5-shorebird concentrations; A-Audubon Society of Washington "Immediate Concern";

[3] Trends: Only trends that have been published for species that occur within the Reserve or nearby waters are shown (V- Vilchis et al. 2014; C – Crewe et al. 2012; A-Altman 2011; B-Bower 2009; W – Whidbey Audubon Birdathon first absence in 2018)

[4] Prairie associate: X – obligate or associated with prairie habitats (Altman 2011).

Table A.2-2 (continued). Birds known or likely present in EBLA: Landbirds (raptors and owls).

Common Name	*Scientific Name*	NPSpecies	Abundance[1]; eBird	Conservation Status[2]	Trend[3] (if known)	Prairie Associate[4]
Northern Saw-whet Owl*	*Aegolius acadicus*	Yes	Rare	–	–	–
Osprey*	*Pandion haliaetus*	Probably Present	eBird record 2016 from Pacific Rim, 2017 Ft. Ebey SP, 2016 Ft. Casey SP	–	–	–
Peregrine Falcon	*Falco peregrinus*	Yes	Uncommon	CC/S	–	–
Red-tailed Hawk*	*Buteo jamaicensis*	Yes	Common	–	–	–
Rough-legged Hawk	*Buteo lagopus*	Probably Present	eBird record 2018 from Pacific Rim	–	–	–
Sharp-shinned Hawk*	*Accipiter striatus*	Yes	Rare	–	–	–
Short-eared Owl	*Asio flammeus*	Unconfirmed	eBird record 2008 Pacific Rim	–	–	X
Swainson's Hawk	*Buteo swainsoni*	Yes	Occasional/ Vagrant	–	–	–
Western Screech-owl	*Megascops kennicottii*	Unconfirmed	Unknown breeding status;	–	Increasing (A)	X

[1] Abundance: Information from eBird database (www.ebird.org, accessed December 15, 2014) and landbird survey reports by Siegel et al. (2006, 2007, 2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2016, 2017);

[2] Conservation Status: CC – Climate Change Vulnerable (wa.audubon.org/climate-change); C – Candidate; T – Threatened; S – Sensitive; G – suggested by Cassidy and Grue (2007) as being of conservation concern; 1-WDFW cavity nesting waterfowl; 2-alcid concentrations; 3-loon and grebe concentrations; 4-waterfowl concentrations; 5-shorebird concentrations; A-Audubon Society of Washington "Immediate Concern";

[3] Trends: Only trends that have been published for species that occur within the Reserve or nearby waters are shown (V- Vilchis et al. 2014; C – Crewe et al. 2012; A-Altman 2011; B-Bower 2009; W – Whidbey Audubon Birdathon first absence in 2018)

[4] Prairie associate: X – obligate or associated with prairie habitats (Altman 2011).

Table A.2-3. Birds known or likely present in EBLA: Waterbirds and shorebirds.

Common Name	***Scientific Name***	**NPSpecies**	**Abundance[1]; eBird**	**Conservation Status[2]**	**Trend[3] (if known)**
American Avocet*	*Recurvirostra americana*	Yes	Occasional	–	–
American Bittern*	*Botaurus lentiginosus*	Probably Present	–	–	–
American Coot*	*Fulica americana*	Yes	Common	–	–
American Dipper	*Cinclus mexicanus*	Unconfirmed	–	–	–
American Widgeon*	*Anas americana*	Yes	Abundant	CC/	Increasing (V)
Baird's Sandpiper	*Calidris bairdii*	Yes	Rare	–	–
Barrow's Goldeneye	*Bucephala islandica*	Yes	Uncommon	G/1	Declining (C)
Bar-tailed Godwit	*Limosa lapponica*	Yes	Occasional	–	–
Black Scoter	*Melanitta nigra*	Yes	Uncommon	–	Declining (V/B/C)
Black Turnstone	*Arenaria melanocephala*	Yes	Common	G/5	Increasing (V)
Black-bellied Plover	*Pluvialis squatarola*	Yes	Uncommon	–	–
Blue-winged Teal*	*Anas discors*	Probably Present	–	–	Increasing (V)
Brant	*Branta bernicla*	Yes	Occasional	–	Increasing (V)
Buff-breasted Sandpiper	*Tryngites subruficollis*	Yes	Occasional	–	–
Bufflehead	*Bucephala albeola*	Yes	Abundant	CC/G/4	–
Cackling Goose	*Branta hutchinsii*	No	eBird record 2010, Ft. Casey SP	–	–

