National Park Service
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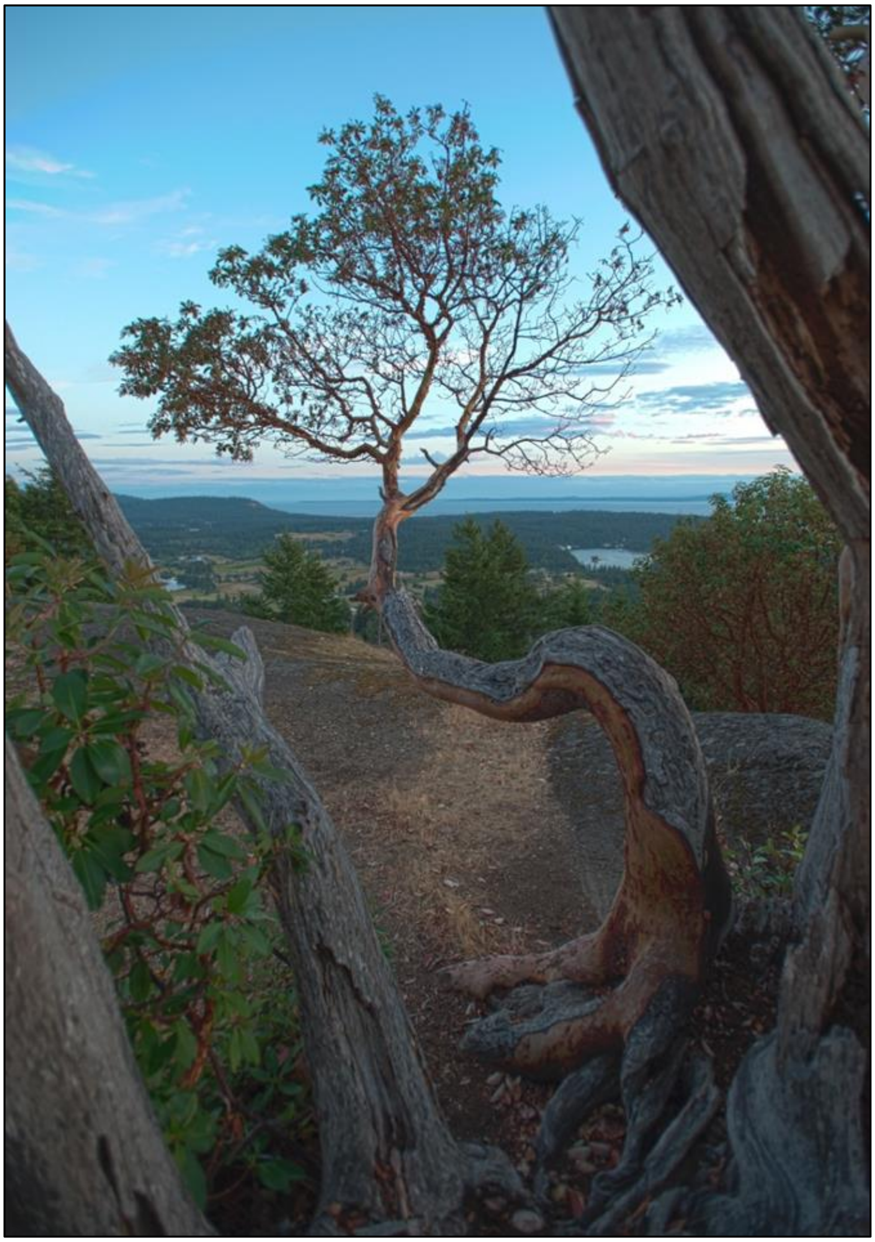
Natural Resource Stewardship and Science

Natural Resource Condition Assessment

San Juan Island National Historical Park

Natural Resource Report NPS/SAJH/NRR—2020/2131



ON THIS PAGE
View east from Mt. Finlayson at American Camp towards Lopez Island in distance. (Photo by Peter Dunwiddie)

ON THE COVER
Pacific madrone (Arbutus menziesii) on Young Hill, English Camp. (NPS)

Natural Resource Condition Assessment

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U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
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Executive Summary

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

Ten focal resource elements were selected for assessment: Air Quality, Climate, Freshwaters, Wetlands, Nearshore Communities, Vegetation and Land Cover, Rare Plants, Birds, Vertebrates, and Habitat Integrity.

Indicators (quantitatively measurable descriptors) were identified to evaluate the condition and trend of these resources. Reference conditions were established for each indicator, though in some cases sufficient data were not available to provide a quantitative evaluation for an indicator. The selection and identification of indicators even when data are not available for analysis is an important exercise, however, because it establishes a need for new data and provides the foundation for future assessments that may be able to incorporate data that currently do not exist.

For each resource, measures for each indicator selected for that resource were compared with reference conditions. In many cases the absence of data for reference conditions and/or the current state of indicators allowed only qualitative comparisons, and for those resources confidence in the assessment was generally low. Evaluation of all indicators for a resource was made subjectively to come to a conclusion regarding the current condition of a resource. With this information the authors then provided their best judgement on each resource condition in terms of management response using the terms "Good", "Of Moderate Concern", or "Of Significant Concern". Trends in condition were described as "Improving", "Stable", "Declining", or "Undetectable." Finally, as mentioned, the confidence in each resource assessment was provided as "High", "Medium", or "Low".

The following table (Table ES-1) briefly summarizes the condition of assessed resources at SAJH. The description of the symbols is provided in Chapter 3, and the assessment process for each resource described in the relevant section of Chapter 4.

Table ES-1. Summary of condition assessments for all focal resources at San Juan Island National Historical Park.

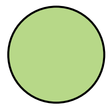
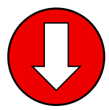
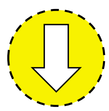
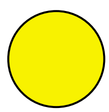
SAJH Resource	Condition and Trend	Assessment
Air Quality (Section 4.1)		Air quality at SAJH is generally good, though visibility warrants moderate concern. Overall the degree of confidence is medium because estimates are based on interpolated data from more distant monitors. No trends are apparent.
Climate (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 declining, and confidence in this assessment is high.
Freshwater Resources (4.3)		Very little is known regarding surface water quality or flow, though there are no indications that either measure is of increasing concern. There are concerns regarding the potential for increasing saltwater intrusion into groundwaters. Groundwater supply appears to be declining due to increasing demand. Confidence in the condition of either surface or groundwater resources at SAJH is low.
Wetlands (4.4)		Vegetation has been surveyed for most wetland sites but there is no ongoing monitoring. Current vegetation information suggests that approximately one quarter of vegetation cover associated with wetlands is dominated by non-native species. No trend information for wetland vegetation is available. Confidence in this assessment is moderate.

Table ES-1 (continued). Summary of condition assessments for all focal resources at San Juan Island National Historical Park.

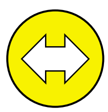
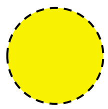
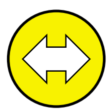
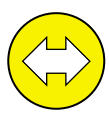
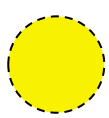
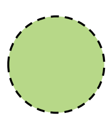
SAJH Resource	Condition and Trend	Assessment
Nearshore Resources (4.5)		Shorelines. The physical conditions of the shorelines in SAJH are good and erosional processes do not appear to be exacerbated by human activities. Erosional trends are unknown, however, and there are few data to quantify physical changes. There are no obstructions to sediment-carrying currents within the park. Bluff erosion is a concern, and rising sea levels and more frequent storm events could result in loss of sand and sediments within park shoreline zones. Confidence in current conditions is moderate to high. Aquatic Vegetation. Although surveys conducted over the past several decades have documented severe declines in eelgrass around SJI and in Westcott Bay, the most recent sampling indicates some recovery. The overall trend is unknown. There are no indications that kelp is declining in or adjacent to park waters, but there are no data to indicate current condition. Confidence in current conditions is moderate. Marine Invertebrates. Current invertebrate community diversity or abundance of any particular species is unknown. Invasive species are an increasing threat, as are rising sea surface temperatures. Confidence in current conditions is low. Marine Fish. Surveys in 2004 found no herring spawning near the English Camp unit of the park despite historic spawning at the site. Juvenile forage fish continue to be found in low numbers, so the condition of forage fish overall is designated of concern but trends are unknown. The abundance of juvenile salmon is unknown, but there are no historic data to indicate that spawning in park waters has ever occurred. Confidence in current conditions for nearshore fish is moderate. Marine Mammals. Harbor seals and Stellar sea lions are commonly seen on beaches near park sites and populations appear stable or increasing. However, no monitoring data are available to determine trends in the numbers or seasonality of animals that haul out. Confidence in current conditions is low to moderate.

Table ES-1 (continued). Summary of condition assessments for all focal resources at San Juan Island National Historical Park.

SAJH Resource	Condition and Trend	Assessment
Native Plant Species (4.6)		Golden Paintbrush – The current status and trend of golden paintbrush at SAJH is unknown but is of concern. Planted populations at other sites appear to be increasing. Confidence for the assessment of paintbrush is moderate. Erect Pygmyweed is listed by the State as threatened, and the absence of data on the species within the park warrants concern for the status of the park population. Trends in the park are unknown and confidence in the assessment of pygmyweed is moderate. Hall's Aster and California Buttercup – Both Hall's aster and California buttercup are of significant concern within the park, with little knowledge of condition or trends. Confidence in the assessment for both species is low. Madrone – The status of madrone in the park appears to be stable, but the threat of disease warrants concern. Trends are stable and confidence is moderate.
Terrestrial Vegetation (4.7)		Prairie and Oak Woodlands are rare and generally declining in the Pacific Northwest, though in the park these habitats are currently relatively well-managed and are being restored. Old-Growth Forests are much reduced in extent but within the park appear stable. Coastal Strand vegetation appears stable and responsive to dynamic dune processes.
Birds (4.8)		Bird diversity is high, supported by multiple habitat types in a relatively small area, though several bird species have been extirpated and others are at risk due primarily to habitat loss and degradation. Seabirds face numerous threats, many originating off-island. Overall bird diversity appears stable while the population trend for some species is declining. Confidence in this assessment is moderate.
Non-avian Vertebrates (4.9)		Almost nothing is known regarding the population size or dynamics of any native vertebrate species. Several native species are extirpated from San Juan Island, while non-native rabbits are invasive. Population trends are unknown for any native vertebrate species other than deer, though there are no indications that any native species is declining. Bats are at high risk from white-nose syndrome. Confidence in this assessment is low.
Habitat Integrity (4.10)		Habitat connectivity has likely improved with efforts to purchase and protect additional lands adjacent to the park. Very little data exist regarding dark night skies and natural quiet, though it is unlikely that either of these indicators are improving. Overall concern is warranted for park habitats, particularly during summer months when visitation to the island and the park sites is high. No trends are detectible and confidence is low.

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National Park Service staff who helped guide this project or who provided key information included Marsha Davis and Allen McCoy (NPS Pacific West Regional Office, Seattle), Jerald Weaver and Jenny Shrum (San Juan Island National Historical Park), Mark Huff (North Coast and Cascades Network, Ashford, WA), Regina Rochefort (North Cascades National Park Service Complex, Sedro-Woolley, WA) and Emma Brown (NPS Natural Sounds and Night Skies Division). We appreciate the earlier efforts made by a University of Washington team to begin preparing this NRCA. Flaxen Conway, director of the Marine Resource Management Program at Oregon State University, administered the project. Chris Chappell (Washington DNR, Natural Heritage Program) was an essential contributor to the vegetation chapter. Greg Jones (Oregon State University, Department of Chemistry) coached us with the climate data analysis. Michael Ewald (Institute for Applied Ecology, Corvallis, OR) analyzed the climate data and conducted the GIS tasks. C. Schwemm thanks David Garcelon (Institute for Wildlife Studies) for continued assistance and support.

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.

List of Acronyms

ARD – NPS Air Resources Division

DNR – Washington State Department of Natural Resources

DO – dissolved oxygen

DOE – Washington Department of Ecology

dv – deciviews

EPA – U.S. Environmental Protection Agency

ESA – Endangered Species Act

FSJ – Friends of San Juan Island

GIS – Geographical Information System

IPCC – Intergovernmental Panel on Climate Change

I&M – Inventory and Monitoring

IPM – Integrated Pest Management

LiDAR – Light Detection and Ranging

MYa – millions of years ago

NCCN – North Coast Cascades Network

NOAA – National Oceanic and Atmospheric Administration NCCN – North Coast and Cascades Network

NPS – U.S. National Park Service

NRCA – National Resources Condition Assessment

NWI – National Wetlands Inventory

PHS – Priority Habitat & Species

PNW – Pacific Northwest

ppb – parts per billion

ppm – parts per million

PSAT – Puget Sound Action Team

PSEMP – Puget Sound Ecosystem Monitoring Program

SAJH – San Juan Island National Historical Park

SJC – San Juan County

SJI – San Juan Island

SST – Sea Surface Termperatures

USGS – U.S. Geological Survey

USFWS/FWS – U.S. Fish and Wildlife Service

WDOE – Washington Department of Ecology

WDFW – Washington Department of Fish & Wildlife

WDOH – Washington Department of Health

WRCA – Water Resource Condition Assessment

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

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[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.

[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.

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Chapter 2. Introduction and Resource Setting

Catherin Schwemm and Paul Adamus

2.1. Introduction

Located in northern Washington State in Puget Sound, San Juan Island National Historical Park (SAJH) is located on San Juan Island within the San Juan Archipelago (Figure 2.1). San Juan Island (SJI) is the second-largest of all the islands at approximately 55 mi^2 (143 km^2). Two spatially discrete units 8.6 miles apart, comprise the park: American Camp (1,223 ac/495 ha) is on the southeastern end of the island and English Camp (923 ac/ 374 ha, including Mitchell Hill and Westcott Bay additions) is on the northwest portion of the island. The total area of the two sites is 2,384 ac (965 ha).

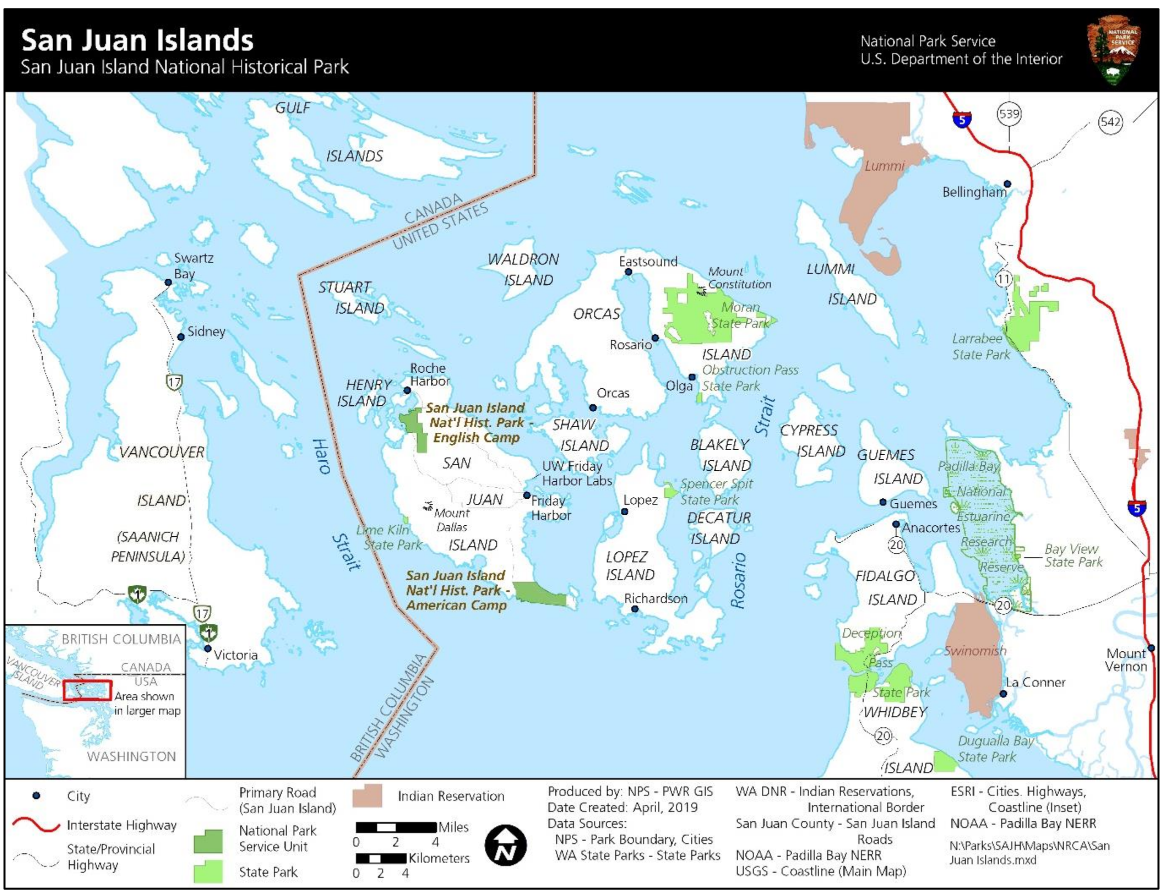

Figure 2.1. Map showing regional setting of San Juan Island National Historical Park (NPS).

2.1.1. Enabling Legislation

In 1966 Congress authorized the National Park Service (NPS) to acquire property on San Juan Island necessary for interpreting the history of the international boundary dispute that occurred between the United States and Britain in the mid-1880s. Disagreement regarding the true location of the US/British Canada boundary peaked in 1859 when a U.S. farmer shot a “British” pig, resulting in the eventually-named “Pig War” (well-described in Avery 2004 and Vouri 2013). The issue was eventually settled amicably, and the park was established in part to highlight that outcome as well as to protect and interpret general historical events that occurred from approximately 1853–1874 (NPS 2008).

The two park sites are named American Camp and English Camp for the personnel—United States Army and British Royal marines, respectively—that were stationed and lived at each location. English Camp also preserves the Crook Family Homestead which was established after the British ended their occupation of the site. Pre-contact archaeological sites and historic-period sites and structures are present at both locations, and management of the park initially focused primarily on historic preservation and interpretation. More recently, park planning and management efforts as well as numerous partners and stakeholders have increasingly focused on protecting and restoring the natural resources and values of the sites. For example, the park’s General Management Plan (NPS 2008) identifies natural and scenic resources as fundamental to the park’s integrity.

2.1.2. Geographic Setting

The San Juan Islands Archipelago is a group of nearly 200 named islands and many hundreds more unnamed rocks and small islands located south of Canada’s Gulf Islands and 16 mi (25.7 km) across Haro Strait, east of the city of Victoria at the south end of Vancouver Island, British Columbia. The international boundary runs through Haro Strait, separating the two countries. The landscapes of American Camp and English Camp are quite different. American Camp is primarily a rolling, windswept prairie with spectacular views of the ocean in most directions (Figure 2.2).

Figure 2.2. Map of American Camp showing terrain features from LiDAR (NPS).

The open landscape at American Camp transitions into forest before extending to the top of Mount Finlayson (290 ft/88 m) in the eastern portion of the site. Located on a peninsula that juts between the Strait of Juan de Fuca and the Strait of Georgia, the south-facing marine waters around American Camp are flushed by the strong tidal currents and ocean swell of the Haro Strait while waters on the north side of the peninsula experience similar tidal dynamics but are more protected from wave impacts. Tides along the shores of SJI are moderate; the average tidal range is 4.3–4.9 ft (1.3–2.7 m; https://tidesandcurrents.noaa.gov/stationhome.html?id=9449880).

Wave processes are influenced by seabed topography hundreds of feet offshore, causing waves to break far from the shoreline. Because of the large fetch (the distance over which the wind blows unobstructed) along the southwest shoreline at American Camp, wave intensity can be great, especially during storms. Along both the south and north shores of American Camp, currents are mostly west to east, and intertidal areas are primarily composed of cobble and gravel (Fradkin 2011). On the south shore of American Camp the intertidal zone is mostly gravel and cobble with some mudflats (Fradkin 2011).

In contrast, English Camp (Figure 2.3), located to the northwest of American Camp on Garrison Bay, is primarily comprised of forest and oak woodlands with some small cleared areas around developed sites. The topography at English Camp is flat or gently sloping near the pre-contact and historical settlements but to the east rises sharply to the high point of Young Hill (650 ft/198 m). Adjacent to English Camp on the east is a fairly large and contiguous area of unfragmented forest. Within the unit, 25-ft (7.6 m) wide West Valley Road creates the only linear opening of significant extent in the forest canopy.