[1] Abundance: Information from eBird database (www.ebird.org, accessed December 15, 2014) and landbird survey reports by Siegel et al. (2006, 2007, 2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2016, 2017);

[2] Conservation Status: CC – Climate Change Vulnerable (wa.audubon.org/climate-change); C – Candidate; T – Threatened; S – Sensitive; G – suggested by Cassidy and Grue (2007) as being of conservation concern; 1-WDFW cavity nesting waterfowl; 2-alcid concentrations; 3-loon and grebe concentrations; 4-waterfowl concentrations; 5-shorebird concentrations; A-Audubon Society of Washington "Immediate Concern";

[3] Trends: Only trends that have been published for species that occur within the Reserve or nearby waters are shown (V- Vilchis et al. 2014; C – Crewe et al. 2012; A-Altman 2011; B-Bower 2009; W – Whidbey Audubon Birdathon first absence in 2018)

Table A.2-3 (continued). Birds known or likely present in EBLA: Waterbirds and shorebirds.

Common Name	*Scientific Name*	NPSpecies	Abundance[1]; eBird	Conservation Status[2]	Trend[3] (if known)
Canada Goose*	*Branta canadensis*	Yes	Common	G	Increasing (V/B/C)
Canvasback	*Aythya valisineria*	Probably Present	–	–	Declining (C)
Cinnamon Teal*	*Anas cyanoptera*	Probably Present	–	–	–
Clark's Grebe	*Aechmophorus clarkii*	Yes	Occasional	–	–
Common Goldeneye	*Bucephala clangula*	Yes	Common	CC/G/1	Declining (B)
Common Loon	*Gavia immer*	Yes	Common	CC/	Declining (V&C)
Common Merganser	*Mergus merganser*	Yes	Uncommon	CC/	Increasing (V)
Downy Woodpecker*	*Picoides pubescens*	Yes	Uncommon	–	Decreasing (A)
Dunlin	*Calidris alpina*	Yes	Common	G/5	Increasing (V)
Eared Grebe	*Podiceps nigricollis*	Yes	Rare	–	–
Eurasian Widgeon	*Anas penelope*	Yes	Rare	–	–
Gadwall*	*Anas strepera*	Yes	Uncommon	–	–
Great Blue Heron*	*Ardea herodias*	Yes	Uncommon	–	Declining (C)
Great Egret	*Casmerodius albus*	Probably Present	–	–	–
Greater Scaup	*Aythya marila*	Yes	Abundant	CC/	Declining (V/B/C)
Greater White-fronted Goose	*Anser albifrons*	Probably Present	–	–	W

[1] Abundance: Information from eBird database (www.ebird.org, accessed December 15, 2014) and landbird survey reports by Siegel et al. (2006, 2007, 2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2016, 2017);

[2] Conservation Status: CC – Climate Change Vulnerable (wa.audubon.org/climate-change); C – Candidate; T – Threatened; S – Sensitive; G – suggested by Cassidy and Grue (2007) as being of conservation concern; 1-WDFW cavity nesting waterfowl; 2-alcid concentrations; 3-loon and grebe concentrations; 4-waterfowl concentrations; 5-shorebird concentrations; A-Audubon Society of Washington "Immediate Concern";

[3] Trends: Only trends that have been published for species that occur within the Reserve or nearby waters are shown (V- Vilchis et al. 2014; C – Crewe et al. 2012; A-Altman 2011; B-Bower 2009; W – Whidbey Audubon Birdathon first absence in 2018)

Table A.2-3 (continued). Birds known or likely present in EBLA: Waterbirds and shorebirds.

Common Name	*Scientific Name*	NPSpecies	Abundance[1]; eBird	Conservation Status[2]	Trend[3] (if known)
Greater Yellowlegs	*Tringa melanoleuca*	Yes	Common	CC/	–
Green Heron	*Butorides virescens*	Probably Present	–	–	–
Green-winged Teal*	*Anas crecca*	Probably Present	eBird record 2018 Ft. Casey SP	–	Increasing (V)
Harlequin Duck	*Histrionicus histrionicus*	Yes	Uncommon	G/4	Declining (C)
Hooded Merganser*	*Lophodytes cucullatus*	Yes	Uncommon	CC/G/1	Increasing (V)
Horned Grebe	*Podiceps auritus*	Yes	Uncommon	CC/3	Declining (V, B &C)
Hudsonian Godwit	*Limosa haemastica*	Probably Present	–	–	–
Least Sandpiper	*Calidris minutilla*	Yes	Common	–	–
Lesser Sandhill Crane	*Grus canadensis*	Yes	Occasional	–	–
Lesser Scaup*	*Aythya affinis*	Yes	Uncommon	CC/	Declining (V/B/C)
Lesser Yellowlegs	*Tringa flavipes*	Yes	Uncommon	–	–
Little Blue Heron	*Egretta caerulea*	Probably Present	–	–	–
Long-billed Curlew	*Numenius americanus*	Yes	Occasional	–	–
Long-billed Dowitcher	*Limnodromus scolopaceus*	Yes	Uncommon	–	–

[1] Abundance: Information from eBird database (www.ebird.org, accessed December 15, 2014) and landbird survey reports by Siegel et al. (2006, 2007, 2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2016, 2017);

[2] Conservation Status: CC – Climate Change Vulnerable (wa.audubon.org/climate-change); C – Candidate; T – Threatened; S – Sensitive; G – suggested by Cassidy and Grue (2007) as being of conservation concern; 1-WDFW cavity nesting waterfowl; 2-alcid concentrations; 3-loon and grebe concentrations; 4-waterfowl concentrations; 5-shorebird concentrations; A-Audubon Society of Washington “Immediate Concern”;

[3] Trends: Only trends that have been published for species that occur within the Reserve or nearby waters are shown (V- Vilchis et al. 2014; C – Crewe et al. 2012; A-Altman 2011; B-Bower 2009; W – Whidbey Audubon Birdathon first absence in 2018)

Table A.2-3 (continued). Birds known or likely present in EBLA: Waterbirds and shorebirds.

Common Name	*Scientific Name*	NPSpecies	Abundance[1]; eBird	Conservation Status[2]	Trend[3] (if known)
Long-tailed Duck	*Clangula hyemalis*	Yes	Uncommon	–	Declining (C)
Mallard*	*Anas platyrhynchos*	Yes	Abundant	CC/	Increasing (V)
Marbled Godwit	*Limosa fedoa*	Yes	Rare	–	–
Northern Pintail*	*Anas acuta*	Yes	Abundant	–	Increasing (V)
Northern Shoveler*	*Anas clypeata*	Yes	Uncommon	–	Increasing (C)
Pacific Golden-Plover	*Pluvialis fulva*	Yes	Rare	–	–
Pacific Loon	*Gavia pacifica*	Yes	Uncommon	G/3	Declining (V&C)
Pectoral Sandpiper	*Calidris melanotos*	Yes	Rare	–	–
Pied-billed Grebe*	*Podilymbus podiceps*	Yes	Rare	–	–
Red Phalarope	*Phalaropus fulicaria*	Yes	Occasional	–	–
Red-breasted Merganser	*Mergus serrator*	Yes	Common	CC/G/4	Increasing (V)
Redhead	*Aythya americana*	Probably Present	–	–	–
Red-necked Grebe	*Podiceps grisegena*	Yes	Uncommon	CC/3	Increasing (V)
Red-necked Phalarope	*Phalaropus lobatus*	Yes	Rare	–	–
Red-throated Loon	*Gavia stellata*	Yes	Uncommon	–	Declining (V, C& B)
Ring-necked Duck	*Aythya collaris*	Yes	Uncommon	CC/	–
Rock Sandpiper	*Calidris ptilocnemis*	Probably Present	–	–	–

[1] Abundance: Information from eBird database (www.ebird.org, accessed December 15, 2014) and landbird survey reports by Siegel et al. (2006, 2007, 2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2016, 2017);

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[3] Trends: Only trends that have been published for species that occur within the Reserve or nearby waters are shown (V- Vilchis et al. 2014; C – Crewe et al. 2012; A-Altman 2011; B-Bower 2009; W – Whidbey Audubon Birdathon first absence in 2018)

Table A.2-3 (continued). Birds known or likely present in EBLA: Waterbirds and shorebirds.