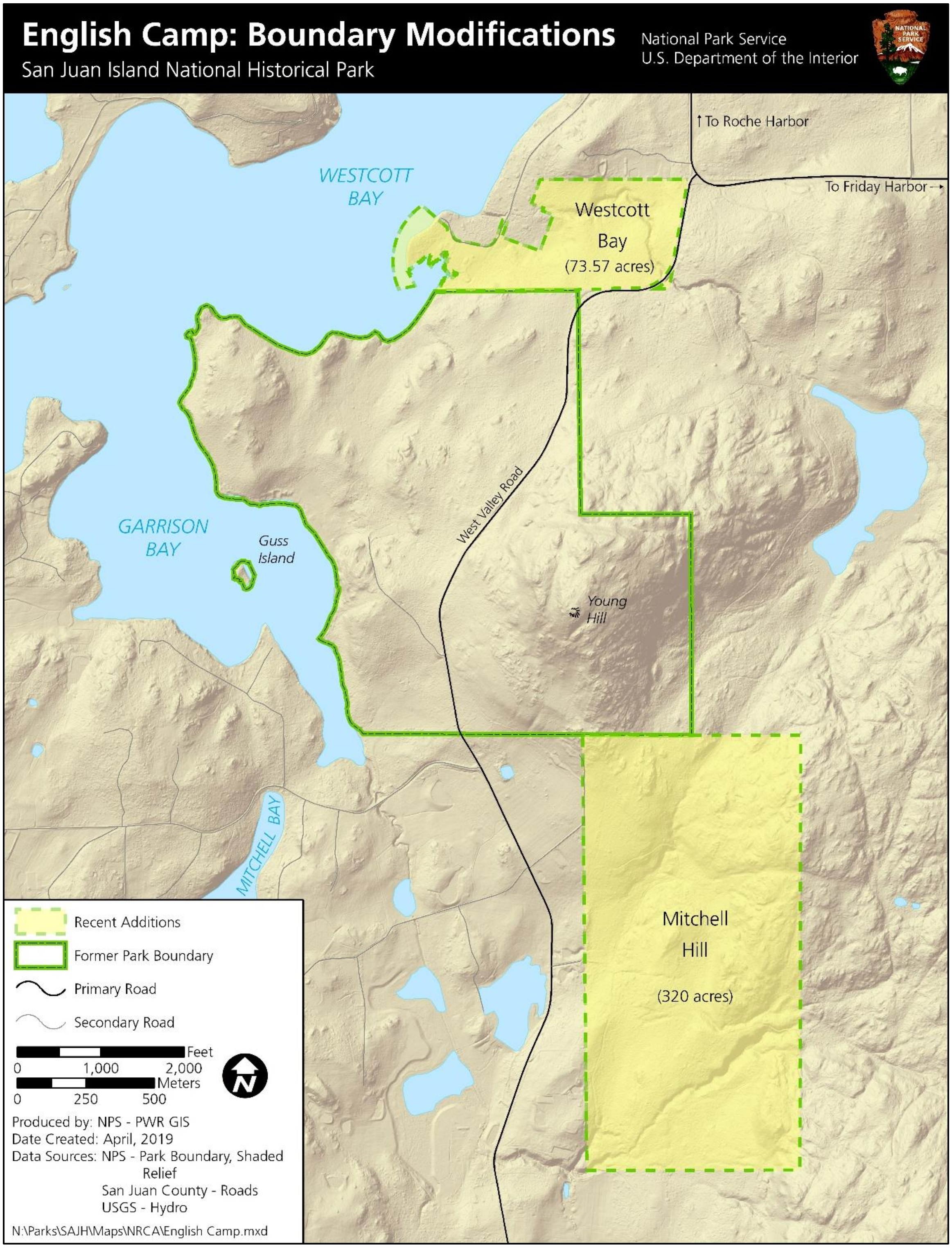

Figure 2.3. Map of English Camp showing terrain features from LiDAR and recent additions of Mitchell Hill and Westcott Bay (NPS).

The coastline of English Camp is relatively sheltered from ocean winds and currents, so tidal and open water influences are less a factor for shoreline processes here than at American Camp. There are no sandy beaches at English Camp; intertidal areas with soft muddy sediments support rich shellfish communities (Flora and Fradkin 2004), while other sites are composed of rocks and gravels (Fradkin 2011). These restricted circulation patterns also increase the risk of elevated bacterial counts and low-oxygen events harmful to aquatic life.

2.1.3. Jurisdiction and Adjacent Land Use

Though the two NPS sites make up a relatively small portion of SJI (7%), an additional 8% of the island is protected by state and county parks and lands owned by the San Juan County Land Trust, San Juan Preservation Trust, State of Washington Lands Division, and the University of Washington. Two areas of commercial activity and settlement are Friday Harbor, approx. 4 mi (6.4 km) north of American Camp, and Roche Harbor, 1 mi (1.6 km) north of English Camp. The population of SJI is approximately 7,000 people and the island is only accessible by boat or airplane.

Lands directly adjacent to American Camp to the east are managed for conservation by the Washington Department of Natural Resources (DNR) and the San Juan County Land Bank, however, further east is a housing development that can only be accessed by a road that runs through American Camp. To the west of the unit is another housing development that is not yet completely built out (there are still open lots). To the northwest of American Camp there are narrow wooded corridors, some of which are protected within the San Juan County Land Bank, that connect with NPS lands to create approximately 500 ac (202 ha) of protected woodland.

While jurisdictional responsibilities of NPS for the upland portions of the two park sites are relatively straightforward, management of the shoreline and coastal segments is shared with other agencies. Collectively the two park sites encompass approximately 6.1 mi (9.8 km) of marine shoreline (8% of the SJI total). Ownership of most of the intertidal zone is retained by the State of Washington under the jurisdiction of DNR, however, NPS jurisdiction extends to the extreme low tide line from the cliffs west of Alaska Packer's Rock (American Camp) to east of the restrooms at South Beach. East of South Beach jurisdiction extends only to the mean high tide line. Along the north shore of American Camp, the jurisdictional line meanders from Grandma's Cove to the western boundary of American Camp and along a short stretch of shoreline north of Jakle's Lagoon. On the north shore of American Camp NPS authority extends to the mean high tide line along Fourth of July Beach from the northwestern boundary to west of First Lagoon. At English Camp the park owns tidelands from the northern edge of the parade ground south to the park boundary with the remainder being owned by the state.

2.1.4. Cultural Significance

Archeological excavations of prehistoric sites in the San Juan Islands, including two at American Camp, provide evidence that humans were active in the islands throughout the Holocene as far back as 9,000 ybp (Hammond and Hoke 2004, NPS 2008). The abundant resources of the San Juan Islands and the surrounding ocean allowed the ancestors of today's Coast Salish Peoples to move between the islands and the mainland to utilize resources seasonally. Native people here used both upland and marine resources on the island, in particular the prairies that were maintained (prevented from succeeding to woodland) by intentionally set fires that perpetuated plant species useful for food and medicine. Intertidal resources, particularly shellfish populations in the relatively sheltered Garrison Bay, as well as immense salmonid stocks were all important sources of food. The history and relevance of SJI and the cultural sites to native peoples are important values of SAJH but outside the scope of this report; for more background the reader is referred to sources such as Stein (2000) and Avery (2004).

The two periods of significance for which SAJH was established are 1) the presence of the US and British military from 1859–1874, and, 2) a period of homesteading represented primary by the Crook family at English Camp from 1875–1963 (NPS 2008). As described above, the presence of troops from both countries on the same, relatively small, island for many years represents a somewhat unique occurrence that ended peacefully, unlike most other interactions between the US and Britain during that period (Vouri 2013). Both sites provide important evidence of how each army lived, construction methods, family associations and relationships with the native people (Hammond and Hoke 2004, Gilbert 2004).

2.1.5. Visitation Statistics

Between 2007 and 2016 annual visitation ranged from ~221,000 to ~316,000, with an average for the period of ~266,000. In 2016 the number of visitors was approximately 22% greater than in 2015 (https://irma.nps.gov/stats). Though it is primarily an historical park, SAJH provides excellent opportunities for quiet and solitude, hiking, whale-watching, and other low-intensity outdoor activities.

2.1.6. Relevant Regional and Landscape-scale Information

The park is in an ecoregion known as the Puget Lowland (sometimes referred to as the Puget Trough). It is also part of a region called the Salish Sea, which includes Puget Sound, the Strait of Juan de Fuca, and the Strait of Georgia. Marine scientists also refer to the area within which the park exists as the Georgia Basin, and the park falls within Water Resource Inventory Area (WRIA) 2 as recognized by Washington State natural resource agencies.

In recent times San Juan Island has moved gradually from a mostly agrarian landscape (including logging) to supporting a high level of tourism and vacation and retirement home developments. While this change has led to some areas of land conversion to housing and related commercial and industrial uses (Kondo et al. 2012), some areas of the island have received greater protection. In the vicinity of English Camp, three separate landowners have constructed trails that link to one another and to the English Camp unit creating a unique network of historical and natural resource-related hiking experiences.

San Juan County is the only county in Washington that has passed a real estate excise tax for purchasing and setting aside significant amounts of land for permanent protection from intensive development. County-owned parks and land bank programs and the San Juan Preservation Trust have together protected over 9% of the county's area primarily for conservation, and an additional 10% of the county's area is within San Juan Island National Historical Park or owned by other Federal or

State agencies or private conservation groups. Several efforts exist that try to integrate island resources stewardship (e.g. http://www.sjcmrc.org/media/1161/msa-plan-02-jul-2007-final.pdf).

2.2. Physical Resources

2.2.1. Air Quality

Because the land is surrounded by oceanic processes, air quality on islands is usually better than equivalent mainland sites, but as far as is known there are no State or local agency air quality monitoring locations on San Juan Island. Section 4.1 describes NPS efforts to monitor and assess air quality at SAJH.

2.2.2. Climate

The climate of the San Juan Islands is affected mostly by oceanic influences and topography, with temperatures moderated by the damping influence of the ocean and rainfall limited by the Olympic Range to the southwest. Summer high temperatures are rarely over 70–75°F/21–24°C, while winter lows average above freezing; temperatures are generally warmer at American Camp. Records from the Friday Harbor airport (approximately 6–7 mi/10–11 km from both sites) show that the highest temperatures (70–75°F/21–24°C) normally occur in late August and low temperatures (35–40°F/2–5°C) in early January (https://climate.washington.edu/climate-data/).

The high levels of precipitation that the Pacific Northwest (PNW) is known for are produced by eastern Pacific storms. The Olympic Mountains often lie directly in the path of these storms, and orographic lifting causes much of the precipitation to fall on the mountains before it reaches the San Juan Islands. As a result the Puget Sound region receives much less rainfall than most of western Washington, and this relative aridity is an important driver of park ecosystems. The southern portion of SJI is very dry; near American Camp on the southeast end of the island average annual precipitation is only 19 in (48 cm), while at a slightly higher elevation and 8 mi (13 km) to the north, English Camp's upper slopes average 29 in (74 cm) of precipitation annually (Cannon 1997). Occasionally in the winter months, freezing temperatures and strong northeasterly winds occur when low-pressure systems off the coast mix with outbreaks of cold air moving down through the Fraser River Valley in British Columbia (Garland 1995). The climate of SAJH is discussed in detail in Section 4.2.

2.2.3. Dark Night Sky 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. Nighttime lights on SJI in the region of SAJH are generally absent, though regional light from the City of Victoria is increasing. The island is also relatively quiet aside from overflights and general traffic noises. These resources are addressed in Section 4.10.

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. As these ice masses moved they carved the bedrock 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 as a result of isostatic rebound upon melting of the glaciers, followed by coastal erosion and glacial moraine and outwash deposition. The relatively flat area at American Camp was created by deposits left as the glacial front melted back. The intertidal shorelines of both American Camp and English Camp are dominated by unconsolidated poorly-sorted fluvial-glacial sediments partially reworked by shoreline processes (Graham 2014).

Glacial erratics on ground moraine at American Camp. (NPS)

2.2.5. Hydrology/Water Quality

The park's limited water resources comprise the headwaters of very small, low-elevation watersheds that drain almost immediately into marine waters. Although relatively little surface water drains into the park and most areas that immediately adjoin the park are managed for conservation, the quality and quantity of the park's limited water are vulnerable to outside impacts. One of the greatest water resource concerns is intrusion of saltwater into groundwater used for drinking (SJC 2004). The San Juan Islands are a mixture of fractured bedrock aquifers and bedrock overlain with glacial deposits; both aquifer types occur at both SAJH sites. Withdrawal of groundwater by residences directly east of American Camp has the potential to endanger the availability and quality of groundwater and surface water within the park, especially if compounded by longer droughts that might be associated with regional climate change. The rate of groundwater withdrawal by these residences that would be sustainable and not threaten park resources is unknown; water resources are already often less than needed, particularly in the summer. The freshwater resource of SAJH is assessed in Section 4.3.

2.2.6. Fire

Prior to human settlement in the region, fires were likely uncommon given the relatively wet conditions of the period (Leopold et al. 2016). When humans arrived they began using fire to clear forests and maintain open prairies which provided plants more useful for food and materials (Avery 2004). Consequently, the extant prairie and oak woodlands now require regular fires to set back succession that would otherwise allow woody species to re-establish (Pellatt and Gedalof 2014). Fire is discussed in more depth in Section 4.7.

2.3. Biological Resources

2.3.1. Vegetation Communities

San Juan Island National Historical Park is within an area that historically included a mix of lowland conifer forest, extensive dry and wet prairies, coastal bluffs, and beach/strand habitats (Agee 1984). The island is located in one of the driest areas of western Washington, directly in the rain shadow cast by the Olympic Mountains to the southwest. Prairies that once covered many areas of the region, but now are rapidly disappearing due to development, are a key feature of the park. In a region that grows trees so well and is dominated by forest, the occurrence of prairies appears anomalous, however, these areas were historically created and largely maintained in their treeless state by frequent burns initiated by Native Americans (Boyd 1999).

A significant amount of the existing vegetation had already been cleared for agriculture or logged prior to establishment of the park (Avery 2004). Currently the park supports 25 vegetation associations considered by the Washington Natural Heritage Program to be “Imperiled” or “Critically Imperiled” within Washington or globally (Table 2.1). Prairies are a dominant community type at American Camp (Dunwiddie and Bakker 2011). Oregon white oak (or Garry oak, *Quercus garryana*) woodlands are declining regionally but are well represented at English Camp (Agee 1987). Prairie and oak woodlands have declined in extent due largely to prolonged fire suppression and herbivory, though substantial recovery of several vegetation communities has occurred with time and aided by modest restoration efforts. The vegetation resource is assessed in Section 4.7.

Table 2.1. Vascular plant associations designated as "Imperiled" or "Critically Imperiled" within Washington or globally by the Washington NHP, and reported in the park's American Camp (AC), English Camp (EC), and Mitchell Hill (MH) units by Rocchio et al. (2012). X = present at that location.

Plant Association	Habitat	AC	EC	MH
Festuca rubra – (Camassia leichtlinii, Grindelia stricta var. stricta) Herbaceous	Bald/bluff	X	–	–
Festuca rubra – Ambrosia chamissonis Herbaceous Vegetation	Coastal sand dunes/ spits	X	–	–
Festuca rubra Stabilized Dune Herbaceous Vegetation	Coastal sand dunes/ spits	X	–	–
Pseudotsuga menziesii / Symphoricarpos albus – Holodiscus discolor Forest	Dry forest	X	–	–

Table 2.1 (continued). Vascular plant associations designated as "Imperiled" or "Critically Imperiled" within Washington or globally by the Washington NHP, and reported in the park's American Camp (AC), English Camp (EC), and Mitchell Hill (MH) units by Rocchio et al. (2012). X = present at that location.

Plant Association	Habitat	AC	EC	MH
Thuja plicata – Abies grandis / Polystichum munitum Forest	Mesic forest	X	X	X
Thuja plicata / Gaultheria shallon Forest	Mesic forest	X	X	X
Quercus garryana / Symphoricarpos albus / Carex inops Woodland	Oak woodland	X	–	–
Populus tremuloides / Carex obnupta Forest	Wetland	X	–	–
Festuca rubra Coastal Headland Herbaceous Vegetation	Bald	X	–	–
Salix hookeriana – (Salix sitchensis) Shrubland	Wetland	X	–	–
Leymus mollis ssp. *mollis – Abronia latifolia* Herbaceous Vegetation	Coastal sand dunes/ spits	X	–	–
Pseudotsuga menziesii / Gaultheria shallon – Holodiscus discolor Forest	Dry forest	X	–	X
Pseudotsuga menziesii / Rosa gymnocarpa – Holodiscus discolor / Festuca occidentalis Forest	Dry forest	X	–	X
Pseudotsuga menziesii – Arbutus menziesii / Holodiscus discolor Forest	Dry forest	X	X	X
Cornus sericea Pacific Shrubland	Wetland	X	–	–
Malus fusca – (Salix hookeriana) / Carex obnupta Shrubland	Wetland	X	–	–

Garry Oak (*Symphoricarpos albus*) on Young Hill, English Camp. (NPS)

2.3.2. Plant Diversity

Considering the relatively small size of the park, the floral resource of SAJH is exceptionally diverse. Rochefort and Bivin (2010) reported a total of 400 species in the park, which represents about 60% of the approximately 684 species recorded for SJI as a whole. Of the total number of species, approximately 30% are non-native (Rocchio et al. 2012).

There are approximately 23 plant species that occur throughout San Juan County that are identified as having some level of either State or Federal conservation status by the Washington Natural Heritage Program (http://www.dnr.wa.gov/publications/amp_nh_vascular_ets.pdf?9h8287). Three species (*Crassula connata*, *Sanicula arctopoides*, and *Castilleja levisecta*) are noted from San Juan NHP or Ft. Casey SP. There are only 12 known naturally occurring populations of *C. levisecta* (golden paintbrush) and five of these occur within the San Juan and Gulf Islands. The species is federally listed as threatened and is likely one of the few plants that serve as a larval food plant for endangered checkerspot butterflies (described below; Dunwiddie et al. 2016). Two additional species listed as threatened were recorded as present in the park by Rochefort and Bivin (2010), including *Symphyotrichum hallii* and *Ranunculus californicus*. One additional species, the lichen *Niebla cephalota*, is proposed as “sensitive” for inclusion on the proposed rare non-vascular plants list for Washington State. Rare plants are addressed in Section 4.6.

Native lily (*Triteleia grandiflora*, var *howellii*), American Camp prairire. (NPS)

2.3.3. Terrestrial Invertebrates

Aside from the focused efforts on island marble butterflies (discussed below), there have been no comprehensive published inventories of terrestrial invertebrates in the park, and status and trends of insects is largely unknown. However, two butterfly species in the region are of conservation concern and have been relatively well studied. Taylor's checkerspot, (*Euphydryas editha taylori*, Schultz et al. 2011), a subspecies of Edith's checkerspot, has been designated as a Candidate for federal listing under the Endangered Species Act, and the WDFW lists it as a Species of Concern. Only 14 populations are known, all in Washington and Oregon, and almost three-quarters of the known populations occur at only two sites, one of which is in San Juan County on private land where its current status is unknown. Taylor's checkerspots could potentially occur in grasslands at American Camp but it has not been reliably documented. Preferred habitat for Taylor's checkerspot includes unmowed grasslands and rocky outcrops, especially where native grasses are dominant near shorelines.

Before its rediscovery on San Juan Island in 1998, the island marble butterfly (*Euchloe ausonides insulanus*), a subspecies of the large marble butterfly, was believed to be extinct (Jordan et al. 2012). At present the San Juan population, located in the park, is the only viable population known, existing in prairie and coastal shoreline habitats. In 2006, 72 known or potential sites in San Juan County were surveyed, and the island marble was found at 16 sites, most in one of three areas: the southeast region of SJI (including portions of American Camp), the San Juan Valley on SJI, and the central valley of Lopez Island. Currently the island marble is only known to occur within or at sites immediately adjacent to American Camp. On May 5, 2020, the USFWS determined endangered species status under the Endangered Species Act of 1973 (Act), as amended, for the island marble butterfly (and designated critical habitat). In total, approximately 812 acres (329 hectares) were designated, which fall primarily in the American Camp Unit of SAJH.

Island Marble Butterfly, American Camp prairie. (NPS)

Host plants include tumble mustard (*Sisymbrium altissimum*), field mustard (*Brassica campestris*), and Puget Sound peppergrass (*Lepidium virginicum menziesii*), all of which occur in SAJH (Pyle 2004, Lambert 2006). In addition to its larval food plants, the island marble depends on at least 10 different plants for nectar (Pyle 2004). Island marbles have been observed laying eggs on other mustard species, however plants desiccated before larvae fully matured indicating that they may not be viable host plants.

Valley silverspot butterflies (*Speyeria zerene bremnerii*) and sand-verbena (*Copablepharon fuscum*) moths are candidates for listing sand-verbena moths are known to be present in the park but the status of valley silverspots in SAJH is unknown. The rare purplish copper (*Lycaena helloides*) and Propertius' duskywing (*Erynnis propertius*) are species being monitored by WDFW; both are documented from park sites but very little additional information is available regarding their distribution in SAJH (WDFW Priority Habitats and Species database).

2.3.4. Marine Invertebrates

Marine invertebrates are abundant in park nearshore waters. Shellfishing for clams and crabs occurs in Westcott and Garrison Bays, including on NPS property. The pinto abalone (*Haliotis* *kamtschatkana*), a shellfish whose populations have declined to the point where harvesting in the region is now prohibited, is present in the vicinity of both American Camp and English Camp. In the inside waters of Washington, abalone is currently found only in the San Juan Islands and the Strait of Juan de Fuca (Dethier et al. 2006). Marine invertebrates are assessed in detail in Section 4.5.

2.3.5. Vertebrates

Fish

The nearshore areas of SAJH support populations of both juvenile salmonids and forage fish (species generally identified as prey for salmon, seabirds, and marine mammals). Eelgrass beds in particular provide habitat for young salmon and small prey fish, and these sites have been in decline in recent decades, as have many individual species of salmon. Fish are addressed in Section 4.5.

Birds

Because of the availability of ocean and terrestrial resources, the San Juan Islands support a diverse community of avian species including landbirds, shorebirds, waterbirds, raptors, and seabirds (Vilchis et al. 2015). Only one bird species that is regularly present in the park is currently federally listed: the marbled murrelet (*Brachyramphus marmoratus*), which does not nest in the park due to the absence of old-growth forest which it requires, feeds regularly in marine waters adjoining both units of the park. Larger numbers (up to 100 individuals) can occur at times in Griffin Bay adjoining American Camp. Marine waters of the San Juan Archipelago contain perhaps the highest concentrations of marbled murrelets in the Pacific Northwest, however populations have been declining for some time (Miller et al. 2012, Falxa and Raphael 2016). The San Juan Islands also support high nesting densities of bald eagles (*Haliaeetus leucocephalus*) and peregrine falcons (*Falco peregrinus*), and bald eagle nesting in the park has been documented. Birds are assessed specifically in Section 4.8.