Common Name	*Scientific Name*	NPSpecies	Abundance[1]; eBird	Conservation Status[2]	Trend[3] (if known)
Ruddy Duck*	*Oxyura jamaicensis*	Yes	Common	–	Declining (V&B)
Ruddy Turnstone	*Arenaria interpres*	Yes	Uncommon	–	–
Sanderling	*Calidris alba*	Yes	Uncommon	–	W
Semipalmated Plover	*Charadrius semipalmatus*	Yes	Rare	–	–
Semipalmated Sandpiper	*Calidris pusilla*	Yes	Rare	–	–
Sharp-tailed Sandpiper	*Calidris acuminata*	Probably Present	–	–	–
Short-billed Dowitcher	*Limnodromus griseus*	Yes	Uncommon	–	–
Snow Goose	*Chen caerulescens*	Unconfirmed	eBird record 2014 Pacific Rim	–	–
Solitary Sandpiper	*Tringa solitaria*	Probably Present	–	–	–
Spotted Sandpiper	*Actitis macularia*	Yes	Uncommon	–	–
Stilt Sandpiper	*Calidris himantopus*	Yes	Occasional	–	–
Surf Scoter	*Melanitta perspicillata*	Yes	Abundant	G/4	Declining (V)
Surfbird	*Aphriza virgata*	Yes	Uncommon	CC/	–
Trumpeter Swan	*Cygnus buccinator*	Probably Present	eBird record 2018 from Gun Battery	–	–
Tundra Swan	*Cygnus columbianus*	Probably Present	–	–	–

[1] Abundance: Information from eBird database (www.ebird.org, accessed December 15, 2014) and landbird survey reports by Siegel et al. (2006, 2007, 2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2016, 2017);

[2] Conservation Status: CC – Climate Change Vulnerable (wa.audubon.org/climate-change); C – Candidate; T – Threatened; S – Sensitive; G – suggested by Cassidy and Grue (2007) as being of conservation concern; 1-WDFW cavity nesting waterfowl; 2-alcid concentrations; 3-loon and grebe concentrations; 4-waterfowl concentrations; 5-shorebird concentrations; A-Audubon Society of Washington “Immediate Concern”;

[3] Trends: Only trends that have been published for species that occur within the Reserve or nearby waters are shown (V- Vilchis et al. 2014; C – Crewe et al. 2012; A-Altman 2011; B-Bower 2009; W – Whidbey Audubon Birdathon first absence in 2018)

Table A.2-3 (continued). Birds known or likely present in EBLA: Waterbirds and shorebirds.

Common Name	*Scientific Name*	NPSpecies	Abundance[1]; eBird	Conservation Status[2]	Trend[3] (if known)
Wandering Tattler	*Tringa incana*	No	eBird record 2011, Ft. Casey SP	–	–
Western Grebe	*Aechmophorus occidentalis*	Yes	Common	CC/C/3	Declining (C)
Western Sandpiper	*Calidris mauri*	Yes	Common	–	–
Whimbrel	*Numenius phaeopus*	Yes	Rare	–	–
Willet	*Catoptrophorus semipalmatus*	Probably Present	–	–	–
Wilson's Phalarope	*Phalaropus tricolor*	Yes	Rare	–	–
Wilson's Snipe	*Gallinago delicata*	Yes	Uncommon	–	–
Wood Duck*	*Aix sponsa*	Probably Present	eBird record 2013 Ft. Casey SP	G/1	–
Yellow-billed Loon	*Gavia adamsii*	Probably Present	–	–	–

[1] Abundance: Information from eBird database (www.ebird.org, accessed December 15, 2014) and landbird survey reports by Siegel et al. (2006, 2007, 2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2016, 2017);

[2] Conservation Status: CC – Climate Change Vulnerable (wa.audubon.org/climate-change); C – Candidate; T – Threatened; S – Sensitive; G – suggested by Cassidy and Grue (2007) as being of conservation concern; 1-WDFW cavity nesting waterfowl; 2-alcid concentrations; 3-loon and grebe concentrations; 4-waterfowl concentrations; 5-shorebird concentrations; A-Audubon Society of Washington "Immediate Concern";

[3] Trends: Only trends that have been published for species that occur within the Reserve or nearby waters are shown (V- Vilchis et al. 2014; C – Crewe et al. 2012; A-Altman 2011; B-Bower 2009; W – Whidbey Audubon Birdathon first absence in 2018)

Table A.2-4. Birds known or likely present in EBLA: Seabirds.

Common Name	***Scientific Name***	**NPSpecies**	**Abundance[1]; eBird**	**Conservation Status[2]**	**Trend[3] (if known)**
Ancient Murrelet	*Synthliboramphus antiquus*	Unconfirmed	eBird record 2016 Ft. Ebey SP, 2017 Ft. Casey	G/2	–
Arctic Tern	*Sterna paradisaea*	Probably Present	–	–	–
Black Oystercatcher	*Haematopus bachmani*	Yes	Rare	CC/S	Increasing (V)
Black Scoter	*Melanitta nigra*	Yes	Uncommon	–	Declining (V/B/C)
Black Tern	*Chlidonias niger*	Probably Present	–	–	–
Bonaparte's Gull	*Larus philadelphia*	Yes	Uncommon	–	Decreasing (V&B)
Brandt's Cormorant	*Phalacrocorax penicillatus*	Yes	Uncommon	C	Increasing (V)
Brant	*Branta bernicla*	Yes	Occasional	–	Increasing (V)
Brown Pelican	*Pelecanus occidentalis*	No	eBird record 2011, Ft. Ebey SP	–	–
California Gull	*Larus californicus*	Yes	Uncommon	CC/	–
Caspian Tern	*Sterna caspia*	Yes	Uncommon	–	–
Common Murre	*Uria aalge inornata*	Yes	Uncommon	C	Decreasing (V&B)

[1] Abundance: Information from eBird database (www.ebird.org, accessed December 15, 2014) and landbird survey reports by Siegel et al. (2006, 2007, 2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2016, 2017);

[2] Conservation Status: CC – Climate Change Vulnerable (wa.audubon.org/climate-change); C – Candidate; T – Threatened; S – Sensitive; G – suggested by Cassidy and Grue (2007) as being of conservation concern; 1-WDFW cavity nesting waterfowl; 2-alcid concentrations; 3-loon and grebe concentrations; 4-waterfowl concentrations; 5-shorebird concentrations; A-Audubon Society of Washington "Immediate Concern";

[3] Trends: Only trends that have been published for species that occur within the Reserve or nearby waters are shown (V- Vilchis et al. 2014; C – Crewe et al. 2012; A-Altman 2011; B-Bower 2009; W – Whidbey Audubon Birdathon first absence in 2018)

Table A.2-4 (continued). Birds known or likely present in EBLA: Seabirds.

Common Name	*Scientific Name*	NPSpecies	Abundance[1]; eBird	Conservation Status[2]	Trend[3] (if known)
Common Tern	*Sterna hirundo*	Probably Present	–	–	–
Double-crested Cormorant*	*Phalacrocorax auritus*	Yes	Common	–	Increasing (V&B)
Elegant Tern	*Sterna elegans*	Unconfirmed	–	–	–
Forster's Tern	*Sterna forsteri*	Probably Present	–	–	–
Franklin's Gull	*Larus pipixcan*	Probably Present	eBird record 2015 Ft. Ebey SP	–	–
Glaucous Gull	*Larus hyperboreus*	Unconfirmed	–	CC/	–
Glaucous-winged Gull*	*Larus glaucescens*	Yes	Common	–	Increasing (V) Decreasing (B)
Heermann's Gull	*Larus heermanni*	Yes	Uncommon	–	–
Herring Gull	*Larus smithsonianus*	Yes	Uncommon	–	–
Long-tailed Jaeger	*Stercorarius longicaudus*	Yes	Occasional/ Migratory	–	–
Marbled Murrelet	*Brachyramphus marmoratus*	Yes	Rare	T/2	Decreasing (V&B)
Mew Gull	*Larus canus*	Yes	Common	–	–
Parasitic Jaeger	*Stercorarius parasiticus*	Probably Present	–	–	–

[1] Abundance: Information from eBird database (www.ebird.org, accessed December 15, 2014) and landbird survey reports by Siegel et al. (2006, 2007, 2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2016, 2017);

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[3] Trends: Only trends that have been published for species that occur within the Reserve or nearby waters are shown (V- Vilchis et al. 2014; C – Crewe et al. 2012; A-Altman 2011; B-Bower 2009; W – Whidbey Audubon Birdathon first absence in 2018)

Table A.2-4 (continued). Birds known or likely present in EBLA: Seabirds.