Juvenile Pileated Woodpecker (*Dryocopus pileatus*), English Camp. (NPS/M. Davis)

2.3.6 Amphibians/Reptiles/Mammals

Though amphibians are common in much of the PNW, amphibian diversity on SJI is relatively low due to the dry climatic conditions. Reptile diversity is even lower with only a few species recorded from all the SJI. Mammal communities include small and medium-size species, but all of the large mammals other than black-tailed deer (*Odocoileus hemionus columbianus*) have been extirpated. Non-native species, in particular European rabbits (*Oryctolagus cuniculus*), have had serious negative impacts on vegetation resources and other processes since their introduction during the military period of the park. 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 is assessed in Section 4.9.

2.4. Threats to Natural Resources

The primary threats to natural resources in SAJH are discussed briefly below. Specific threats and stressors to individual resources are discussed in detail in Chapter 4.

2.4.1. Invasive Plants

Rochefort and Bivin (2010) estimated that 33% of the vascular plant species in the park are exotic, and Rocchio et al. (2012) reported 52% of all mapped area at American Camp classified as ruderal (species that colonize disturbed lands), with less at English Camp. Some invasive plant species are classified as “noxious weeds” by government jurisdictions due to their economic and/or biological effects, and control of them is required by law. Noxious weeds that are common on the island or are likely to appear (or reappear) in the park include Scotch broom (*Cystisus scoparius*) and yellow archangel (*Lamiastrum galeobdolon*; Table 2.2).

Table 2.2. Species designated as Class A, B, or C noxious weeds in Washington, and reported from the park. Sources: NPSpecies, National Park Service 2008, and https://extension.wsu.edu/sanjuan/noxious/ (Also—Draft Noxious Weed List for 2020: https://s3.wp.wsu.edu/uploads/sites/2054/2020/02/2020-SJC-Noxious-Weed-List__DRAFT6.pdf) .

Scientific Name	WA Weed Category
*Centaurea stoebe**	B
Cirsium arvense	C
Cirsium vulgare	C
*Daphne laureola**	B
*Dipsacus fullonum ssp. sylvestris**	C
*Geranium robertianum**	B
*Hedera helix**	C
Hypericum perforatum	C
Hypochaeris radicata	C
Leucanthemum vulgare	C
Phalaris arundinacea	C
Rubus armeniacus	C
Rubus laciniatus	C
*Senecio jacobaea**	B

* Species selected for control within San Juan County

2.4.2. Invasive Animals

The European green crab (*Carcinus maenas*) was recently found on San Juan Island, and the establishment of the species in the Salish Sea may have been the result of warmer ocean temperatures (Yamada et al. 2017). European green crabs arrived on the North American continent near Cape Cod nearly 150 years ago, and have expanded their range across the US and Canada to the West Coast. European green crabs are strong predators of many native invertebrates including species of economic value such as Dungeness crab (*Metacarcinus magister*; Mach and Chan 2013).

Introduced European rabbits have impacted vegetation and soils in many areas of the park. Non-native rabbits were first documented on SJI in 1929 (Couch 1929), and by the early 1930s the rabbit population had increased dramatically, especially within the American Camp unit of the park. In some years rabbits have inhabited over 1,000 ac (405 ha) of the prairie at American Camp and adjoining areas. Population size has been monitored since the early 1970s and has fluctuated since that time, but at any levels the non-native rabbit population poses a threat to native vegetation (NPS 2010). Rabbit population dynamics are discussed in detail in Section 4.9.

2.4.3. Climate Change

Climate change is already affecting natural resources and ecological systems at SAJH. Seabirds, marine mammals, and other marine life along the park's shorelines in particular are facing threats from ocean warming, acidification (Feely et al. 2012), and changing sea levels. Climate change is discussed in Section 4.2, and specific effects of climate change on ocean processes are discussed separately in Chapter 5.

2.5. Resource Stewardship

2.5.1. NPS Inventory and Monitoring Program

The park is included in the NPS Inventory and Monitoring (I&M) Vital Signs Program (Weber et al. 2009). To date, a relatively comprehensive inventory of the park's flora has been completed (Rochefort and Bivin 2010) as well as detailed mapping of vegetation associations (Rocchio et al. 2012). Vegetation response to controlled burns and invasive plant control efforts has been monitored to varying degrees.

Landbirds have been monitored along standard transects for over five years as reported by Siegel et al. (2006, 2007, 2008, 2009), Wilkerson et al. (2010), and Holmgren et al. (2011, 2012, 2013). Preliminary surveys have been conducted of intertidal fish (Fradkin 2004, Beamer and Fresh 2012), amphibians, and bats. No systematic surveys have been conducted of intertidal invertebrates, seaweeds, seagrasses, marine birds, marine mammals, terrestrial mammals, reptiles, or butterflies and other terrestrial invertebrates. Monitoring of visibility, air quality, and water quality and quantity has been very limited, and there has been no systematic monitoring of dark night sky or the park's soundscape.

2.5.2. General/Resource Plans and Natural Resource Documents

- *2014 – San Juan Island National Historical Park, Geologic Resources Inventory Report (Graham 2014)*. Graham summarized the geologic history, resources, and management issues for the park and provided an updated geologic map.

- *2008 – General Management Plan 2008 (NPS 2008)*. With relevance to natural resources, the SAJH GMP focused on a) protection of increasingly rare vegetation communities such as prairie, mixed coniferous and Garry oak; b) the coastal marine community; c) freshwater resources; and d) rare plants.

- *2006 – Assessment of Coastal Water Resources and Watershed Conditions at San Juan Island National Historical Park (Klinger et al. 2006)*. The predecessor to the NRCA, this WRCA summarized current knowledge regarding both freshwater and marine hydrologic resources, existing data, and ongoing management issues.

- *2005 – San Juan Island National Historical Park: Fire Management Plan-Environmental Assessment (Rankin 2005).* The FMP focused primarily on fire history and the role of applied fire in restoration of vegetation communities of conservation concern.

- *2004 – San Juan Island National Historical Park: An Environmental History (Avery 2004).* This report summarized both the historic natural landscape, as far as is known, and the interactions of humans with the natural environment of SAJH to the present (2004).

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Chapter 3. Study Scoping and Design

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 from the North Coast and Cascades Network (NCCN) and 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. Rawhouser, 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 and potential data sources. The study team then traveled to San Juan Island National Historical Park and discussed issues at both the American Camp and English Camp units.

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) with data and GIS analysis and support from Michael Ewald. The remainder of the second phase of the study was assessed and written primarily by Paul Adamus. The third phase included a review and modification of resource topics, (including the elimination of Natural Quality of the Park Experience), organization of the material into the required NPS NRCA structure, and additional writing and editing to update some topics. The third phase was coordinated by Marsha Davis (NPS) and the writing and editing 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 SAJH:

- Effects of European rabbits on vegetation and soil properties.
- Restoration of prairies.
- Occurrence and effects of exotic plants.

- Impacts from visitor use.
- Development around the park.
- Effects of global climate change.
- Impacts from oil spills and other catastrophic anthropogenic events.

As part of the scoping process for the NRCA, the above list was synthesized with more recent observations and concerns regarding natural resources, and ten focal natural resource themes selected for the SAJH NRCA:

- Shoreline erosion.
- Hillslope erosion (rill and gullying).
- Wetland and riparian areas.
- Invasive species (plant, animal) and areas with evidence of invasive plant or animal species.
- Fire regimes.
- Native plant restoration.
- Areas of pristine or old-growth vegetation.
- Habitat and populations of focal species; areas of focal species.
- Solitude and silence.
- Urban encroachment/rural development.

Both the NCCN and the SAJH lists presented above include stressors (e.g. effects of rabbits, invasive species) and elements of the visitor experience (e.g. solitude and silence) in addition to natural resouces. Because NRCAs are intended to assess conditions of natural resources and ecological processes only, subsequent discussions during the second and third phases of the project resulted in a reorganization of the selected focal natural resources around the ecological framework selected for the study.

3.2.2. Indicators and Reference Conditions

An ecological indicator is any measurable attribute that provides insights into the state of the environment and provides information beyond its own measurement (Noon 2003). Indicators are usually surrogates for properties or system responses that are too difficult or costly to measure directly. Indicators differ from estimators in that functional relationships between the indicator and the various ecological attributes are generally unknown (McKelvey and Pearson 2001).

Not all indicators are equally informative—one of the key challenges of an NRCA is to select those attributes whose values (or trends) provide insights into ecological integrity at the scale of the ecosystem (Kershner et al. 2011). In developing the list of indicators and specific measures, the team considered the idealized guidance of Harwell et al. (1999): “Useful indicators need to be understandable to multiple audiences, including scientists, policy makers, managers, and the public; they need to show status and/or condition over time; and there should be a clear, transparent scientific basis for the assigned condition.”

For the resource elements selected for the SAJH NRCA, indicators were identified based largely on those described for focal resources within the North Coast and Cascades Network’s Vital Signs planning process (Weber et al. 2009). Higher priority was assigned to reviewing data for indicators that were a) collected according to a standardized protocol, b) from multiple years and with the greatest time span, and/or c) from multiple locations within the park. The team assessed most indicators at the unit or park scale, although connections to regional conditions were noted where supported by previously published or our own analyses. Depending on the indicator being examined, the team often used either San Juan Island or San Juan County as the frame of reference for these comparisons.

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 pre-settlement historical conditions as best as they could be determined or surmised.

3.2.3. Ecological Framework

The team reviewed and considered several frameworks for organizing this NRCA effort and ultimately decided to follow the National Park Service Inventory and Monitoring Framework (Fancy et al. 2009). This framework assists in the selection of resource elements and subsequent ecosystem systheses by organizing all natural resouces and processes in a park (or other natural system) into five categories: Air and Climate, Geology and Soils, Water, Biological Integrity, and Ecosystem Pattern and Process.

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

Level 1 Category	SAJH Resource	Indicators
Air and Climate	Air Quality (Section 4.1)	• Visibility • Ozone • Nitrogen and Sulfur Deposition
	Climate (4.2)	• Temperature • Precipitation
Geology and Soils*	–	–

* Though no resource is included in the soils category, erosion of bluffs and shorelines is addressed in relation to several resources in Chapter 4.

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

Level 1 Category	SAJH Resource	Indicators
Water	Freshwater (4.3)	• Surface Water Quality • Surface Water Quantity (Flow) • Groundwater Quality • Groundwater Quantity (Levels)
Biological Integrity	Wetlands (4.4)	• Plant Species Composition
	Nearshore Resources (4.5)	• Extent of Kelp and Aquatic Plants (Seagrasses) • Intertidal Invertebrate Diversity • Forage Fish Diversity • Abundance of Juvenile Salmonids • Presence/Absence of Marine Mammals
	Native Plant Species of Concern (4.6)	• Abundance and Extent by Species
	Terrestrial Vegetation and Land Cover (4.7)	• Extent of Prairies • Plant Species Diversity in Prairies • Presence/Absence of Obligate Bird Species • Extent of Oak Woodlands • Coastal Strand Species Composition
	Birds (4.8)	• Species Diversity by Habitat • Presence/Absence of Rare and At-risk Species
	Vertebrates (4.9)	• Species Diversity of Amphibians and Reptiles • Species Diversity of Mammals • Presence/Absence of Invasive Species • Deer Abundance
Ecosystem Pattern and Processes	Habitat Integrity (4.10)	• Connectivity • Dark Night Sky • Natural Quiet

* Though no resource is included in the soils category, erosion of bluffs and shorelines is addressed in relation to several resources in Chapter 4.

3.2.4. Data and Methods

To identify relevant documents for review, the 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 park, searching with phrases such as "San Juan County," "Salish Sea," and "Georgia Strait." The team obtained complete digital copies (PDFs) of many publications that reported relevant research results from the park 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.

3.2.5. Reporting Areas

This park does not have large conventional watersheds due to its small size, relatively low topographic relief, and adjacency to marine waters. Therefore, as reporting areas the team chose the two park units (American Camp, English Camp), however, in most cases the information available was sufficient only to attempt a rating for the entire park rather than for these individual units.

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 SAJH. 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/tradnrca.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 Figure 5.1.

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

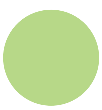
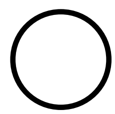
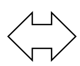
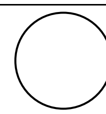
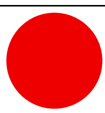
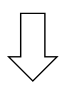
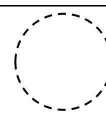
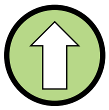
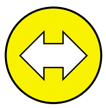
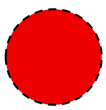
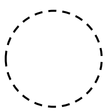
Condition Status		Trend in Condition		Confidence in Assessment	
Condition Icon	**Condition Icon Definition**	**Trend Icon**	**Trend Icon Definition**	**Confidence Icon**	**Confidence Icon Definition**
	Resource is in Good Condition		Condition is Improving		High
	Resource warrants Moderate Concern		Condition 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	Verbal Description
	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

The report is presented in the format required by the NPS NRCA 2017 guidelines (https://www.nps.gov/orgs/1439/tradnrca.htm) with a few exceptions. Because the project was initiated prior to the development of some of the revised and updated guidelines, not all sections are presented as directed by the most recent report templates, though all of the information required is included. The report outline used for each resource category assessed in Chapter 4 is as follows:

<u>4.X Resource Name and Descriptive Condition Summary</u>

Condition Summary

This section briefly summarizes the condition findings including a composite graphic from the symbols shown in Table 3.2, in accordance with the NPS NRCA guidelines (https://www.nps.gov/orgs/1439/tradnrca.htm). A brief descriptive summary of condition is provided at the beginning of each Section in Chapter 4, and a summary for all resources is discussed and presented graphically in Chapter 5 and Figure 5.1.

<u>4.X.1 Background and Importance</u>

This section provides information regarding the relevance of the resource to the park and explains the characteristics of the resource that help the reader understand subsequent sections of the document.

<u>4.X.2 Reference Conditions</u>

This section describes the indicators for each resource and the reference conditions that will be compared with current indicator values. Ideally the indicators and reference conditions are selected because they provide information about the resource and not because there are particular data available.

4.X.3 Data and Methods
This section describes the existing datasets used for evaluating the indicators and methods used for processing or evaluating the data (where applicable). In many cases the most appropriate and relevant data were not available.

4.X.4 Resource Condition and Trend
This section provides a summary of the condition and trend of the resource based on available literature, data, and expert opinions. This section highlights the key elements used in defining the condition and trend designation represented by the condition/trend graphic located in Table 5.1.

4.X.5 Level of Confidence
This section presents the level of certainty ascribed to the assessment based on available data, published and unpublished literature and expert opinion.

4.X.6 Data Gaps and Research Needs
This section discusses the information and data that were not available for the assessment but which the authors and/or other experts feel are needed to provide a rigorous and scientific basis for future assessments.

4.X.7 Sources of Expertise
If there were subject matter experts who provided information for the assessment but who are not authors they are identified here.

4.X.8 Literature Cited
All literature referenced in each Section of Chapter 4 is provided.

3.3. Literature Cited

Fancy, S.G., Gross, J.E. and Carter, S.L., 2009. Monitoring the condition of natural resources in US national parks. Environmental Monitoring and Assessment, 151(1), pp.161–174.

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Weber, S., A. Woodward, and J. Freilich. 2009. North Coast and Cascades network vital signs monitoring report (2005). Natural Resource Report NPS/NCCN/NRR—2009/098. National Park Service, Fort Collins, CO.

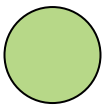
Chapter 4. Natural Resource Conditions

4.1. Air Quality and Air Quality Related Values

By Tonnie Cummings

4.1.1. Condition Summary

Air quality at SAJH is generally good, though visibility warrants moderate concern. Overall the degree of confidence is medium because estimates are based on interpolated data from more distant monitors. No trends are apparent.



4.1.2. Background

Air quality is a fundamental resource of all units of the National Park System. It affects human health and visitor enjoyment, and good air quality helps ensure the integrity of park resources and values. 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 San Juan Island National Historical Park (SAJH), 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 in Class II areas. Air quality related values are resources sensitive to air pollution and include visibility, lakes, streams, vegetation, soils, and wildlife.

<u>Air Pollutants and Sources</u>

There are many sources of air pollution; some are natural and some are anthropogenic, i.e., human-caused. Air pollutants of concern include sulfur and nitrogen compounds, fine particulates, ground-level ozone, and persistent bioaccumulative toxics, such as mercury. Potential effects include visibility impairment; ozone-induced human health problems and damage to vegetation; aquatic and terrestrial acidification and eutrophication; and neurological, respiratory, and other health issues associated with exposure to toxins.

The NPS focuses on reducing the impact of anthropogenic pollution on park resources. Most human activities, including manufacturing and industrial processes, agricultural practices, land disturbance, and fossil fuel combustion, produce air pollution. San Juan Island National Historical Park 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 park (Figure 4.1-1). Trans-Pacific transport is also a significant source of air pollution to the west coast of North America (Yu et al. 2012).

The main source of sulfur pollution is coal combustion at power plants and industrial facilities. Oxidized nitrogen compounds (i.e., nitrogen oxides) result from fuel combustion by vehicles, power plants, and industry. Reduced nitrogen compounds (e.g., ammonia and ammonium) are the result of agricultural activities, fire, and other sources. Ozone is formed 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 and organic compounds such as pesticides. Coal combustion, incinerators, mining processes, and other industries emit mercury.

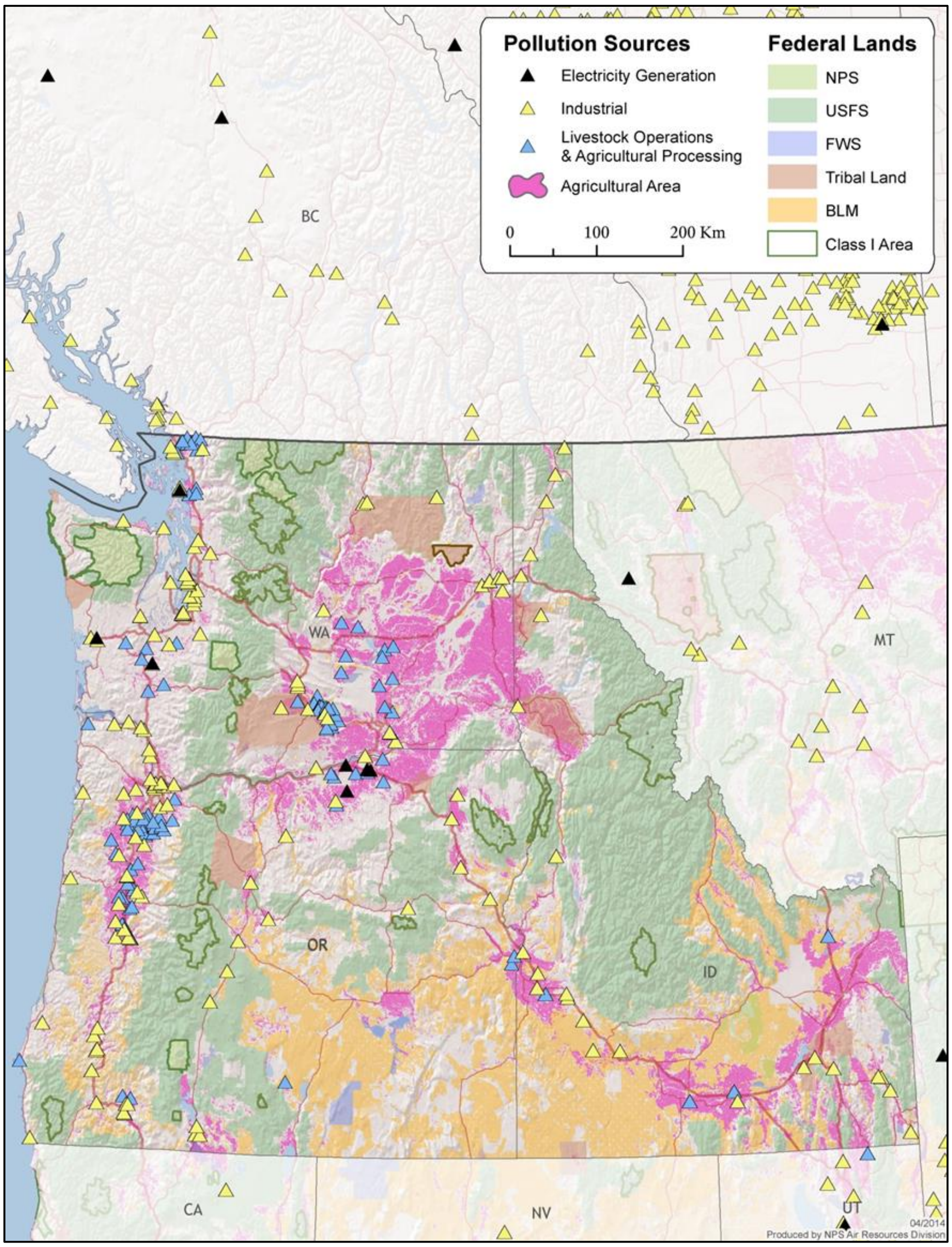


Figure 4.1-1. Public lands and air pollution sources in the Pacific Northwest. Triangles designate point sources that emit greater than 100 tons per year of nitrogen oxides (from Cummings et al. 2014).

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 (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 (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.

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.