Common Name	*Scientific Name*	NPSpecies	Abundance[1]; eBird	Conservation Status[2]	Trend[3] (if known)
Pelagic Cormorant	*Phalacrocorax pelagicus*	Yes	Common	–	Increasing (B)
Pigeon Guillemot*	*Cepphus columba columba*	Yes	Uncommon	CC/G/2	Increasing (V&B)
Rhinoceros Auklet	*Cerorhinca monocerata*	Yes	Rare	CC/G/2	Decreasing (V)
Ring-billed Gull	*Larus delawarensis*	Yes	Uncommon	–	–
Surf Scoter	*Melanitta perspicillata*	Yes	Abundant	G/4	Declining (V)
Thayer's Gull	*Larus thayeri*	Probably Present	–	–	–
Tufted Puffin	*Fratercula cirrhata*	Probably Present	–	C	–
Western Gull	*Larus occidentalis*	Probably Present	eBird records 2015 Ft. Casey SP and Ft. Ebey SP	CC/	–
White-winged scoter	*Melanitta fusca*	Yes	Abundant	–	Declining (V/C)

[1] Abundance: Information from eBird database (www.ebird.org, accessed December 15, 2014) and landbird survey reports by Siegel et al. (2006, 2007, 2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2016, 2017);

[2] Conservation Status: CC – Climate Change Vulnerable (wa.audubon.org/climate-change); C – Candidate; T – Threatened; S – Sensitive; G – suggested by Cassidy and Grue (2007) as being of conservation concern; 1-WDFW cavity nesting waterfowl; 2-alcid concentrations; 3-loon and grebe concentrations; 4-waterfowl concentrations; 5-shorebird concentrations; A-Audubon Society of Washington "Immediate Concern";

[3] Trends: Only trends that have been published for species that occur within the Reserve or nearby waters are shown (V- Vilchis et al. 2014; C – Crewe et al. 2012; A-Altman 2011; B-Bower 2009; W – Whidbey Audubon Birdathon first absence in 2018)

Appendix 3. LiDAR Analysis of Canopy Heights

By Peter Dunwiddie

Analysis of LiDAR fine-resolution data for the entire Reserve (16,629,312 pixels) produced a comprehensive profile of the vegetation canopy heights (Figure A3-1; a shapefile map of that is available) (Table a3-1). The total forested area of the Reserve is between 4,567 ac and 4,810 ac (LiDAR analysis using a 20-ft tree canopy height to define forest). The current distribution of forest age classes on the Reserve appears to be strongly weighted toward the "young" (50–100 ft) age class, with much less old-growth than would have been present in reference conditions. The LiDAR analysis indicates that a tree canopy higher than 100 ft—not all of it mature or old growth—occupies 492 ac. Mature stands (>100 years of age) occupy substantial acreage but have not been thoroughly delineated. Total area of old growth is probably less than 200 ac (Chappell, pers. obs., 2007 Natural Heritage Program surveys).

Table A.3-1. Distribution of canopy heights for the Reserve's vegetation from LiDAR data. (% based on Reserve area of 11,931 ac, of which 4,567 are forested).

Statistic	Vegetation Height (ft)
mean	27.51
median	6.07
standard deviation	30.29
minimum	0.00
maximum*	130.00
1st quartile	0.56
3rd quartile	59.96
% at <3 ft	44.32
% at 3–6 ft	5.59
% at 6–20 ft	10.02
% at 20–50 ft	10.10
% at 50–100 ft	26.24
% at > 100 ft	3.73

* Artificially truncated at 130 ft due to a few anomalous readings; assumed 130 feet is approximate maximum tree height in this part of Whidbey Island.

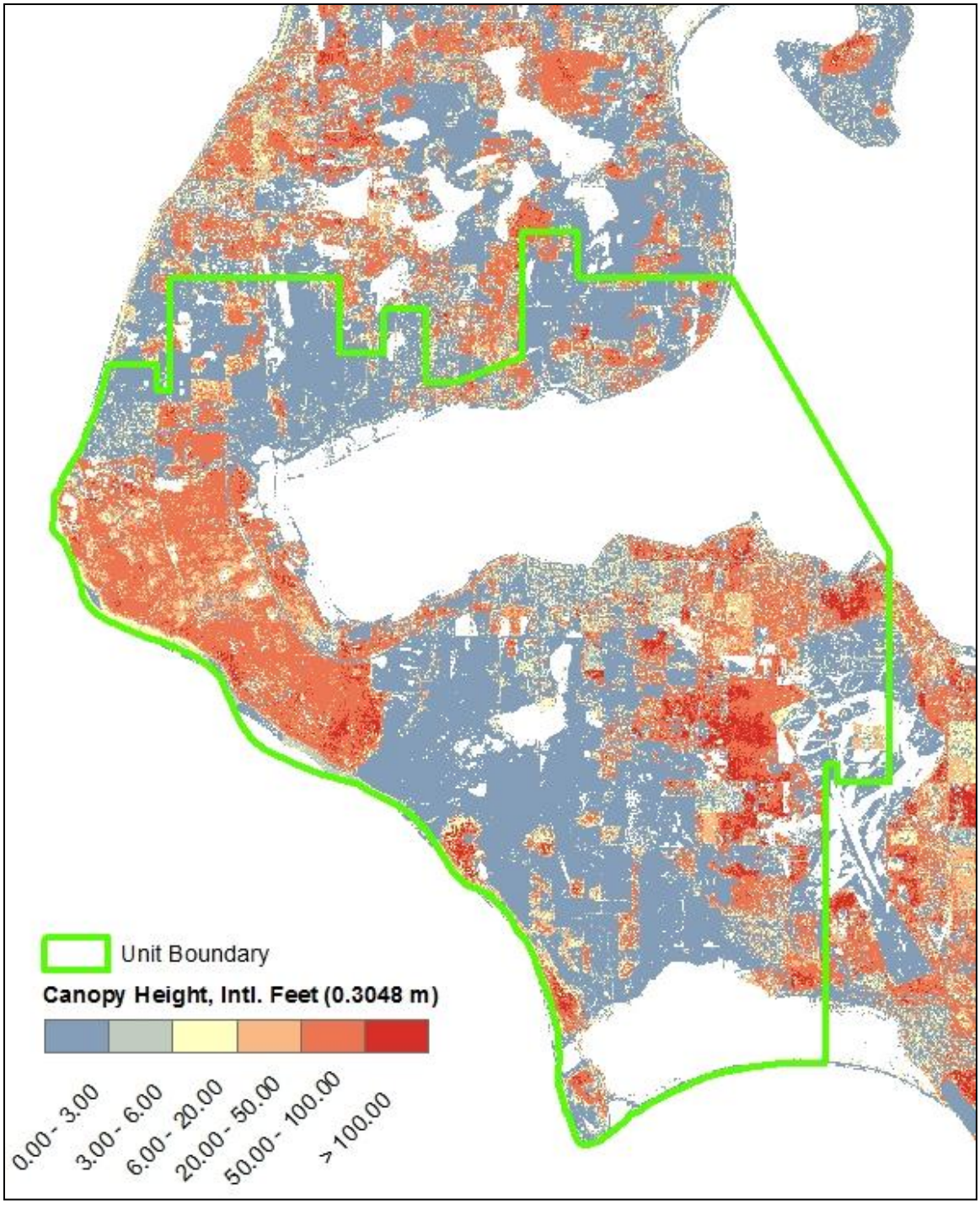


Figure A.3-1. Canopy heights throughout the Reserve. [from LiDAR analysis, this report].

Appendix 4. Recommendations for Prairie Restoration

By Paul Adamus

Prairie restoration within the Reserve is still in its infancy and faces significant hurdles that are distinct from those encountered in other prairies in Washington. In most areas, prairie restoration has largely involved enhancing existing prairie by controlling invasive species and enhancing the diversity of natives. At the Reserve, virtually all prairie restoration must begin without the benefit of an extant example of native species composition.

Much more research is needed to develop and refine prairie restoration strategies. Herein is provided a number of critical research questions that are suggested by existing information gaps.

1) How can prescribed fire be used most effectively to enhance target native species and communities, and without encouraging the further spread and increase of undesirable non-natives?