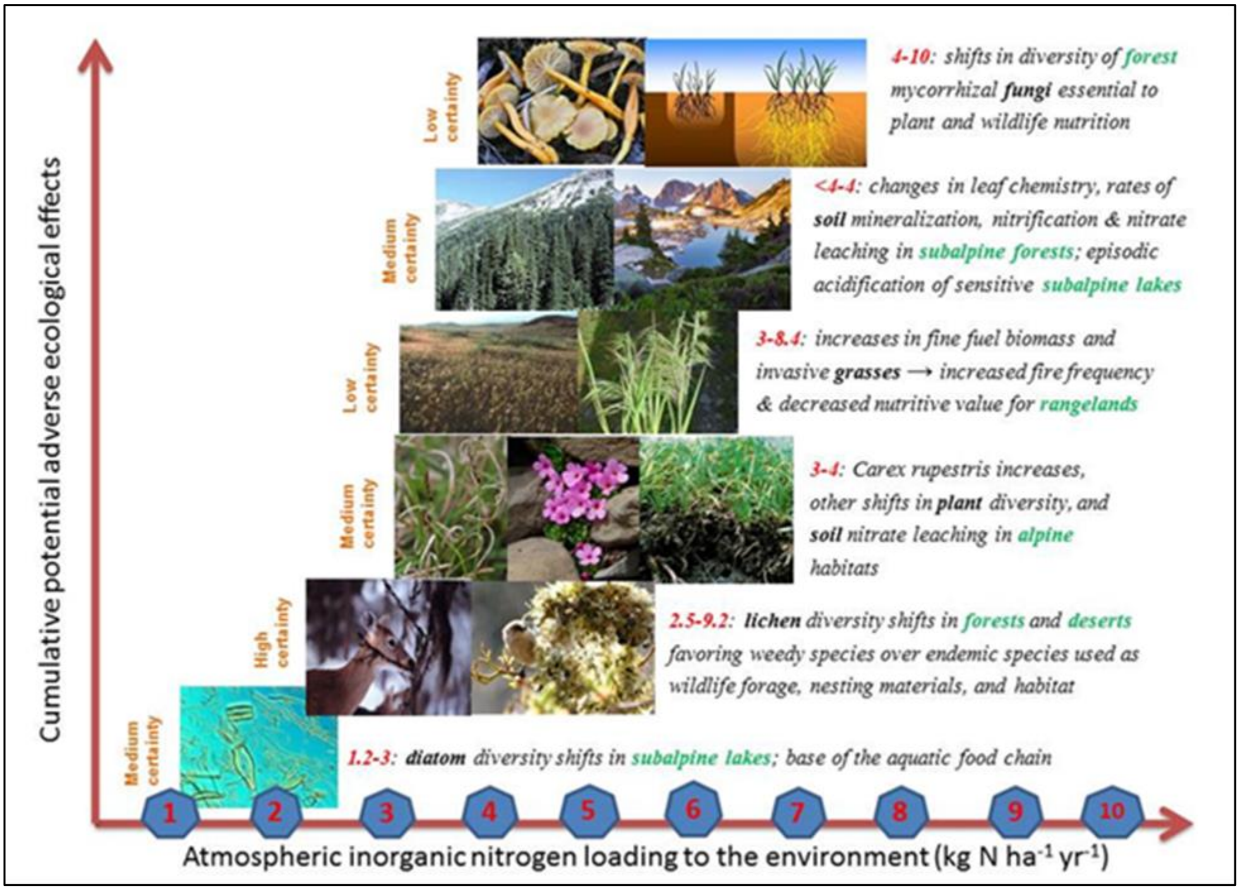


Figure 4.1-2. Cumulative potential adverse ecological effects associated with atmospheric nitrogen deposition in the Pacific Northwest. The reliability assessments are as follows: High Certainty when a number of published papers of various studies show comparable results, Medium Certainty when the results 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).

4.1.3. 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*
Deposition	Sulfur wet deposition
	Nitrogen 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 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 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 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, EPA has not set a secondary standard that focuses on vegetation. However, in its recent policy assessment of the ozone standards, EPA discussed use of the W126 to assess plant response (EPA 2014). The W126 preferentially weights the higher ozone concentrations most likely to affect plants and sums all of 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 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

<u>Nitrogen and Sulfur Deposition</u>

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

4.1.4. 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 park.

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 (CEC 1997). San Juan Island National Historical Park is located in the Marine West Coast Forests ecoregion, and critical loads have been identified for three out of five terrestrial ecosystem components in that ecoregion: forests (i.e., trees and soils), lichen and bryophytes, and mycorrhizal fungi. Critical loads were compared to estimated total nitrogen deposition to identify possible exceedances. An exceedance suggests increased potential of ecological harm.

4.1.5. Resource Condition and Trend

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

<u>Visibility</u>

Estimated average visibility on mid-range days at SAJH was 9.7 dv. Subtracting the park's estimated natural visibility of 5.1 dv on mid-range days, the assumed contribution from human-caused haze was 4.6 dv. Compared to ARD's benchmarks, visibility at SAJH warranted moderate concern.

<u>Ozone</u>

The 4th-highest daily maximum 8-hour ozone concentration for SAJH was 52.9 ppb, which is well below both the former primary National Ambient Air Quality Standard of 75 ppb as well as the new

70 ppb value. The maximum 3-month 12-hour W126 was 1.6 ppm-hrs, which is much lower than levels known to harm vegetation, i.e., 7–13 ppm-hrs. Compared to ARD benchmarks for ozone, human health and vegetation were in good condition. Kohut (2004) assessed the risk of ozone-induced foliar injury at all Inventory and Monitoring parks based on species sensitivity, ozone concentrations, and soil moisture (which influences ozone uptake). He concluded there was low risk of ozone injury at SAJH.

Deposition

Estimated wet nitrogen deposition at SAJH was 0.4 kg ha^{-1} yr^{-1}. Compared to ARD deposition benchmarks, this level indicates nitrogen deposition was in good condition. However, estimated sensitivity to nitrogen nutrient enrichment ranked high at SAJH relative to all Inventory and Monitoring parks (Sullivan 2016) because studies indicate added nitrogen can favor exotic species over native prairie vegetation. Estimated wet sulfur deposition at the park was 0.4 kg ha^{-1} yr^{-1}, a level that indicates good condition compared to ARD deposition benchmarks. San Juan National Historical Park was ranked as having very low sensitivity to acidification relative to other Inventory and Monitoring parks (Sullivan 2016). Based on the estimated 2010–2012 total average nitrogen deposition at SAJH of 2.5 kg ha^{-1} yr^{-1}, it does not appear minimum nitrogen critical loads were exceeded for any terrestrial ecosystem components (Table 4.1-6).

Table 4.1-6. Estimated 2010–2012 three-year average total (i.e., NADP-NTN monitored wet plus modeled dry) nitrogen deposition and minimum critical loads for five terrestrial ecosystem components at San Juan Island National Historical Park (from NPS 2016a).

Ecoregion	Total Nitrogen Deposition	Forests*	Herbaceous plants and shrubs	Lichens and bryophytes	Mycorrhizal fungi	Nitrate Leaching
Marine West Coast Forests	2.5	5.0	NA	2.7	5.0	NA

* Trees and soils

Summary of Air quality conditions at SAJH:

- Visibility warrants moderate concern. The degree of confidence is medium because estimates are based on interpolated data from more distant monitors.
- Ozone is in good condition for human health. The degree of confidence is medium because estimates are based on interpolated data from more distant monitors.
- Ozone is in good condition for vegetation health. The degree of confidence is medium because estimates are based on interpolated data from more distant monitors.
- Nitrogen deposition is in good condition. The degree of confidence is medium because estimates are based on interpolated data from more distant monitors.
- Sulfur deposition is in good condition. The degree of confidence is medium because estimates are based on interpolated data from more distant monitors.

4.1.6. Level of Confidence

Medium

4.1.7. Data Gaps and Research Recommendations

- Sullivan (2016) indicated nitrogen enrichment may be a concern at SAJH. Conducting a nitrogen fertilization experiment in the prairie ecosystem could confirm if deposition is affecting park native vegetation.

- It is not clear how climate change will affect air pollution levels and effects on air quality related values at SAJH. Changes in precipitation amount and timing could affect deposition of sulfur, nitrogen, and persistent bioaccumulative toxics. Increased temperature and changes in precipitation patterns could enhance nitrogen deposition-associated effects on plant biodiversity and nutrient cycling in ecosystems (Cummings et al. 2014). Changes in agricultural practices in response to weather patterns or pests could result in additional pesticide deposition at SAJH. Increased summertime temperatures may lead to higher ozone levels (EPA 2009).

- Data indicate that Tran-Pacific air pollution is increasing (Lin et al. 2014). While there are encouraging reports recently that China is taking steps to reduce emissions, it is unclear the degree to which these changes will resolve concerns across all air pollutants, and whether other nations upwind of SAJH will also strengthen emission controls.

4.1.8. Source(s) of Expertise

- Tonnie Cummings, Air Quality Specialist, National Park Service, Pacific West Region

- 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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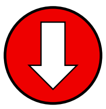
4.2. Regional and Local Climate

By Catherin Schwemm, Paul Adamus and Anna Packenham

4.2.1. Condition Summary

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 declining, and confidence in this assessment is high.



4.2.2. 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).

<u>Pacific Decadal Oscillation and El Nino Southern Oscillation</u>

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). It is a dynamic ocean-atmosphere coupled climate phenomenon. 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. The El Nino Southern Oscillation (ENSO) describes the part of the coupled system’s interaction between the ocean and atmosphere in the tropical latitudes in the Pacific Ocean, especially the eastern and central part, which consequently influence climate variations at higher latitudes in the Americas. ENSO transitions in a shorter, quasi-periodic variation between three phases: warm (positive; El Nino), cold (negative; La Nina) and neutral.

In recent decades ENSO has been identified as one of the primary drivers of climate in the PNW (Abatzoglou et al. 2014). 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 Mantua and Hare (2002) and Newman et al. (2016).

In general during El Nino years winter sea surface temperatures in Puget Sound are higher than average (Moore et al. 2008, PSEMP 2016). As a result, weather conditions in the Pacific Northwest are usually warmer and dryer during these periods (Mote et al. 2014). Mote et al. (2003) found that the North Pacific Index (NPI), which reflects the variability of both the PDO and ENSO and their influence on atmospheric circulation in the region, accounts for about 40% of the 20th century warming trend in winter months, but has very little influence over the trends observed in other seasons (all of which contribute to the average annual temperature).

4.2.3. Reference Conditions

Given the realities of climate change it is not possible to determine reference conditions for climate variables at SAJH. (The general climate of SAJH 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 SAJH are average annual and seasonal temperatures and total precipitation, and these two climate elements will be used as indicators for assessing climate. (Changing ocean conditions also have the potential to strongly affect park resources; these are addressed in Section 4.5 and Chapter 5.) Because the requirements of the park'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.

4.2.4. Data and Methods

There are no weather stations at the park that have sufficient long-term data to describe past conditions or trends in temperature or precipitation. (A station located at English Camp has been collecting data only since 2008; Baccus and Huff 2013). As a proxy, data from the Olga weather station on Orcas Island (“Olga”), approximately 14 mi (22 km) northeast of American Camp and the same distance east of English Camp, were utilized as the nearest source of sufficient long-term records (Davey et al. 2007). The full-time series from Olga is the period 1893–2012, with 7% of the months during the period lacking precipitation data.

However, because these data cannot be used to calculate meaningful trends for park sites, spatially interpolated averages were generated by the PRISM Climate Group models at Oregon State University (Daly et al. 2008; Daly et al. 2009) for the years 1971–2000 to obtain estimates for these indicators. Two spatial climate data sets from PRISM were used. The first dataset is an 800-m resolution gridded monthly time series of mean maximum and minimum temperature and total precipitation for the conterminous United States that covers the period January 1895 through December 2007.

The second dataset is the 400-m resolution gridded monthly climate normals from 1971–2000. Monthly grids of mean maximum and minimum temperature and total precipitation are used to assess the spatial characteristics in annual and seasonal (winter, spring, summer, and fall) for the two units of the park. For the 1971–2000 climate normal maps, the data are further summarized by minimum, maximum, median, and quartiles (25%, 75%) for all grids that fall within each park boundary. The climate indices were calculated using the "climdex.pcic" R package (version 1.0-3), linear regressions were fit using the R "lm" command, and loess smoother applied to obtain the smoothed lines in Figures 4.2-1 and 4.2-2.

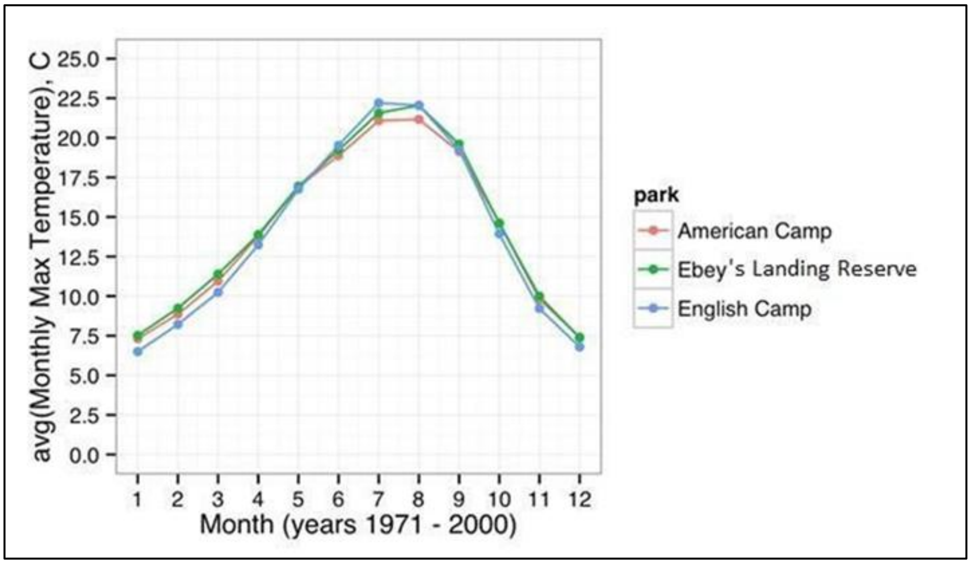


Figure 4.2-1. Mean monthly maximum temperature from the modeled PRISM 30-year climate normals (this study).

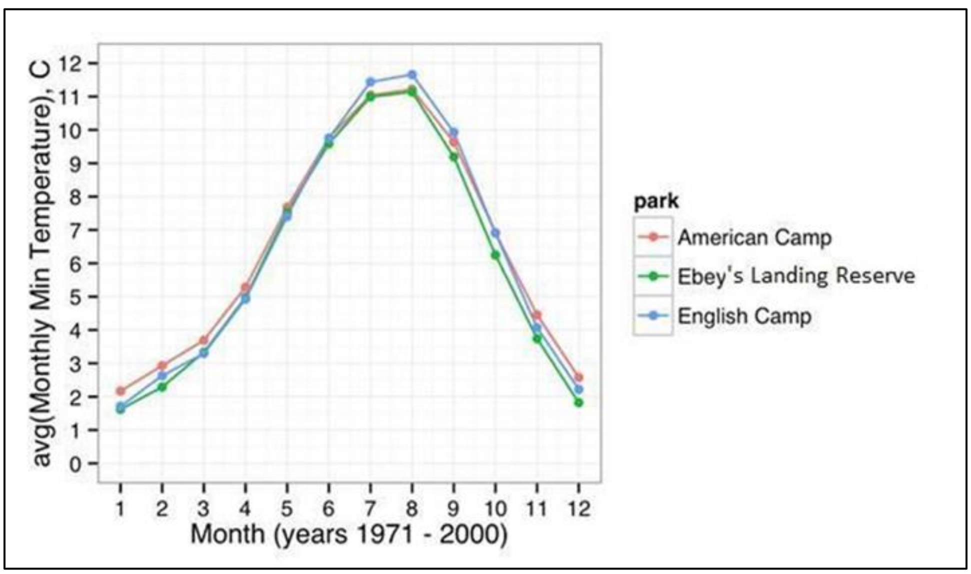


Figure 4.2-2. Mean monthly minimum temperature from the modeled PRISM 30-year climate normals (this study).

Finally, until recently, there was little standardization of the indices that climatologists calculated to describe specific aspects of temperature and precipitation. Recognition emerged that analysis of average climate conditions, while important, may not be as critical as understanding the change in the frequency or severity of extreme climate events. In response, the CCl/CLIVAR/JCOMM Expert Team (ET) on Climate Change Detection and Indices (ETCCDI) developed a suite of 41 indices (Tables 4.2-1) for use in understanding the behavior of climate at a given station (Karl et al. 1999; Wang et al. 2003; Peterson 2005). Accurate computation of these indices requires accounting for the many gaps (e.g., measurements missing erratically from various months) that typify most long-term climate records. The ETCCDI has a tool that checks for such gaps as well as addressing outliers (unrealistic values, bad data points, etc.) that could bias an analysis (Peterson et al. 1998). This tool was utilized in the trends analyses described here.

Table 4.2-1. The 27 core climate indices from CCl/CLIVAR/JCOMM Expert Team (ET) on Climate Change Detection and Indices (ETCCDI). From Karl et al. 1999, Peterson 2005.

Attribute	Code	Indicator Name	Definition	Units
Temperature	FD0	Frost Days	Annual count when TN(daily minimum)<0°C	Days
	SU25	Summer Days	Annual count when TX(daily maximum)>25°C	Days
	SU35	Stress Days	Annual count when TX(daily maximum)>35°C	Days
	ID0	Ice Days	Annual count when TX(daily maximum)<0°C	Days
	TR20	Tropical Nights	Annual count when TN(daily minimum)>20°C	Days
	GSL	Growing season Length	Annual (1st Jan to 31st Dec in NH) count between first span of at least 6 days with TG>5°C and first span after July 1 (NH) of 6 days with TG<5°C	Days
	TXx	Max Tmax	Monthly maximum value of daily maximum temperature	°C
	TNx	Max Tmin	Monthly maximum value of daily minimum temperature	°C
	TXn	Min Tmax	Monthly minimum value of daily maximum temperature	°C
	TNn	Min Tmin	Monthly minimum value of daily minimum temperature	°C
	TN10p	Cool nights	Percentage of days when TN<10th percentile	Days
	TX10p	Cool days	Percentage of days when TX<10th percentile	Days
	TN90p	Warm nights	Percentage of days when TN>90th percentile	Days
	TX90p	Warm days	Percentage of days when TX>90th percentile	Days
	WSDI	Warm spell duration indicator	Annual count of days with at least 6 consecutive days when TX>90th percentile	Days
	CSDI	Cold spell duration indicator	Annual count of days with at least 6 consecutive days when TN<10th percentile	Days
	DTR	Diuranal temperature range	Monthly mean difference between TX and TN	°C

Table 4.2-1 (continued). The 27 core climate indices from CCI/CLIVAR/JCOMM Expert Team (ET) on Climate Change Detection and Indices (ETCCDI). From Karl et al. 1999, Peterson 2005.

Attribute	Code	Indicator Name	Definition	Units
Precipitation	RX1day	Max 1-day precipitation amount	Monthly maximum 1-day precipitation	Mm
	Rx5day	Max 5-day precipitation	Monthly maximum consecutive 5-day precipitation	Mm
	SDII	Simple daily intensity index	Annual total precipitation divided by the number of wet days (defined as PRCP>=1.0mm) in the year	Mm/day
	R10	Number of heavy precipitation days	Annual count of days when PRCP>=10mm	Days
	R20	Number of very heavy precipitation days	Annual count of days when PRCP>=20mm	Days
	Rnn	Number of days above nn mm	Annual count of days when PRCP>=nn mm, nn is user defined threshold	Days
	CDD	Consecutive dry days	Maximum number of consecutive days with RR<1mm	Days
	CWD	Consecutive wet days	Maximum number of consecutive days with RR>=1mm	Days
	R95p	Very wet days	Annual total PRCP when RR>95th percentile	Days
	R99p	Extremely wet days	Annual total PRCP when RR>99th percentile	Mm
	PRCP TOT	Annual total wet-day precipitation	Annual total PRCP in wet days (RR>=1mm)	mm

4.2.5. Resource Condition and Trend

Temperature

During the twentieth century, from 1895–2011, average temperatures across the PNW increased by approximately 1.3°F/0.7°C, with most of the increase occurring since about 1970 (Mote et al. 2014, IPCC 2014). Since 1880, the 10 warmest years globally have occurred since 1998 (https://www.ncdc.noaa.gov/sotc/global/201613). Winter months warmed 2.7°F/1.5°C on average since 1950 (Hamlet et al. 2007), while average spring and summer temperatures for 1987 to 2003 were 1.6°F/0.9°C 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).

There was approximately a 2.3°F/1.3°C warming during the last century in the Puget Sound region (Mote et al. 2005, Melillo et al. 2014). Most 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). Indicators also showed increased temperatures of coldest nights (TN10p), longer freeze-free season (FD0), and increased evapotranspiration potential during the growing season (Abatzoglou et al. 2014, Table 4.2-1). However, a non-significant but noticeable cooling trend was observed during spring from 1980 to 2012 (Abatzoglou et al. 2014).

Historical maximum and minimum temperature compilations from Olga data are shown in Figures 4.2-3 and 4.2-4, respectively, and additional calculations summarized in Table 4.2-2. Trends found to be statistically significant ($p<0.10$) for either the recent period 1971–2013 or the full historic time series (1891–2013) are listed below; indices or trends not listed (but presented in Table 4.2-1) were not significant. In summary, 10 of the 17 temperature indices from Olga data showed a statistically significant warming trend for the historic period, the recent period, or both.

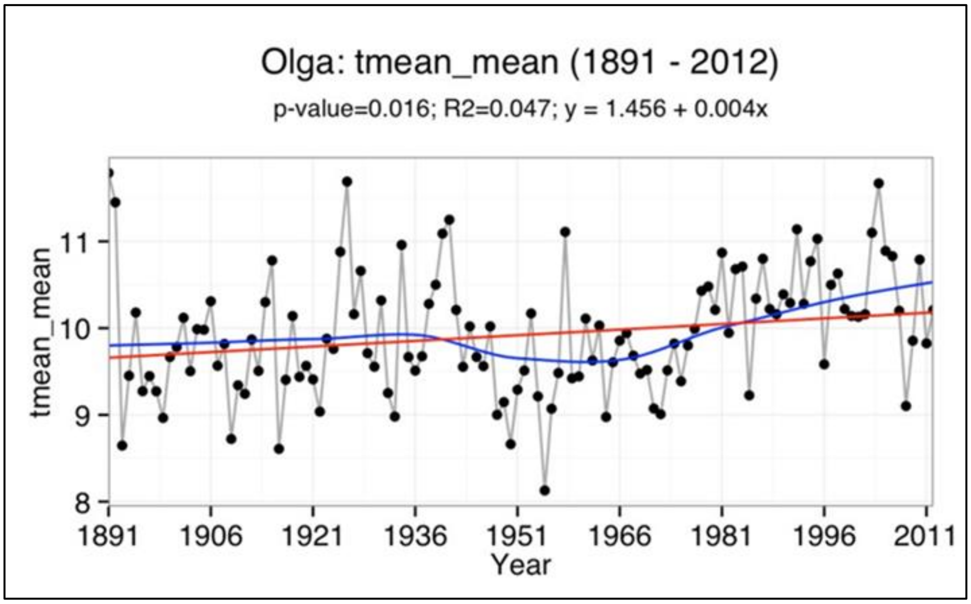


Figure 4.2-3. Annual mean daily temperature at Station Olga for 1891–2012.

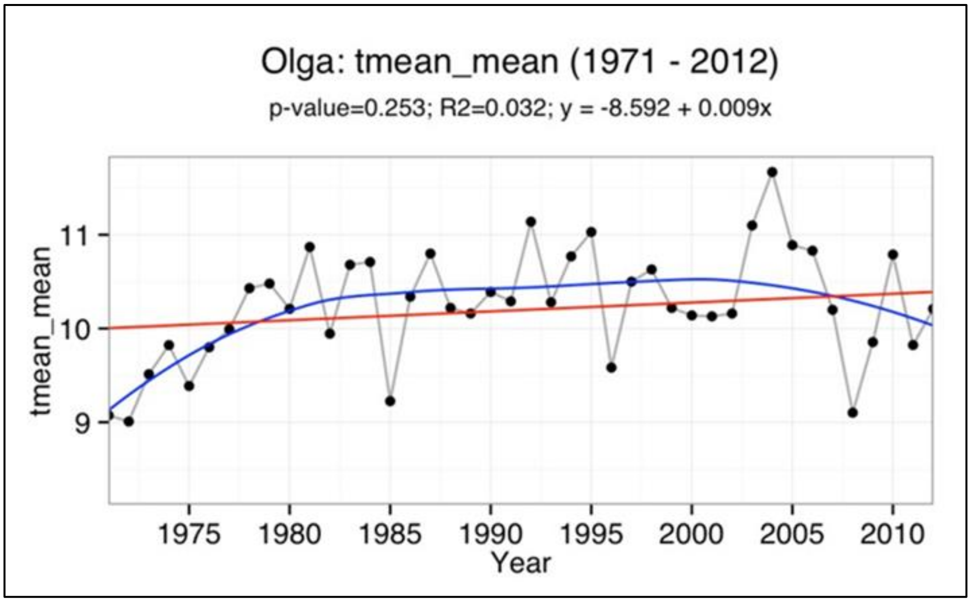


Figure 4.2-4. Annual mean daily temperature at Station Olga for 1971–2012.

Table 4.2-2. Temperature trends determined from Station Olga (Orcas Island) data. The historic time series is 1891–2013, the recent period is 1971–2013.

Measure	Trend per year (°F/°C)	Period
Annual mean daily mean	↑ 0.02°/0.01°	Historic
	↑ 0.07°/0.04°	Recent
Annual mean daily max	↑ 0.02°/0.01°	Historic
	↑ 0.04°/0.02°	Recent
Monthly minimum value of daily maximum	↑ 0.02°/0.01°	Historic
Monthly maximum value of daily maximum	↑ 0.02°/0.01°	Historic
diurnal temperature range (monthly mean difference between daily max and daily min)	↑ 0.02°/0.01°	Historic
	↑ 0.04°/0.02°	Recent
# of ice days (daily max less than 0°C/32°F	↓ 0.017 days	Recent
	No change	Historic
# days daily max>25°C/77°F	↑ 0.03 days	Historic
	↑ 0.18 days	Recent
# warm days (days temperature exceeded the 90th percentile)	↑ 0.06 days	Historic
	↑ 0.19 days	Recent

Future Temperatures

Nearly all climate models predict that average temperatures in the PNW will increase measurably 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°F/0.1–0.6°C per decade, with a best estimate of 0.5°F/0.3°C per decade (IPCC 2014). For comparison, warming in the second half of the last century was approximately 0.4°F/0.2°C per decade (Mote et al. 2008, 2014). Models incorporating scenarios with continued high CO_2 emissions generally converge on a 5–11°F/3–6°C 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).

Historical compilations of precipitation from Olga data are shown in Figures 4.2-5 (maximum number of consecutive wet days (precip >=1mm 1971–2011) and 4.2-6 (annual number of days of heavy precipitation (>= 10mm) 1891–2012). Trends from Olga data found to be statistically significant ($p<0.10$) for either the period 1971–2012 or the full time series are listed in Table 4.2-3; indices or trends not listed below were not significant. Mean annual precipitation, the total number of days with precipitation, and the number of very heavy precipitation days were all less in the recent decade than from 1994–2003. For both periods – recent and historical – six of the 11 precipitation indices calculated from Olga data showed progressively drier conditions, one (CDD) showed wetter conditions, and one index (SDII) did not exhibit a trend. PRISM analysis results for mean monthly precipitation are presented in Figure 4.2-3.

Table 4.2-3. Precipitation trends determined from Station Olga (Orcas Island) data. The historic time series is 1891–2013, the recent period is 1971–2013.

Measure	Trend (per year)	Period
Monthly max 1-day precipitation	↓ 0.01 mm	Historic
Monthly max 5-day precipitation	↓ 0.03 mm	Historic
# heavy precipitation days (precip >= 10mm)	↓ 0.05 days	Historic
# very heavy precipitation days (precip >= 20mm)	↓ 0.01 days	Historic
# consecutive dry days	↓ 0.07 days	Historic
# consecutive wet days	↓ 0.09 days	Recent
simple daily intensity index	↓ 0.007	Historic
	↑ 0.016	Recent

Annual maximum number of consecutive wet days at Olga for 1971–2011 are presented in Figure 4.2-5, and the annual number of days with heavy precipitation presented in Figure 4.2-6.

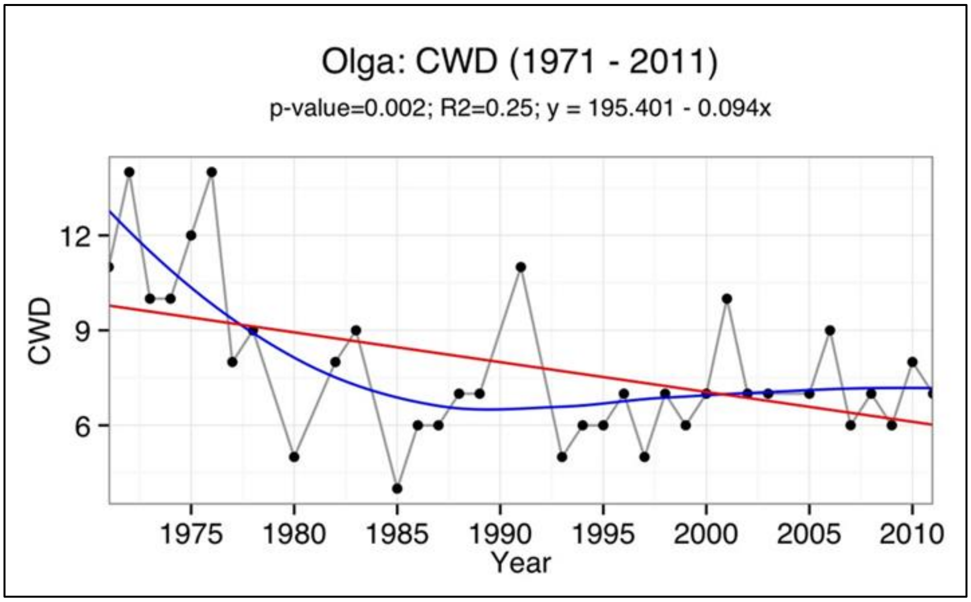


Figure 4.2-5. Annual maximum number of consecutive wet days (precip >=1mm) at Station Olga for 1971–2011.

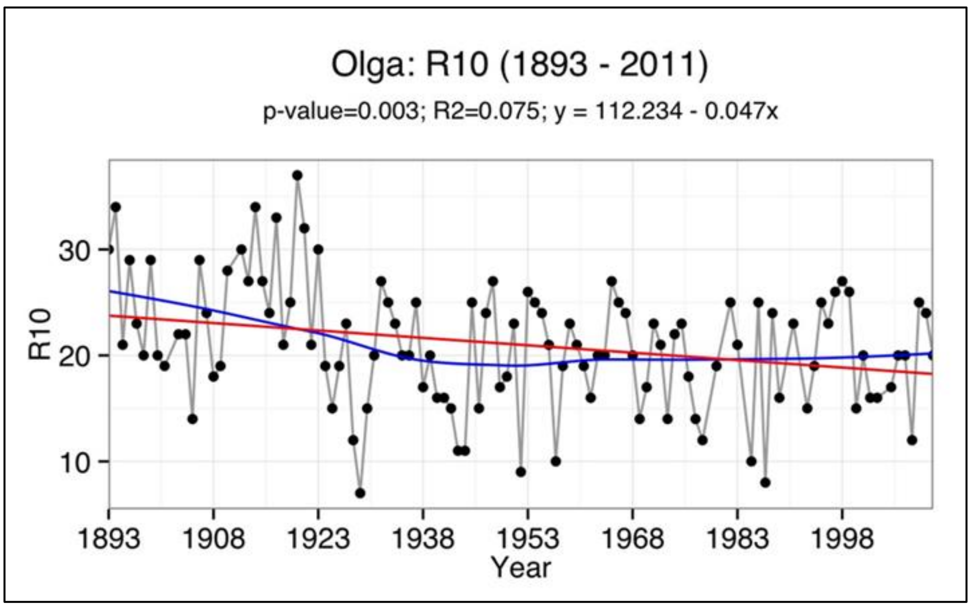


Figure 4.2-6. Annual number of days of heavy precipitation (>= 10mm) at Station Olga for 1891–2012.

4.2.6. Level of Confidence

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

4.2.7. 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 park's flora and fauna to long-term changes in temperature and precipitation remain unknown.

- The degree to which Station Olga data located 14 miles away represents accurately the trends in precipitation and temperature in either or both of the park's units remains undetermined, particularly given the important microclimatic difference between American Camp and English Camp (Section 2.1.2). Records from the station installed in 2008 at English Camp will provide important climate data from within the park and maintenance and support of this station should continue.

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- Greg Jones, Oregon State University, Department of Chemistry, Corvallis, OR
- Michael Ewald, Institute for Applied Ecology, Corvallis, OR

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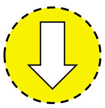
4.3. Freshwater Resources

By Paul Adamus and Catherin Schwemm

4.3.1. Condition Summary

Very little is known regarding surface water quality or flow, though there are no indications that either measure is of increasing concern. There are concerns regarding the potential for increasing saltwater intrusion into groundwaters. Groundwater supply appears to be declining due to increasing demand. Confidence in the condition of either surface or groundwater resources at SAJH is low.



4.3.2. Background

Surface Waters

American Camp

Nearly all surface waters at American Camp flow into the park from higher elevations to the northwest through mostly undeveloped woodland. There are no freshwater lakes, large ponds, or perennial streams within AC but there are several springs, small wetlands and short reaches of seasonal flow (NPS 1995), including a small pond on the north side of Mt. Finlayson (M. Davis, pers. comm. April 18, 2018). A channelized stream approximately 500 ft. (152 m) to the north and generally parallel to the park boundary separates American Camp from the Burden Field (Rabbit Run) air strip further north, and eventually flows into Griffin Bay. East-sloping topography on the unit’s east side shields the park from surface runoff originating in the Cattle Point residential developments to the east. There is a small (~0.3 acres/0.1 ha) wetland (though the largest at AC) between Jakles and Third lagoons (Graham 2014), and a very small one (0.07 acres/0.03 ha) near the American Camp visitor center (S. Dolan pers. comm. 2019).

English Camp

A shallow, seep-fed seasonal stream is present just below the highway on the west flank of Young Hill that adjoins the foot trail from the parking lot to Young Hill. The stream passes around the parking lot and flows toward Crook House. The area around the stream is boggy with hydrophilic vegetation. Water flow spreads out and infiltrates when it reaches the gently sloping parade grounds along the Garrison Bay shoreline.

Another wetland is located north of the parade grounds in a topographic depression between Belle Point to the west and the lower west flank of Young Hill. Shallow standing water levels fluctuate seasonally and are drained by a small channel flowing north into Westcott Bay. South of the parade grounds a few short, storm runoff activated intermittent streams flow over a bedrock escarpment into the southern-most part of Garrison Bay (M. Davis pers. comm. 2018).

Mitchell Hill contains three first-order channels, two of which originate outside the park, with a collective length of approximately 1.7 mi (2.7 km). One of the channels is usually perennial, and all three join together approximately one-half mile downslope from the park’s west boundary and then flow eventually into Garrison Bay. The two channels that originate outside the park are shaded by forest for the entire length. About 0.3 mi (0.4 km) north of the English Camp park boundary, a separate, mostly-wooded stream feeds into Westcott Bay.

Quality of Surface Waters

Concerns regarding surface water quality have been raised periodically since the park was established (Klinger et al. 2006, NPS 2008). San Juan Island currently has no large commercial or industrial developments, dairy farms, or livestock feedlots, which are common sources of freshwater contaminants, but very little is known about the quality of the limited surface waters in SAJH.

Groundwater

Groundwater must be recharged by fresh water from precipitation and infiltration at a faster rate than it is withdrawn or source aquifers will either go dry or become saline via saltwater intrusion. All groundwater recharge on SJI comes from precipitation and occurs primarily between October and April (Graham 2014). Average annual recharge rates on San Juan Island are relatively low, at English Camp approximately 1.0–4.0 in (2.5–10.2 cm) per year, and at American Camp 1.0–3.5 in (2.5–8.9 cm) per year (Orr et al. 2002, Klinger et.al. 2006). A reduction in vegetated surfaces decreases recharge because water evaporates or flows away much faster when it falls on non-porous surfaces (Harbor 1994, O'Driscoll et al. 2010). Collectively the two SAJH units include 30.1 acres (12.2 ha) of roads, parking lots, buildings, and bare terrestrial areas, as well as 15.4 acres of mowed lawn (Rocchio et al. 2012).

Because of minimal fresh surface water supplies, groundwater is a critical source of drinking water for all of SJI (Graham 2014). Groundwater additionally feeds all the springs and likely many of the wetlands to some extent and may connect to one or more of the lagoons (Graham 2014). At American Camp there is one well that draws groundwater to supply the needs of the visitor center. Three shallow community wells that lie just outside the east boundary of American Camp tap an aquifer beneath the park's Mount Finlayson and provide the main source of water for approximately 270 residences. At English Camp, water is drawn from aquifers by means of two wells, each of which have relatively low yields. One was drilled in 2000 to supply the needs of the maintenance facility including a low-water washing machine, two sinks, and one toilet; this water is not potable. A second well supplies water to the drinking fountain in the parking lot, two trailer pads, and a group campsite used during the summer.

Groundwater Quality

Toxic materials and other contaminants introduced to surface water sources have the potential to directly enter the groundwater system (SJC 2004, Graham 2014). Saltwater intrusion into groundwaters is a particularly serious concern of park mangers. When groundwater levels near the ocean are below or near sea level, saltwater can flow into aquifers making the subterraining groundwater too saline for human consumption and harmful to freshwater organisms (Barlow and Reichard 2010). During dry summer months groundwater supplies can be depleted to the point where wells are unusable and may become susceptible to saltwater intrusion (Graham 2014). Increasing the withdrawals of groundwater, or decreasing recharge by covering the ground with extensive areas of impervious surface (buildings, roads), will eventually cause most groundwater that is withdrawn within about 1,000 ft (305 m) of the marine shore to become unpalatable. Drawdown of the aquifer from high use during dry recharge periods can result in saltwater intrusion of the portion of the aquifer that will later refill with fresh water during wetter seasons. This usually results in residual saline deposits adhering to the pore spaces contaminating the recharging fresh groundwater to varying degrees of brackishness, thus rendering adverse potability.

Threats to Freshwater Resources

The relatively low amounts of rainfall that the island receives means that surface water sources are not always perennial and groundwaters are not always recharged at rates that balance withdrawals (Orr et al. 2002). If the present century-long trend toward warmer and drier conditions in the park continues (Section 4.2), freshwater resources could be impacted. Water quality at other locations on the island is affected by low summer instream flows, grazing, pesticide use, and road runoff (Barsh et al. 2010).

Increasing populations on the island will likely exert greater pressure on the groundwater resource (Adolphson 2014). At American Camp, NPS maintains a water right to pump 3.5 gallons per minute or 5,000 gallons per day for use at the visitor center. This supply is sufficient for current needs, but the water tests high in total suspended solids and chloride rendering it undesirable as drinking water. In accordance with NPS policy, park managers continue to deny requests for water from adjacent landowners/developments to access water from within park boundaries due to the possibilities of exhaustion of park freshwater supplies and detrimental effects on water-dependent resources (NPS 2008). There has been at least one situation in the past when well levels were so low during the summer that the well had to be shut down until winter precipitation could generate sufficient recharge (Graham 2014). Continued declining groundwater levels could result in increased saltwater intrusion.

4.3.3. Reference Conditions

Surface Water

Hydrology

Very little fresh water flows on SJI and in park sites, but any reduction in streamflow from historical averages (if known) would be cause for concern.

Quality

Surface waters should not contain chemical or biological contaminants that pose a risk to humans or wildlife. Contaminants include certain detergents and various hormone disrupters which may not currently be regulated by government but which peer-reviewed science shows can cause endocrinologic harm to humans, wildlife, and aquatic organisms. All freshwater sources within the park should meet state or federal water quality standards.

Components generally measured to assess water quality include temperature, pH, dissolved oxygen (DO), turbidity, conductivity, bacteria, nutrients, metals, and other toxic compounds such as hydrocarbons (San Juan County). However, because as far as is known there are no data from the small water sources in the park to compare with reference data, specific values for these measures will not be discussed.

Groundwater

Quantity

Groundwater supplies and recharge rates are generally assessed by measuring the depth of water in existing wells to interpret water table levels (Scanlon et al. 2002). Any declining trends in well levels (or groundwater quantity measure by other methods; Sun et al. 2010) would be cause for concern. As far as is known there are no historic data for groundwater quantity on SJI in the region of SAJH.

Quality

As mentioned, of greatest concern to SAJH managers is the potential for increased saltwater instrusion into groundwater supplies. Any increasing trends in groundwater salinity would be cause for concern. As with supply, as is known there are no historic data for groundwater quality for SAJH wells.

4.3.4. Data and Methods

Surface Water

In 2016–2017 the park participated in the citizen-science based Dragonfly Mercury Project, which collects and samples mercury levels in dragonfly larvae (family Anisoptera). In SAJH larvae were collected from a pond at Westcott Bay. As far as is known there are no water quality data for surface waters at SAJH (NPS 2012, Conway-Cranos et al. 2016). Salinity and conductivity were recorded during a 1998 wetland inventory, but no other water quality parameters were measured and those data apparently were not archived.

Groundwater

No permanent points have been monitored to determine if groundwater supply is declining more rapidly than can be attributed to weather changes alone. There are no wells on SJI that are monitored by the State. NPS conducts periodic monitoring of park wells but those data were unavailable for this report.

4.3.5. Resource Condition and Trends

Surface Water

Hydrology

Water sources and hydrologic function are likely very similar to conditions present in the mid-1880s (NPS 1995), but almost nothing is known regarding current or historic flows.

Quality

Results from the Dragonfly Mercury Project (Eagles-Smith et al. 2018) showed levels of mercury within safe levels for wildlife. Aside from those data there are no other current data related to surface water quality. Though Conway-Cranos (2016) could not report on water quality condition in SAJH due to the absence of relevant data, for other sites on SJI the parameters they measured generally fell within the criteria used by the National Shellfish Sanitation Program (Schneider 2004, Woolrich 2012).

Groundwater

Quantity

Well levels have not been monitored with sufficient regularity to detect trends in aquifer levels. Consequently, the rate of groundwater withdrawal that can occur in the future without compromising acceptable-quality drinking water from any of the wells in or near the park is not precisely known. Low yielding wells (less than a few gallons per minute) with unpalatable water typify the condition at both English Camp and American Camp. In Washington State a well can be drilled without a water rights permit ("Groundwater Permit Exemption"), for small quantities on private land, for personal use and some irrigation (www.ecy.wa.gov/programs/wr/nwro/hirst.html). At present, water rights are still available for these uses on SJI, subject to all other water rights laws (DOE 2016).

Quality

From 1981 to the present, the American Camp well has not met the drinking water standards for chloride (Graham 2014). Analysis of samples collected from the park between 1999 and 2000 showed that the overall quality of groundwater was good but that the American Camp well contained elevated specific conductance and chloride concentrations and an ammonia-to-nitrate ratio indicating increased saltwater intrusion (National Park Service 2012). Adolphson (2014) found that the level of saltwater intrusion on San Juan Island is increasing.