It is essential to recognize that fire alone will not restore native species to these systems and, in many cases, can make situations worse by enhancing some invasive plant species. Successful use of fire in the restoration of prairie must approach the process holistically to address diverse restoration issues in a comprehensive manner. It is widely recognized today that prescribed fire is required to restore and maintain many of these fire-adapted ecosystems. While mechanical treatments (cutting of trees, mowing of brush and grass) can mimic some of the effects of fire, many of the ecologically significant impacts are difficult or impossible to recreate in other ways. Fire is particularly important in establishing and maintaining conditions that favor native herbaceous species in prairies and savannas. It is important to recognize, however, that these species are usually extremely seed-limited, and that merely restoring fire to a system that is dominated by non-natives will not result in much, if any, increase in the natives. Therefore, in most areas, the use of prescribed fire to restore native prairie species is only recommended when it is accompanied by other methods, such as the use of herbicides, to help control invasive species, together with extensive seeding of natives.

2) How can prairies be restored and managed using prescribed fire and other techniques to enhance habitat elements critical for sustaining less common or sensitive wildlife species, such as the endangered Island Marble butterfly, and avoid inadvertent negative impacts?

As an example, key host plants for the Island Marble (*Euchloe ausonides insulanus*) include *Brassica rapa* and *Sisymbrium altissimum*, both of which are non-native weeds that thrive on frequent disturbance. Such types of disturbance may be incompatible with restoration of other assemblages of native prairie species, and may need to be separated from one another, either spatially, or temporally by rotating disturbances across the landscape over time. As another example, frequent burning generally reduces cover of ground-dwelling mosses and lichens. This can be an important goal for creating conditions under which the seed of native prairie species will germinate. Yet little is known about the composition and abundance of these non-vascular organisms in island communities and burning may inadvertently result in negative impacts to such species that have been poorly studied. Careful inventory of these taxonomic groups across the Reserve, particularly in areas where fire will

be used as a management tool, is needed. In general, prairie management and restoration regimes need to be based on a thorough understanding of habitat requirements and life histories of target species, and carefully balance management practices that account for conflicting or competing resource requirements.

3) What are appropriate target values for species diversity, mean Coefficient of Conservatism (C), and native/non-native ratios?

Work has only just begun applying principles of Floristic Quality Assessment to prairie communities in the Pacific Northwest. Ecologists have assigned C values (Coefficients of Conservatism) to prairie species across the region, making these values much more generally applicable. However, much remains to be learned about how these parameters can be used to inform and guide prairie restoration practitioners. These parameters need to be carefully evaluated for existing sites throughout the region, and further refined as sites are restored and managed and ecological processes such as fire are re-established.

4) What is the minimum size for restored prairie remnants to ensure that most native species will survive, important ecological processes are intact, and invasion of non-native species is reduced to the greatest degree possible?

To some extent, the answers to this will depend on the restoration goals and the ecological requirements of target taxa. Such data are better known, for example, for various species of grassland-nesting birds. There is little data describing similar requirements for plants, butterflies, or other taxa. Some general guidance for vascular plant diversity can be obtained by examining species-area curves for native prairies across the region. Available data suggest that even prairies of several hundred acres are missing significant components of the biota. Finally, prairies at the Reserve are physically constrained by the size of the Reserve itself, and more particularly by the land that is potentially available for restoration of native prairie. Therefore, at least initially, it is most prudent to conclude that native remnants should be restored to the maximum size that resources and space allow, and that future restoration efforts should focus on increasing overall area by adding to existing cores and connecting fragments.

5) How can sufficient quantities of native seed from appropriate sources be made available for restoration efforts?

Lack of native seed sources and insufficient quantities of seed and plugs have been a major impediment for prairie restoration in Washington and Oregon. This hurdle is only beginning to be addressed on Whidbey Island as various nurseries are starting to develop supplies, although unless a steady market for this can be guaranteed, nurseries will be reluctant to invest heavily. For most species, however, no efforts have yet been made to identify local, wild populations from which seed can be collected to begin the seed-increase process. Or, if such populations are known, many have not yet been collected to provide material to nurseries. Finally, for a significant number of species, no local sources exist, and restoration will need to rely on sources from elsewhere in Washington.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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