Sampling efforts in 1999 by USGS at two wells, one at each site, found elevated chloride concentrations that suggest saltwater intrusion (Weber et al. 2009). Well water samples are routinely analyzed to ensure the park is complying with the state of Washington Department of Health drinking water standards for bacteria, and to date, all bacterial samples have been within allowed limits. The park also analyzes well water for nitrate once annually as required by state regulations, and the results indicate water quality is within state parameters (Klinger et al. 2006). The potential for increased saltwater intrusion is of concern.

4.3.6. Level of Confidence

Confidence in any assessment of surface or groundwater conditions is low.

4.3.7. Data Gaps and Research Recommendations

- Very little is known about the natural hydrologic regimes of the park's few ephemeral streams, and water quality within the park is not currently monitored.

- Because well yields in and around the park are already low (e.g., Werrell 1994), longer droughts associated with regional climate change could bring increased pressure from surrounding communities and park operations on the already scarce groundwater supplies. The amount of groundwater recharge needed to sustain the park's wetlands and maintain good water quality is unknown, making the implementation of a well-monitoring program within the park an ongoing need (Flora and Fradkin 2004, NPS 2008, Graham 2014).

4.3.8. Sources of Expertise

- Jenny Shrum, Biologist, San Juan Island National Historical Park

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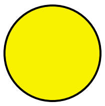
4.4. Wetlands

By Paul Adamus and Catherin Schwemm

4.4.1. Condition Summary

Vegetation has been surveyed for most wetland sites but there is no ongoing monitoring. Current vegetation information suggests that approximately one quarter of vegetation cover associated with wetlands is dominated by non-native species. No trend information for wetland vegetation is available. Confidence in this assessment is medium.



4.4.2. Background

This section addresses freshwater wetland plant communities; tidal wetlands are discussed in Section 4.5.

Surface waters potentially supports a wide variety of plants and animals, including both aquatic species that live in or along the water and terrestrial species that depend on wetland habitats for water, food, and cover (Gibbs 1993, Gibbons et al. 2006). Though they comprise a relatively small portion of the park (Holmes 1998), several wetland sites are present in SAJH and are a priority conservation concern for park managers (NPS 2008).

Holmes (1998) identified approximately 26 wetland sites totaling approximately 80 acres (32 ha) in American Camp, and nine wetlands comprising approximately 13 acres (5 ha) in English Camp. The Mitchell Hill addition, which was not surveyed for wetlands by Holmes (1998), is shown in the coarser-scale National Wetlands Inventory (NWI) and county maps as having no wetlands, but in the center of the Mitchell Hill addition, Rocchio et al. (2012) mapped one forested swamp of western redcedar (dominant) with salmonberry and skunk cabbage, as well as two patches of riparian bigleaf maple-alder swamp along the western edge.

Both wooded and herbaceous wetlands are present and include the following assemblages (“associations”) that are considered imperiled globally or in Washington (Holmes 1998, Rocchio et al. 2012; Table 4.4-1):

Table 4.4-1. Wetland plant assemblages of conservation concern (Holmes 1998; Rocchio et al. 2012). X = present at that location.

Wetland Plant Assemblage of Conservation Concern	American Camp	English Camp/ Mitchell Hill
Populus tremuloides / Carex obnupta Forest	X	–
Salix hookeriana – (Salix sitchensis) Shrubland	X	–
Cornus sericea Shrubland	X	–
Malus fusca – (Salix hookeriana) / Carex obnupta Shrubland	X	–
Salicornia virginica – Distichlis spicata – Triglochin maritima – (Jaumea carnosa) Herbaceous	X	X
Tsuga heterophylla – (Thuja plicata – Alnus rubra) / Lysichiton americanus – Athyrium filix-femina Forest.	–	X

Two Imperiled vegetation associations identified in the park by Rocchio et al. (2012) contain species which in some situations are wetland indicators; at English Camp this association is *Camassia quamash – Triteleia hyacinthina* Herbaceous Bald, and at American Camp it is *Festuca roemeri – Camassia quamash – Cerastium arvense* Herbaceous Vegetation.

4.4.3. Reference Conditions

The ecological condition of a wetland can be assessed in numerous ways (Brinson and Rheinhardt 1996, Sutula et al. 2006, Stevens and Jensen 2007). Because of challenges otherwise imposed by species mobility and sample processing costs, vascular plants are used most often. Assessment procedures (e.g., Rocchio and Crawford 2013) are available for distilling exhaustive plant lists into one or more "floristic quality" scores which summarize the wetland's condition, quality, or integrity—as predicted only by vascular plants (different conclusions may be reached by assessing other taxonomic groups or wetland functions).

Non-native plants, especially those that are highly invasive, can rapidly out-compete native species and thus depress overall species richness. The presence of exotic species is typically associated with past disturbance of a wetland's soil structure and/or water table, such as by cultivation, grazing, compaction, excavation, or regrading (Zedler 2000). Vegetation communities around wetlands should support native mesic species, indicating sufficient water supplies, and have small or no populations of invasive species. Terrestrial vertebrate and bird species should be present (Roegner et al. 2008, Alldredge et al. 2012).

4.4.4. Data and Methods

Wetlands were mapped in the park at a relatively coarse resolution in the 1980s using aerial imagery by the National Wetlands Inventory (NWI). A wetlands map covering just the park, and featuring higher resolution than the NWI mapping and with some ground-truthing, was prepared for the NPS by Holmes (1998) but did not cover the new Mitchell Hill addition. It was never published, and a copy suitable for review could not be located for this NRCA project. San Juan County refined the NWI map in 2010 using LiDAR and new aerial imagery but without ground-truthing within the park (Adamus 2011).

For American Camp, the very recent ground-truthed vegetation map indicates wetlands based on field identifications of diagnostic plant communities. The Washington State Department of Fish and Wildlife maintains a publicly-accessible spatial database of habitat occurrences from the Priority Habitat and Species list including wetlands (PHS; http://apps.wdfw.wa.gov/phsontheweb/); descriptions of how map source data were acquired are available at https://wdfw.wa.gov/conservation/phs/list/.

4.4.5. Resource Condition and Trends

Approximately 33% of all vascular plant species in the county (Atkinson and Sharpe 1985) as well as in the park (Rochefort and Bivin 2010) are believed to be exotic, i.e., non-native. A survey in 2010 of 102 San Juan County wetlands found that, in an average quadrat (n= 412), the relative cover of vegetation consisted of 32% non-native (exotic) species, and 24% invasive species, which are a subset of non-native species (Adamus 2011). The survey found an average of 18 plant species per wetland (range 3–39), averaging 3.23 species per 1 m x 1 m quadrat (range 1–10). The invasive *Phalaris arundinacea* was present in 73% of the wetlands, and the non-native *Holcus lanatus* was in 54%.

Although floristic quality index values have not been calculated for any San Juan County wetland, if they were it is expected that they would correlate with dominance of non-native plants within a wetland. In San Juan County, herbaceous wetlands tend to be more vulnerable to invasion by non-native plants than do densely shaded wetlands. Or perhaps, herbaceous wetlands are more likely to have once been cultivated and thus have suffered greater soil disturbance, including the intentional planting of non-native species as forage for livestock. Much of the western part of the American Camp unit was cropland or pasture before the park was established, having been converted from prairie or wetland. Similarly, part of the English Camp unit was cleared during the military occupation and some of it has been maintained as lawn (non-native grasses) for historical interpretive purposes and to maintain the cultural landscape (S. Dolan pers. comm. 2019).

The comprehensive vegetation mapping conducted by Rocchio et al. (2012) shows several of the park's mapped vegetation units classified as "ruderal alliances", meaning they have a high component of non-native species as commonly associated with past disturbances. A large proportion of these sites may represent wetlands because they do include a significant component of wetland indicator species. Alliances that may be indicated wetland conditions are shown in prevalence order in Table 4.4-2.

Table 4.4-2. Prevalence of ruderal vegetation alliances at SAJH with a likely wetland component (Rocchio et al. 2012).

Ruderal Vegetation Alliance with a Likely Wetland Component	Acres
Holcus lanatus – Poa pratensis	259.1
Agrostis (capillaris, stolonifera)	148.2
Alnus rubra – Pseudotsuga menziesii	79.1
Crataegus monogyna / Mixed Forbs & Graminoids Wet Shrubland	16.1
Alnus rubra / Nonnative Grasses Provisional Ruderal Flooded Forest	13.3
Leymus mollis ssp. *mollis – Holcus lanatus*	8.4
Equisetum arvense – Mixed Graminoid Wet Meadow	5.0
Schedonorus pratensis Wet Meadow	2.4
Juncus gerardii Wet Meadow	1.3
Alnus rubra / Carex obnupta Flooded Forest	0.8
Carex leporina Wet Meadow	0.5
Prunus emarginata Flooded Forest	0.4
TOTAL	**534.6**

Thus, a very rough estimate of the percentage of the park's wetland area that has significant cover of non-native plants is 23%. However, not all of the ruderal species are highly invasive and thus detrimental to native plant richness. Any efforts to restore native wetland plant communities should focus on ways to remove and avoid re-establishment of non-native species that are most invasive and fare the best in wetlands of the type that occur in the park. These include *Phalaris arundinacea, Holcus lanatus, Vicia sativa,* and *Cirsium arvense*. No trend information is available regarding changes in the relative or total cover of non-native species associated with wetlands.

4.4.6. Level of Confidence

Moderate

4.4.7. Data Gaps and Research Recommendations

- Monitoring of wetland vegetation should be implemented at least at a level to determine whether cover of invasive species is increasing.

- Efforts to restore native wetland plant communities should focus on ways to remove and avoid re-establishment of invasive species, primarily Phalaris arundinacea, Holcus lanatus, Vicia sativa, and Cirsium arvense.

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4.5. Nearshore Resources

By Paul Adamus and Catherin Schwemm

4.5.1. Condition Summary

This section wholistically assesses the condition of the nearshore environment using five indicators.

<u>Shorelines</u>

The physical condition of the shorelines in SAJH is fair; some of the shoreline areas are actively eroding though there are few data to quantify physical changes. There are no obstructions to sediment-carrying currents within the park. Bluff erosion is a concern, and rising sea levels and more frequent storm events could result in loss of sand and sediments within park shoreline zones. Confidence in current conditions is moderate to high.

<u>Aquatic Vegetation</u>

Although surveys conducted over the past several decades have documented severe declines in eelgrass around SJI and in Westcott Bay, the most recent sampling indicates some recovery. The overall trend is unknown. There are no indications that kelp is declining in or adjacent to park waters, but there are no data to indicate current condition. Confidence in current conditions is medium.

<u>Marine Invertebrates</u>

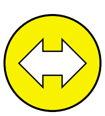
Current invertebrate community diversity or abundance of any particular species is uknown. Invasive species are an increasing threat, as are rising sea surface temperatures. Confidence in current conditions is low.

<u>Marine Fish</u>

Surveys in 2004 found no herring spawning near the English Camp unit of the park despite historic spawning at the site. Juvenile forage fish continue to be found in low numbers, so the condition of forage fish overall is designated of concern but trends are unknown. The abundance of juvenile salmon is unknown, but there are no historic data to indicate that spawning in park waters has ever occurred. Confidence in current conditions for nearshore fish is medium.

<u>Marine Mammals</u>

Harbor seals and Stellar sea lions are commonly seen on beaches near park sites and populations appear stable or increasing. However, no monitoring data are available to determine trends in the numbers or seasonality of animals that haul out. Confidence in current conditions is low to medium.



4.5.2. Background

Nearshore resources include the physical and biological resources of the intertidal, shallow subtidal (seaward to a depth of about 66 ft/20 m), and marine riparian (defined here as landward perpendicular to shoreline about 164 ft/50 m beyond extreme high tide level) zones. Although the park's legal jurisdiction does not include all of the intertidal zone nor any of the subtidal (elevations below extreme low tide), NPS resources along the shore interact strongly with physical processes and nearshore ecosystems, so processes in the intertidal and subtidal zones are relevant to park managers. Coastal and shoreline vegetation is discussed in Section 4.7.

Physical Shoreline

The nearshore environment of the San Juan Islands (SJI) is structured atop bedrock shorelines overlain by shallow sediments (MacLennan et al. 2010, SJC 2012). The dominant features of the shoreline landscape are the coastal bluffs, defined generally as slopes of sediment and vegetation that cover the underlying bedrock. The coastal bluffs of the SJI formed fairly recently, approximately 4,000–5,000 years ago (MacLennan et al. 2010), and are found on approximately 60% of island shores. Most SJI beaches are comprised mainly of sediments eroded from the bluffs (Johannessen and MacLennan 2007), while wave action and tidal currents both deposit and remove sand (Finlayson 2006, Shipman 2008, Curtiss et al. 2009, MacLennan et al. 2010, SJC 2012).

The presence of a surf zone defines the overall geomorphology of the shore and the associated ecological communities. For example, surf typically precludes eelgrass and most other vascular plants that live entirely below the water surface. Sediment transport is also intense within the surf zone, creating a highly abrasive environment. Thus, coastal erosion, driven both by ocean and upland processes, is the primary determinant of shoreline morphology in the San Juan Islands. The dynamics of sediment transport and erosion around the SJI are complex and described in detail in sources such as Finlayson (2006), Johannessen and MacLennan (2007), SJC (2012), Graham (2014), and WDOE (2014).

Because of its sheltered location along Garrison and Westcott Bays, the shoreline of English Camp is characterized by mostly low relief, mud-dominated intertidal areas with scattered salt marsh. In contrast, the south-facing shoreline of American Camp is much more exposed to the prevailing winds and consists of jutting headlands and gravel pocket beaches on the west that grade into a long sandy beach toward the east and return to rocky headlands at Cattle Point. Along American Camp’s northern shore, at Griffin Bay, intertidal areas are composed of gravel, sand, and cobble, much of which is covered with drift logs. Rocky areas are interspersed with these unconsolidated areas. At its eastern end, the sandy shore of South Beach is backed by a steep eroding bluff face. Dethier and Ferguson (1998) observed that the upper- and mid-intertidal zones of rocky areas within Griffin and Westcott bays were similar to other rocky shores in the San Juans, but the low zones in most areas were covered with or affected by muddy sediment.

Rocky headlands with coves and distant bluffs of unconsolidated glacial deposits, south shore of American Camp. (NPS)

Lagoons

When ocean currents encounter an obstacle that slows water movement, sediments settle out of the water column. Where large amounts of sediment accumulate sandbars may form that restrict tidal processes and eventually form lagoons (Kjerfve and Magill 1989, Shipman 2008). Healthy lagoons are extremely productive (Alvarez-Borrego 1994, Alongi 1998), and because tidal processes and wave energies are reduced in lagoons the sites provide critical habitat for many organisms, particularly larval and juvenile stages of fish and marine invertebrates (Beck et al. 2003, Anthony et al. 2009). Lagoons are recognized by the Washington Department of Ecology as important natural features (Flora and Fradkin 2004), and have been identified as being particularly at risk from impacts of climate change (Anthony et al. 2009, Cloern et al. 2016).

There are three tidal lagoons on SJI, all of them located at American Camp: Old Town Lagoon is the smallest and dries in most summers, Jakle's Lagoon is the largest and deepest and contains water even in very dry summers, and Third Lagoon is smaller and shallower than Jakle's but water persists year-round. (Salinity data collected from Jakle's Lagoon suggest there may be groundwater input to this portion of the shore [Flora and Fradkin 2004]). The park's tidal lagoons are notable because they are the only lagoons on SJI.

Jackel's Lagoon, American Camp. (NPS)

Biological Resources

Nearshore and ocean processes have important roles in structuring nearshore biologic communities (Fresh et al. 2004, Mumford 2007, Sobocinski et al. 2010, and Brennan et al. 2009). Important nearshore and intertidal species are presented in Table 4.5-1; birds that utilize the intertidal zone are discussed in Section 4.8.

Table 4.5-1. Selected nearshore species of conservation or commercial interest found in SAJH or adjacent waters.

Classification	Species	Common Name	Notes/Locations/References
Plants and Alga	*Zostera marina*	Eelgrass	–
	Z. japonica	Eelgrass	Non-native
	Phylloxpadix torrey	Seagrass	Rocky substrates
	P. scouleri	Seagrass	Rocky substrates
	Sargassum muticum	Alga	Non-native
	S. japonica	Alga	Non-native
Invertebrates	*Protothaca staminea*	Native littleneck clam	Westcott Bay (EC)/Griffin Bay (AC)
	Nuttalia obscurata	Varnish clam	Westcott Bay/Griffin Bay
	Saxidomus gigantea	Butter clam	Westcott Bay/Griffin Bay
	Panopea generosa	Geoduck clams	Westcott Bay/Griffin Bay
	Venerupis philippinarum	Manila clam	Westcott Bay/Griffin Bay; Non-native
	Crassostrea gigas	Pacific oyster	Westcott Bay (EC), Griffin Bay (AC); Non-native
	Mytilus trossulus	Mussels	Westcott Bay/Griffin Bay

Table 4.5-1 (continued). Selected nearshore species of conservation or commercial interest found in SAJH or adjacent waters.

Classification	Species	Common Name	Notes/Locations/References
Invertebrates (continued)	*Haliotis kamtschatkana*	Pinto abalone	Federal Species of Concern, Washington Candidate species; occur in waters adjacent to both AC and EC (WDFW PHS data); all areas closed to harvest.
	Cancer magister	Dungeness crab	Important fishery resource; listed on WDFW's Priority Habitat and Species list; Distribution in San Juan County is poorly known but Dungeness crab occur near the EC unit.
	Pandalus goniurus	Pandalid shrimp (humpy shrimp)	WDFW priority species; Concentrations of this shrimp have been documented throughout much of San Juan County's marine waters, including in Griffin Bay.
	Dendraster excentricus	Sand dollar	Sandy substrates
	Strongylocentrotus spp.	Sea urchins	Important sub-tidal grazers;
Fish	*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 of their life-history stages; Smelt breeding grounds occur in nearshore areas of the EC unit, around the perimeter of Bell Point (Friends of the San Juans 2004b).
	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 of their life-history stages
Mammals	*Phoca vitulina*	Harbor seal	–
	Eumetopias jubatus	Stellar sea lion	–

Aquatic Vegetation

Seagrasses are flowering plants that require sunlight but are rooted in the ocean floor and grow completely submerged. Seagrass beds are often the basis of small-scale marine ecosystems that provide habitat and physical stability for nearshore environments exposed to wave and tidal energy (Murphy et al. 2000, Bostrom et al. 2006, Duffy 2006, Plummer et al. 2013). The condition of seagrasses ecosystems is often an important indicator of water quality and marine conditions, including effects of climate change, at local scales (Orth et al. 2006, Thom et al. 2014). *Phyllospadix* seagrasses, particularly *P. torreyi* and *P. scouleri*, are the most common seagrasses around SJI and are associated with rocky substrates (Christiaen et al. 2017). *Phyllospadix* are present in the waters around American Camp but not English Camp (SJC 2012, Christiaen et al. 2017).

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 beds occur near mean lower low water (MLLW), extending up to 6.5 ft/2 m above and −30 ft/9 m below MLLW (Reeves 2006, PSAT 2007, Christiaen et al. 2016). The depth to which eelgrass grows is determined mainly by water clarity and sedimentation (Kaldy 2014), and eelgrass can be buried and killed by sediment deposition during storms (Takesue et al. 2005). Eelgrass beds increase in extent in spring and summer in response to warming water temperatures then retreat during fall and winter (Kaldy 2014). The native eelgrass *Zostera marina* is the most common species around SJI and provides important habitat for invertebrates, juvenile salmon and forage fish (Ferraro and Cole 2007, Mumford 2007, Christiaen et al. 2017).

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. 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. 2017).

Kelp are large marine algae that acquire nutrients from the water column and anchor to rocky seafloor substrates by means of holdfasts (Mumford 2007). Kelp are typically much taller than seagrasses, and many species also have blades that float on the water surface while seagrasses generally do not extend above the water. Kelp prefer high-energy environments where tidal currents renew available nutrients and prevent sediments from burying young plants (Mumford 2007, Britton-Simmons et al. 2012). Kelp "forests" provide food and refuge for many species from invertebrates to marine mammals (Mumford 2007). Several species of kelp commonly occur along the west coast of SJI in the shallow subtidal zone from MLLW to about −65 ft/−20 m (SJC 2012). Kelp are present in some locations along the shoreline of American Camp but not in the bay near English Camp.

In addition to kelp and other seaweeds, several species of emergent vascular plants occupy the shores of the park and its lagoons. The lagoons or surrounding salt marshes host several species listed by the Washington Natural Heritage Program as Sensitive such as sharpfruited peppergrass (*Lepidium oxycarpum*), Nuttall's quillwort (*Isoetes nuttallii*), and erect pygmy-weed (*Crassula connata*) as well as a noteworthy vegetation assemblage: *Salicornia virginica – Distichlis spicata – Triglochin maritima* – (*Jaumea carnosa*) Herbaceous Vegetation.

Marine Invertebrates

Nearshore invertebrates include marine species that inhabit the intertidal or shallow subtidal zones. Of particular economic and ecological importance around the SJI are mollusks (barnacles, clams, oysters, and abalone), crustaceans (crabs) and echinoderms (sea urchins, sea stars). The group that includes mollusks and crustaceans—marine invertebrates with exoskeletons or shells—are often referred to as “shellfish” though they are not fish. Shellfish utilize tidal marsh vegetation, are attached to rocks, and burrow in soft sediments (Dethier and Berry 2008). Adults forage amid tidal marsh vegetation, attach to rocks (e.g., barnacles), rest on or burrow in the sediment (e.g., clams), or are highly mobile (e.g., crabs). In general, shellfish depend on specific sediment compositions (such as grain size, amount of different grain and gravel sizes, organic content (Dethier et al. 2006).

Marine Fish

Forage fish are species that may be prey for salmonids, seabirds, and marine mammals. In general forage fish species require specific substrate types, clean water with low suspended sediment levels, and suitable spawning and refuge habitat such as eelgrass beds (Morgan and Levings 1989, Levings and Jamieson 2001, Penttila 2007). A survey of intertidal fish in November 2002 at 11 sites in English Camp and 15 in American Camp yielded 14 species, including surf smelt, sandlance, and herring (Fradkin 2004).

Pacific sand lance (*Ammodytes personatus*), along with surf smelt (*Hypomesus pretiosus*) and Pacific herring (*Clupea pallasii*) are particularly important forage fish in the Salish Sea (Selleck et al. 2015, Bizarro et al. 2016). Pacific herring have been federally designated as a Species of Concern and use nearshore habitat for all life-history stages, often utilizing intertidal rocky substrates for feeding and resting while depositing eggs almost exclusively on eelgrass or other marine vegetation (Penttila 2007). Surf smelt and sand lance also use nearshore habitat; smelt breeding grounds occur in nearshore areas of the English Camp unit, around the perimeter of Bell Point (FSJ 2004), while sand lance spawning has been documented near False Bay and north of Cattle Point (SJC 2012).

Large numbers and multiple life stages of several salmon species are found along the nearshore of SJI from early spring through late summer, though spawning of any salmon species near park sites has not been documented (Kerwin 2002, Wyllie-Echeverria and Barsh 2007, Wyllie-Echeverria 2008, Beamer and Fresh 2012). All nearshore areas of Puget Sound, including San Juan County, have been designated Critical Habitat for Puget Sound Chinook (*Oncorhynchus tshawytscha*) and Hood Canal summer-run chum salmon (*O. keta*). A designation of Critical Habitat for Puget Sound steelhead (*O. mykiss*) was completed in 2016 and includes nearly all shoreline areas of SJI (81 FR 9252).

Marine Mammals

Pinnipeds (marine mammals with front and rear “flippers”) that utilize SAJH beaches include Stellar sea lions (*Eumetopias jubatus*) and harbor seals (*Phoca vitulina*), though neither species breeds within park boundaries (Jeffries et al. 2000). Harbors seals are the most common marine mammal observed throughout the San Juan Islands (Zier and Gaydos 2014). Females haulout from June through August and are often seen at Grandma’s Cove (Jeffries et al. 2000). Harbor seals breed on SJI but not in or adjacent to SAJH.

Pacific harbor seals (*Phoca vitulina*) in Westcott Bay, Engish Camp. (NPS)

Steller sea lions were federally listed as threatened in 1990 though there is no critical habitat designated in Washington (Wiles 2015). In the fall, winter, and spring months an estimated 800 to 1,000 stellar sea lions move through the Strait of Juan de Fuca and Strait of Georgia to feed (PSAT 2007, Wiles 2015). Stellar sea lions haulout on SAJH beaches, and evidence suggests that individuals exhibit site fidelity to haulout sites as well as to rookeries, dependent on factors such as food availability and human disturbance (Wiles 2015).

Approximately five species of cetaceans and baleen whales utilize marine waters around SJI both seasonally and year-round: killer whales (*Orcinus orca*), gray whales (*Eschrichtius robustus*), humpback whales (*Megaptera novaeangliae*), Dall's porpoise (*Phocoenoides dalli*), and harbor porpoise (*Phocoena phocoena*). Sea otters (*Enhydra lutris*) were extirpated from Washington but were re-introduced in 1969 and are occasionally sighted throughout the SJI. Though whales, dolphins and sea otters are critical elements of oceanic ecosystems, they rarely utilize waters adjacent to SAJH sites so will not be further assessed.

4.5.3. Reference Conditions

Coastal Processes

Natural sediment-transport processes should be unimpeded. For this to occur there should be no impacts of artificial structures on tidal movements (MacLennan et al. 2010, Shipman et al. 2010). Bluff erosion should be maintained as a natural process but not accelerated by human activities (Johannessen and MacLennan 2007).

Biological Resources

There are few references for determining overall reference conditions for nearshore biological resources. Ideally, reference conditions for the entire nearshore environment surrounding SAJH would include the absence of invasive plant and invertebrate species and would include all native plant, algal, and fish species historically recorded. Marine mammals would utilize SAJH beaches in abundances similar to historical records. The extent of eelgrass beds should not decline and the growing depth not change. Spawning by forage species should occur and be successful at historic levels (Simenstad and Cordell 2000). Though salmonids are present seasonally in nearshore waters of both park units, the presence/absence and abundance of salmon is not one of the stronger indicators of local conditions because they do not spawn here and individuals move over larger areas on a daily basis.

4.5.4. Data and Methods

Coastal Processes

MacLennan et al. (2010) did a thorough job of classifying all shoreline and bluff segments in San Juan County, including SJI; methods are described therein. However, as far as is known there are no data or sources of information that describe shoreline morphology prior to settlement and armoring. The State provides an interactive mapping tool for coastal resources that includes data on vegetation, shoreline geomorphology, historic aerial photography, shoreline modifications, historical shoreline photographs, and other data sets with metadata (fortress.wa.gov/ecy/coastalatlas/tools/Map.aspx; fortress.wa.gov/ecy/waterresources/map/WaterResourcesExplorer.aspx).

Biological Resources

The NCCN intertidal monitoring protocol (Fradkin and Boetsch 2012) includes methods for sampling invertebrate and macroalgal communities at SAJH. Two sites in the rocky intertidal have been established, one at American Camp (east of Grandma's Cove) and one at English Camp (Bell Point), but as far as is known no monitoring has been conducted at these sites since Dethier (1993, cited below). 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/); descriptions of how map source data were acquired are available at https://wdfw.wa.gov/conservation/phs/list/.

Aquatic Vegetation

The Washington Department of Natural Resources (DNR) conducts annual monitoring of seagrass populations across Puget Sound, including several sites near SAJH as part of its Submerged Vegetation Monitoring Program (Sewell et al. 2001). Sampling methods are referenced and results are presented in numerous reports including Christiaen et al. (2017).

Marine Invertebrates

Permanent plots for habitat sampling were established by Delthier and Ferguson (1998) at six sites within American Camp and two within English Camp. Within and near the English Camp unit, Dethier and Ferguson (1998) conducted a more intensive survey of Westcott and Garrison Bays for the San Juan County Department of Community Development and Planning. In addition to characterizing the invertebrate faunal diversity, the study compared intertidal areas that were opened versus closed to harvesting of clams. Beginning in 2000, J.E. Byers conducted research in several marine reserve sites around the SJI including one in Griffin Bay to assess relative abundance and diversity of native and non-native clam species (Byers 2005).

Marine Fish

A survey of intertidal fish was conducted in November 2002 at 11 sites in English Camp and 15 in American Camp (Fradkin 2004). Some salmon surveys have occurred near the park, for example Beamer and Fresh (2012) provided estimates of fish densities for several species in waters around the SJI (Table 4.5-2).

Table 4.5-2. Densities of fish/ha around the San Juan Islands. All densities are fish/ha, log-transformed, and approximate from figures; from Beamer and Fresh (2012).

	Locations			
Species	**Bluff-backed beach densities (most of AC and EC)**	**Straight Juan de Fuca – SJI (South side AC;2)**	**Haro Strait NE (EC;3)**	**San Juan Channel – South (North side AC;10)**
Juvenile wild Chinook	0.23	0.10	0.08	0.05
Juvenile Chum	0.32	0.18	0.25	0.22
Juvenile pink	0.22	0.10	0.08	0.28
Pacific herring	0.15	0.04	0.25	0.08
Surf smelt	0.18	0.10	0.30	0.38
Pacific sand lance	0.40	0.36	0.18	0.50
Lingcod/greenling	0.80	0.38	0.44	1.00

Marine Mammals

Gaydos and Pearson (2011) provide a list of mammals that use Salish Sea waters. Jeffries et al (2000) surveyed mammals at several sites near AC and EC as part of a larger survey of Washington State. As far as is known there are no ongoing surveys for presence/absence or abundance of either harbor seals or Stellar sea lions within SAJH.

4.5.5. Resource Condition and Trend

<u>Coastal Processes</u>

The park's shoreline currently contains no artificial structures. The Washington Department of Fish and Wildlife (Wilhere et al. 2013) found that the American Camp shoreline is in "moderate" condition while English Camp received a lower rating (Figure 4.5-1). However, the authors of that study strongly cautioned against interpreting the ratings at anything finer than a regional or watershed scale since the ratings are related only to other shoreline segments in Puget Sound. The State Department of Ecology classifies the amount of human-caused shoreline modification along all shorelines of SAJH sites to be 11–30% except for a small portion west of the pier at English Camp which is classified at 61–80% modified (https://fortress.wa.gov/ecy/coastalatlas/tools/Map.aspx).

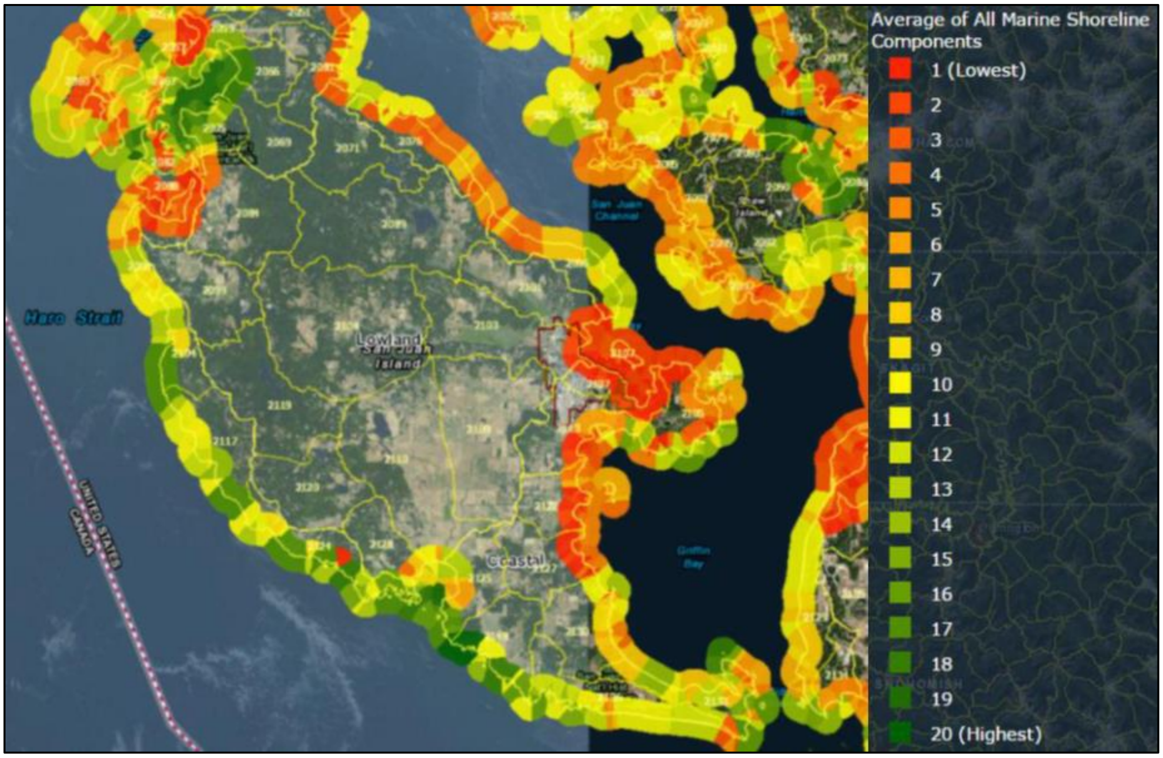


Figure 4.5-1. Ratings of San Juan Island marine shoreline segments as assigned by WDFW. Green colors indicate higher habitat quality while red colors are lower quality. See Wilhere et al. (2013) for rating criteria.

Along the Cattle Point Road that bisects American Camp, natural erosion of a coastal bluff is proceeding at a rate of 1.7 ft (0.5 m) per year and is expected to come within 2 ft (0.6 m) of the road by approximately 2026, severely threatening the stability of the bluff (FHWA and NPS 2012). Realignment of 4,950 ft (1,509 m) of road is now completed. The realignment of the Cattle Point Road was done to maintain vehicular access to the community at Cattle Point and to mediate further coastal erosion in that area (Graham 2014). Elsewhere in the park, staff have partnered with the Washington Conservation Corps to control erosion and stabilize an exposed shell midden, an archaeologically significant feature, on the north coast of the English Camp in Garrison Bay. The project has protected archaeological resources from being washed away or exposed to poachers, and this stabilization will also protect plant and animal habitat.

<u>Biological Communities</u>

Aquatic Vegetation

Overall benthic communities around Puget Sound appear to be improving (PSEMP 2017), though conditions for eelgrass in Westcott Bay are still poor (Ferrier and Berry 2010). The total areal extent of eelgrass at SJI has not significantly changed from 2004–2015, nor the total abundance of eelgrass across the entire Puget Sound (Shelton et al. 2016, Christiaen et al. 2017).

Within or near the park approximately 86 acres (35 ha; 77%) of eelgrass were lost in Westcott-Garrison Bays between 2000 and 2004 for unknown reasons (Pentilla 2007, SSPS 2007, Ferrier and

Berry 2010). Current monitoring of eelgrass at four sites on SJI indicate that three populations are still in decline (including Westcott Bay; Ferrier and Berry 2010), while one population near Friday Harbor has expanded (Christiaen et al. 2016, Christiaen et al. 2017), and eelgrass remains abundant along Fourth of July Beach and occurs in shallow areas near Salmon Camp (offshore of South Beach). Christiaen et al. (2017) found that although eelgrass at two sites near AC and EC declined from 2000–2015, those same sites were stable from 2010–2015. The introduction of non-native eelgrasses is a potential threat (Mach et al. 2014; Shafer et al. 2014).

The floating kelp canopy area in the Strait of Juan de Fuca has increased in recent years (Berry et al. 2005). However, the lack of appropriate reference data makes it impossible to determine if current kelp abundance and extent is within the natural range of variation. Very little is known regarding species composition and richness of other macroalgae species within the park.

Marine Invertebrates

Dethier (1993) documented the occurrence of 149 species of macroscopic invertebrates and fishes as well as 58 species of vascular plants, lichens and algae. The author suggested that if more habitat types and sites had been sampled, encompassing greater temporal and tidal variation, the species total might have been 30% higher. She found little overlap between the taxa in rocky versus soft substrates.

Long et al. (2005) found diversity of bottom-dwelling invertebrates (127 taxa) was higher at one site in Griffin Bay than at nearly any other of the 30 sites sampled throughout a region encompassing the San Juan Islands, Eastern Strait of Juan de Fuca, and Admiralty Inlet. Dethier and Barry (2008) conducted a follow-up survey to their work in the 1990s which found that species diversity appeared to remain high over time at one sample site near English Camp.

Mollusks and Shellfish

Pinto abalone have experienced dramatic declines in the last few decades (Rothaus et al. 2008); in the inside waters of Washington abalone is currently found only in the San Juan Islands and the Strait of Juan de Fuca (Dethier et al. 2006). Abalone declined from 351 individuals per site to 103 per site at ten long-term monitoring stations In the San Juan Archipelago between 1992 and 2005 (PSAT 2007), and at current levels are likely below effective population size (Dethier et al. 2006).

Byers (2005) found an abundance of both native and non-native clams at a site adjacent to British Camp, and further found the biomass of native clams to be more than twice as great as non-native clam biomass. Very little is known regarding shellfish abundance or trends off the coast of SJI given that habitat for these species in the area is limited (SJC 2012). The PHS database includes records of Dungeness crab, other hardshell crabs and oysterbeds in waters adjacent to English Camp

Echinoderms

Sea stars along the western coast of North America experienced a stunning die-off beginning in the fall of 2013, later attributed to a virus and possibly warmer ocean temperatures (Eisenlord et al. 2016, Kohl et al. 2016, Menge et al. 2016). As far as is known no specific studies have been conducted since that time on the west coast of SJI to assess current conditions for sea stars. In general the Puget

Sound sea urchin population is considered stable, although population declines in specific geographic areas have been noted (PSAT 2007).

Marine Fish

Friends of the San Juans (FSJ 2004) documented 14 species of forage fish including surf smelt, sandlance, and herring that utilize nearshore habitats around the SJI. The same surveys failed to find evidence of spawning by herring in the Westcott Bay/ Roche Harbor region despite historic records of spawning in the area (FSJ 2004, Stick and Lindquist 2009). The absence of spawning was coincidental with the loss of eelgrass from that area (Penttila 2007). Juvenile herring continue to be present in low numbers (Beamer and Fresh 2012). The PHS database includes records of surf smelt breeding at many locations adjacent to English Camp

Juvenile pink salmon use Westcott Bay near the English Camp unit to a lesser degree than in most other appropriate habitat areas around the San Juan Islands. Use of both park units by juvenile Chinook and chum salmon, and use of the American Camp nearshore by pink salmon, is at or below average compared with the rest of the San Juans. In general salmon recovery throughout the SJI is inadequate for the goals of self-sustaining populations (PSP 2013).

Marine Mammals

As far as is known there is no trend information for the number of Stellar sea lions or harbor seals that utilize SAJH beaches. Jeffries et al. (2000) noted two groups of less than 100 harbor seals using sites north of American Camp and several additional small groups at several sites around Roche Harbor. No use by Stellar sea lions along the west coast of SJI was noted in that report (Jeffries et al. 2000). The stellar sea lion population that includes Puget Sound (eastern DPS; NMFS 2008) is likely greatly reduced from historic pre-hunting numbers but appears to be increasing (NMFS 2008, Wiles 2015), and there appear to be no threats to continued recovery for the eastern DPS of Stellar sea lions (NMFS 2008).

4.5.6. Level of Confidence

Overall there is only low to moderate confidence in the condition of any nearshore indicators at SAJH given the near absence of monitoring of these resources in recent years.

4.5.7. Data gaps/Research needs/Management recommendations

<u>Coastal Processes</u>

- To better facilitate management of shoreline resources, ongoing efforts by NPS and cooperating agencies to define the boundaries of tidal ownership along the coast within or along the park's borders should continue.

- Erosional processes at American Camp should be monitored.

- Monitoring of nearshore water quality parameters is needed. There has been no systematic, multi-year monitoring of water quality in the park's nearshore habitats, and offshore marine water samples have not been analyzed for a full spectrum of chemicals or with sufficient frequency to determine if contaminants are present in concentrations potentially harmful to biologic organisms.

Biologic Resources

- Intensified efforts to monitor biological resources in the nearshore environment within the park are needed. For example, eelgrass and kelp are not currently being sampled in park waters. Although the floating kelp canopy area in the Strait of Juan de Fuca in recent years has increased (Berry et al. 2005), the condition and trends of kelp distribution or abundance have not been monitored specifically along the shores of San Juan Island or the park.

- For invertebrates, permanent plots that were established have not been monitored, surveys have not covered all parts of the park's shoreline, and surveys have generally not been taxonomically comprehensive.

- The year-to-year condition and trends of salmonid fish have not been monitored specifically along the shores of American Camp or English Camp. Reasons for the relatively low use (compared to other areas of the San Juans) of the park's shorelines by salmonids, and whether that condition is normal, are unknown.

- The adaptability of salmonid populations under various scenarios of climate change is unknown.

- Cooperative projects with local stakeholders, other state and local agencies, and citizen science groups could facilitate greater success in monitoring fish, shoreline habitat, intertidal communities, water quality, shell fish population dynamics, exotic species introductions, and eel grass. Likewise, maintaining and strengthening relationships with researchers at the University of Washington Friday Harbor Laboratories could help facilitate needed research, particularly regarding invertebrates, algae, and ecosystem processes.

- Regular monitoring for the introduction of invasive aquatic plants and invertebrates is particularly important.

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4.6. Native Plant Species of Concern

By Peter Dunwiddie and Catherin Schwemm

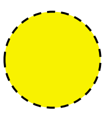
4.6.1. Condition Summary

<u>Golden Paintbrush</u>
The current status and trend of golden paintbrush at SAJH is unknown but is of concern. Planted populations at other sites appear to be increasing. Confidence for the assessment of paintbrush is medium.

<u>Erect Pygmyweed</u>
Erect pygmyweed is listed by the State as threatened, and the absence of data on the species within the park warrants concern for the status of the park population. Trends in the park are unknown and confidence in the assessment of pygmyweed is medium.

<u>Hall's Aster and California Buttercup</u>
Both Hall's aster and California buttercup are of significant concern within the park, with little knowledge of condition or trends. Confidence in the assessment for both species is low.

<u>Madrone</u>
The status of madrone in the park appears to be stable, but the threat of disease warrants concern. Trends are stable and confidence is medium.



4.6.2. Background

<u>Golden paintbrush (*Castilleja levisecta*)</u>
Golden paintbrush is a perennial herbaceous species in the Scrophulariaceae family. Plants have multiple single stems with sticky (viscid) leaf surfaces and yellow flowers. Individual plants are perennial but relatively short-lived (5–6 years) and reproduce only by seed. Plants can self-pollinate and set seed when separated from pollinators, however, research shows that pollination greatly increases seed set (Caplow 2004). Many species of the genus *Castilleja* including *C. levisecta* are parasitic or semi-parasitic on host plant roots (Lawrence and Kaye 2008). Greenhouse studies have demonstrated that while plants can survive without host plants, survival and vigor of *C. levisecta* individuals are significantly increased when preferred host plants are available (Lawrence and Kaye 2008). A detailed description of *C. levisecta* biology and ecology is provided in the recovery plan (FWS 2000).

Golden paintbrush (*Castilleja levisecta*); photo by J. Shrum with permission.

C. levisecta is listed as Federally Threatened and State Endangered. At present there are only 11 extant populations of this species known, all of which occur in the Puget Trough (FWS 2007). A number of populations historically known from Oregon are all now extirpated (Caplow 2004), though at other sites restoration efforts appear to have resulted in at least short-term success (appliedeco.org/painting-the-prairie-following-golden-paintbrush). Much work has been done to determine critical habitat variables for the species and investigate propagation techniques (e.g. Lawrence and Kaye 2011, Dunwiddie et al. 2013, Dunwiddie and Martin 2016). In general *C. levisecta* requires open prairie-herbaceous communities on either steep or relatively flat slopes and on west and southwest-facing aspects (Caplow 2004). The herbaceous sites preferred by *C. levisecta* are also apparently associated with forest types dominated by western red cedar/western hemlock/Douglas-fir as are found at SAJH (Caplow 2004). In general, the most suitable habitats tend to retain higher levels of soil moisture and are dominated by a diversity of perennial native grasses and forbs (FWS 2007).

Historic records include an occurrence of *C. levisecta* at Cattle Point, although the record lacks sufficient detail to know precisely whether it occurred within the boundary of the park (Washington Natural Heritage Program). In addition to this historic record from the park there are several extant populations within 2–3 mi (3–5 km) of American Camp, indicating that SAJH is within the historical range. Attempts to establish (perhaps re-establish) this species in the park began in 2009 when 400 seedlings were planted at selected sites at American Camp. Subsequent surveys found one flowering plant that survived until 2010 but no additional data on this outplanting are available. More seedlings were planted in the fall of 2012, with 57 flowering plants recorded in the spring of 2013. Another planting occurred in 2019 but flowering success has not yet been recorded (S. Dolan pers. comm. 2019).

Pacific Madrone (Arbutus menziesii)

Pacific madrone ("madrone") is not imperiled globally, however, the plant community with which it is frequently associated—the *Pseudotsuga menziesii/Arbutus menziesii* (Douglas fir-madrone) forest and woodland alliance—is of conservation concern. Both Douglas fir and madrone are resilient to fire and on many sites can be co-dominant over substantial successional transitions. Madrone is one of the few evergreen, broadleaf trees in the area, and provides important wildlife habitat (Gurung et al. 1999).

Pacific madrone (*Arbutus menziesii*). (NPS/J. Shrum with permission)

One factor that makes the persistence of madrone of concern is the fungus Fusicoccum arbuti that is contributing to a regional decline of madrone (Elliott et al. 2002, Farr et al. 2005, McGregor et al. 2016). The fungi's increase since the 1970s is hypothesized to be related to the absence of fire, which is thought to be the agent most responsible for mortality of mature madrone trees (Elliott et al. 2002). Another fungus—*Phacidiopycnis washingtonensis*—has also recently been noted in western Washington and Oregon and causes excessive leaf blight that may be caused by cold stress (Elliott et al. 2014). Madrone-dominated forest associations are discussed in Section 4.7.

<u>Erect Pygmy-weed (Crassula connata)</u>
C. connata ("pygmyweed") is listed by the State of Washington as Threatened. Pygmyweed is an annual that requires winter precipitation to germinate but is located on drier, open summer sites near rocky outcrops and well-drained soils. Pollinators and seed dispersers are unidentified. A population of approximately 750 plants within a one-acre site at the base of the bluffs on South Beach was discovered in the park in 2000, but as far as is known there is none present in the park in 2019 (J. Shrum pers. comm. 2019).

<u>California Buttercup (Ranunculus californicus var. californicus)</u>
A state Threatened species, California buttercup occurs in several locations at American Camp, with >1800 plants mapped in 33 patches in 2005 (R. Rochefort, personal communication, 2014). However, this species in the park commonly hybridizes with *R. occidentalis*, and the two are often difficult to distinguish (J. Shrum pers. comm. 2019).

California buttercup (*Ranunculus californicus* var. *californicus*). (NPS/J. Shrum with permission)

Hall's Aster (*Symphyotrichum hallii*)

Also listed as state Threatened, Hall's aster is an herbaceous, perennial species that grows in relatively dry open spaces in valleys and plains. At present none is known to exist in the park (J. Shrum pers. comm. 2019).

4.6.3. Reference Conditions

Reference conditions are presented here only for the specific populations in and near SAJH, not for the entire range of any species. For all populations within the park, general reference conditions would (at a minimum) be the existing distribution and abundance. Populations should be self-sustaining.

Golden paintbrush

There are no reference data for natural occurrences of this species at the park, and little is known regarding the actual extent of the species within the park before the initiation of habitat loss (FWS 2000). However, because this is a managed population, a substantial amount of research and experimentation has been conducted in relation to this species and goals for recovery success are well-documented. Specific criteria for evaluating recovery success of the park populations (FWS 2000) include:

- Two and preferably three self-sustaining populations within the park. (The Recovery Plan sets a goal of 20 self-sustaining populations distributed across the extant and historic range of the species; four viable populations in the San Juan Islands would be appropriate towards meeting this goal.) Populations must be separated by at least 0.6 mi (1.0 km) to be considered distinct.

- All populations must be self-sustaining and stable (not declining) with a 5-year (running) average size of at least 1,000 flowering individuals and evidence of successful reproduction.

- The extent of each population should be at least several acres.

Additional population variables, such as survival and mortality rates, limiting factors, and seed bank abundance, are of critical ecological importance (Caplow 2004), however, almost nothing is known about these measures for this species (FWS 2000, Longer-term factors such as resilience and persistence are also important but difficult to measure within the protocols of a basic monitoring program as is currently in place (FWS 2000).

Madrone

Aside from the threat of fungal infection the current stands of madrone do not appear to be at risk, so the absence of disease in park sites is the reference condition for this species at SAJH.

State-listed species

Criteria to evaluate the three state-listed rare plant species found at the park should include the number of populations, abundance within each population, extent, and population trend. However, specific metrics for these criteria for each species have not been quantified. At present the current extent of each population and estimated abundance should be considered.

4.6.4. Data and Methods

Much work has been conducted on golden paintbrush given its rarity and efforts to re-establish populations across the range (Dunwiddie et al. 2013, Dunwiddie and Martin 2016) but as far as is known there are no data available for the current status of the population within SAJH. There are no data available for any of the other rare species within the park, though the Washington State Department of Fish and Wildlife maintains a publicly-accessible spatial database of rare plant 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://wdfw.wa.gov/conservation/phs/list/.

4.6.5. Resource Conditions and Trends

Attempts to re-establish golden paintbrush in the park are underway. Re-establishment was initiated at American Camp in 2009 when 400 plugs were installed. One flowering plant was recorded in 2010, but no additional data on this outplanting are available. Additional plugs were outplanted in fall of 2012 and in the American Camp prairie habitat plots in 2019 (S. Dolan pers. comm. 2019); 57 flowering plants were recorded in spring 2013 but flowering success for those planted in 2019 is not yet known. Also, attempts have been made to establish new local populations on Waldron, Lopez, and Shaw Islands, and San Juan Island, including at American Camp. These efforts began in 2007, and have included outplanting of nursery-grown plugs of this species, as well as some site management, which has included control of invasive species, cutting of encroaching shrubs and trees, burning, and fencing to reduce access of grazing animals.

Arnett (2014) reported increases in populations at nearly all sites monitored, though most increases came from planted sites not wild populations (cascadiaprairieoak.org/wp-content/uploads/2014/12/CALE-2014-population-summary.pdf). Recent data from the SAJH sites were unavailable for this report.

As far as is known the populations of madrone within SAJH are free of disease and are stable. Information to fully assess the condition of pygmyweed is insufficient, as is information on its historical abundance here or elsewhere in the state. Likewise, there is insufficient information to assess the current conditions of either California buttercups or Hall's asters.

Therefore, all species are rated here as being of significant concern. The population of California buttercup at American Camp comprises a relatively small number of individuals, and road construction, invasive species, and hybridization with western buttercup all pose significant potential threats. Given what is known about the habitat preferences of Hall's aster and California buttercup and their current distribution, it is likely that they were both more widespread and abundant in the pre-contact period than they are currently on San Juan Island. Both species are associated with prairie and related habitats that have declined greatly in area and condition.

Non-native species have the potential to negatively impact populations of rare species. The most problematic non-natives are herbaceous species (Table 2.3) though invasive shrubs, like Scotch broom (*Cytisus scoparius*) and Himalayan blackberry (*Rubus armeniacus*), can be extremely deleterious if they become established because they may lead the community in a successional trajectory from prairie to shrubland.

4.6.6. Level of Confidence

Medium

4.6.7. Data Gaps and Research Recommendations

- The recovery plan for *C. levisecta* (FWS 2000) highlights reintroduction as a necessary element for recovery. Considerable habitat exists within the park that could potentially sustain new populations of *C. levisecta*, positioning the park to play a critical role in the recovery of this species. Information needs related to this effort with SAJH can be grouped into propogation, site management, monitoring and determination of survival and mortality factors. A summary of research and monitoring needs for *C. levisecta* recovery are presented in Table 4.6-1.

- No regular monitoring has occurred for most of the park's rarer species of vascular plants such as *Crassula connata*, *Ranunculus californicus* var. *californicus*, and *Symphyotrichum hallii*, so trends in size or extent of populations are unknown.

- Annual forbs and other species that may be especially adapted to regular burning could be particularly vulnerable to loss (Dunwiddie et al., in press). Up-to-date surveys are needed to document population numbers, area occupied, exact locations, and other important data for management.

- A greater effort should be made to assemble known information, through a combination of literature review and expert interviews, about rare plant species within the state in order to better put in context the populations found at the park.

- Unregulated deer populations have effects on vegetation even at very low densities (Arcese et al. 2014). Herbivory is a strong limiting force on native plants, particularly for species dependent on specific habitats such as oak meadows (Gonzales and Arcese 2008).

Table 4.6-1. Research and monitoring needs for *C. levisecta* population recovery inside SAJH.

Recovery Element	Needs	References
Propogation	Success has been achieved in the last several years in establishing *C. levisecta* at several sites and NPS efforts to coordinate with others active in this endeavor should continue. Specific tasks that might be addressed cooperatively in relation to propogation include determining the best seed sources and finding ways to grow plants most efficiently.	Lawrence and Kaye 2011
Site Management	Exotic species, especially annual and perennial grasses, should be scarce and easily controlled. More host plants are needed Identifying and quantifying associated species in recovery habitat to evaluate the presence and abundance of host species and competitors. In the absence of more frequent fires, it is assumed that natural succession will allow more woody species to expand into prairie and grassland sites where *C. levisecta* is most common, so more information on the need for burning or other actions that might create microhabitats more suitable for seed establishment is needed.	Lawrence and Kaye 2011
Survival/Mortality	Monitoring of grazer numbers and behavior to determine factors that contribute to herbivore impacts should be included with population monitoring, and consideration given to herbivore control.	Caplow 2004

Table 4.6-1 (continued). Research and monitoring needs for C. levisecta population recovery inside SAJH.

Recovery Element	Needs	References
Monitoring	Annual monitoring of all outplanted *C. levisecta* individuals to assess survival, productivity, and mortality, and surveys to locate any individuals that may have recruited from seed, are necessary for all reintroduction programs.	Caplow 2004, Ewen and Armstrong 2007, Drayton and Primack 2012

4.6.8. Sources of Expertise

- Christopher Chappell, Washington Department of Natural Resources, Natural Heritage Program

4.6.9. Literature Cited

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4.7. Terrestrial Vegetation and Land Cover

By Peter Dunwiddie and Catherin Schwemm

4.7.1. Condition Summary

Prarie and Oak Woodlands

Prairie and oak woodlands are rare and generally declining in the Pacific Northwest, though in the park these habitats are currently relatively well-managed and are being restored.

Old-Growth Forests

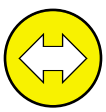
Old-growth forests are much reduced in extent but within the park appear stable.

Coastal Strand

Coastal strand vegetation appears stable and responsive to dynamic dune processes.

Summary

Herbivory by rabbits and deer is of concern, as are invasive species. Trends are stable to improving, and confidence in current conditions is high.



4.7.2. Background

Prairies and Oak Woodlands

For this assessment "prairies" refers to vegetation communities in SAJH that are dominated by native herbaceous species. Prairies generally have few shrubs or conifers, and if oaks or other trees are present there is a relatively open understory (Peterson and Reich 2008). 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).

Puget Lowland prairies, such as the rocky bald and oak savanna vegetation on Young Hill at English Camp, are some of the most endangered habitats in Washington (Noss et al. 1995, Chappell et al. 2001, Chappell 2006a and b, Dunwiddie and Bakker 2011, WDFW 2015). Specifically, six prairie-complex plant associations found in the park are designated as "Imperiled" or "Critically Imperiled" either within Washington or globally (Table 4.7-1). Plant species diversity varies greatly across sites identified as prairie/oak woodland, and these communities occur on a variety of substrates, including rocky exposures and coastal bluffs, and on diverse soil types. Prairie plants are critical resources for pollinators (e.g. bees; Neame et al. 2013), and birds (Altman 2011; prairie/oak woodland-dependent bird species are discussed in section 4.8).

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 et al. (2011).

Table 4.7-1. Frequency and areal extent of prairie associations in SAJH (excepting dunes and coastal strands), with imperiled associations (if applicable) as modified from Rocchio et al. (2012).

Alliance/Species	**Description**	**Total Acres**	**Conservation Status (if applicable)**
Symphoricarpos albus (snowberry)	Pacific Coast Shrubland	68	–
Quercus garryana (Oregon white oak)	Woodland	20.5	–
Quercus garryana / Symphoricarpos albus / Carex inops	Woodland	–	G2/S2
Racomitrium canescens (hoary fringe moss)	Nonvascular	17.4	–
Festuca roemeri – Agrostis pallens – Koeleria macrantha (Roemer's fescue/bentgrass/junegrass)	Herbaceous	16.3	–
Carex tumulicola (foothill sedge)	Herbaceous	9.3	GUSUQ
Festuca rubra – Calamagrostis nutkaensis (red fescue/Pacific reedgrass)	Coastal Headland Herbaceous	4.6	G1S1
Festuca rubra – (Camassia leichtlinii, Grindelia stricta var. *stricta)*	Bald/bluff	–	G1S1
Carex inops (long-stolon sedge)	Herbaceous	0.2	–
Camassia quamash (camas)	Herbaceous	0.1	GNRS1S2
Plectritis congesta (seablush)	Herbaceous	0	GNR S1Q
Holcus lanatus – Poa pratensis	Provisional Ruderal	259.1	N/A
Agrostis (capillaris, stolonifera)	Provisional Ruderal	148.2	N/A
Bromus (diandrus, hordeaceus, sterilis)	Provisional Ruderal	105.1	N/A
San Juan Islands Ruderal Forbs and Graminoids	Provisional Ruderal	34.6	N/A
Arrhenatherum elatius	Provisional Ruderal	14.3	N/A
Bromus sitchensis – Elymus glaucus	Provisional Ruderal	8.9	N/A
Festuca roemeri Alliance	Provisional (Restoration) Ruderal	1.3	N/A

History

Prairies of the Pacific Northwest are thought to have been maintained by Native Americans who used fire to slow succession by retarding establishment of young trees while allowing mature oaks and conifers to persist (Agee 1984, Avery 2004, NPS 2005). Without fire seeds of conifers and shrubs distributed by wind or animals from adjacent stands will germinate and survive in open sites, eventually leading to communities dominated by woody species (Peterson and Reich 2001). The use of fire to maintain prairies and grasslands largely ended when Europeans and settlers arrived in the mid-late 1800s, as indicated by the coincidental establishment of an oak woodland at Young Hill just after settlement (Thompson 1972, Agee 1987, Boyd 1999, Walsh 2008). The conversion of prairies and remnant forests to agricultural uses during the Hudson Bay Company period (1853–1875) permanently altered many of the existing prairie sites extant at the time (Rolph and Agee 1993). Shrubs and trees such as snowberry (*Symphoricarpos albus*), the introduced one-seed hawthorn (*Crataegus monogyna*), and Douglas fir (*Pseudostuga menziesii*) have expanded into some prairie/grassland areas following the cessation of farming and burning.

Ecological Function

Prairies historically supported diverse invertebrate and wildlife communities. Several butterfly species, in particular the island marble butterfly (*Euchloe ausonides insulanus*), depend on specific prairie plants as egg and larval hosts (Altman 2011, Schultz et al. 2011). The island marble butterfly was recently (1998) rediscovered on San Juan Island after being thought extinct, and now the population at American Camp may be one of the only viable populations remaining (Schultz et al. 2011, Jordon et al. 2012), making the preservation of remaining prairies critical to preserving this and other prairie-dependent butterfly species (Schulz et al. 2011). Prairie and oak woodlands should also support diverse bird communities. Particularly characteristic prairie bird species include the lazuli bunting (*Passerina amoena*) and the western bluebird (*Sialia mexicana*; Altman and Stevens 2012.) Many bird species that are tied strongly to prairie habitats are in decline (Altman 2011; Section 4.8).

<u>Forests</u>

Forest types described for SAJH and the Pacific Northwest include old-growth and sites dominated by Pacific madrone (*Arbutus menziesii*), as well as more open woodlands dominated by deciduous species other than oak (Franklin and Dyrness 1973). Forests are the primary vegetation type across western Washington, with various communities dominated by Douglas-fir, western hemlock, grand fir, western red cedar (*Thuja plicata*), bigleaf maple (*Acer macrophyllum*) and red alder (*Alnus rubra*). On drier sites, shore pine (*Pinus contorta* var. *contorta*) and Pacific madrone (*Arbutus menziesii*), are important constituents. Within SAJH, forest stands include western hemlock (*Tsuga heterophylla*), grand fir (*Abies grandis*), and Douglas-fir (*Pseudotsuga menziesii*), interspersed with smaller ruderal and wetland sites.

History

Prior to human disturbance, much of the park was likely a combination of fir, hemlock, cedar, alder, and oak (Agee 1987). Chappell's (2006a and b) surveys of Puget Lowland remnant undisturbed forests, along with J. Henderson's fire history data from the adjacent national forests (Henderson et al. 1989), suggest that relative cover of old-growth on the pre-contact landscape probably fluctuated over time in response to rare but periodic large-scale fires. Fires also removed many of the snags and downed wood that provided important wildlife habitat. Similar to the rest of Washington, logging activities prior to 1925 were intense across the San Juan Islands, but perhaps less-so than on the mainland given the relatively open landscape maintained by native burning (Avery 2004). Estimates are that the proportion of the region's landscape with old-growth prior to the introduction of logging likely averaged more than 30%, with mature trees reaching ages of up to 400–800 years.

Cumulatively the San Juan Islands include approximately 70,000 ac (28,328 ha) of forestland, 60,000 ac (24,281 ha) of which are in private ownership and open to logging. Harvest yields have been declining as a result of practices that remove the largest trees ("high-grading"), for example timber yields in the 1990s were only one-third those in the 1950s. A survey in 2007 of the San Juan County shoreline reported an average 25 percent loss of marine riparian forest cover between 1977 and 2006 (MacLennan and Johannessen 2008). At present there are approximately 1,433 forested ac (580 ha) within the park units (Table 4.7-2).

Table 4.7-2. Area in total acres of mapped forested alliances at SAJH. Modified from Rocchio et al. 2012.

USNVC Alliance	Growth Form	Total Acres
(Acer macrophyllum – Alnus rubra)	Riparian Forest	66.0
(Alnus – Fraxinus – Populus) / Lysichiton americanus	Deciduous Swamp Woodland	3.4
(Tsuga heterophylla – Picea sitchensis – Thuja plicata – Abies) / Lysichiton americanus	–	3.0
Acer macrophyllum – (Pseudotsuga menziesii)	Forest	4.4
Alnus rubra / Nonnative Grasses Provisional Ruderal	Flooded Forest	13.3
Alnus rubra – (Picea sitchensis – Tsuga heterophylla)	Forest and Woodland	1.0
Alnus rubra – Pseudotsuga menziesii	Provisional Ruderal	79.1
Alnus rubra / Carex obnupta	Provisional Ruderal Flooded Forest	0.8
Prunus emarginata	Provisional Ruderal Flooded Forest	0.4
Pseudotsuga menziesii – (Arbutus menziesii)	Forest and Woodland	784.2
Pseudotsuga menziesii – Pinus contorta	Provisional Ruderal	16.7
Pseudotsuga menziesii /	Nonnative Grasses Provisional Ruderal	36.2
Thuja plicata – (Abies grandis)	Maritime Forest	333.6
Tsuga heterophylla – Pseudotsuga menziesii / (Holodiscus discolor)	Forest	91.3
TOTAL		**1,433.4**

Madrone

One particular forest community of note is the *Pseudotsuga menziesii – Arbutus menziesii/Holodiscus discolor* forest where Pacific madrone (*A. menziesii*) is a co-dominant.

Madrone is one of the few native evergreen broadleaf trees in the region, and is an important structural component that provides resources such as nesting cavities for birds and fruit for frugivorous birds (Raphael 1987, Gurung et al. 1999). Data and observations suggest that longer fire return intervals have allowed a fungal pathogen—Fusicoccum arbuti—to persist longer in forest systems. This fungus has a sexual stage that is present in other fungi in the genus *Botryosphaeria* that remains latent in healthy twigs and branches until the tree becomes stressed (Elliott and Edmonds 2008). Fungal infections can damage and kill trees, and while *F. arbuti* has been present in Washington since at least 1968 and is likely native to the region, recent infestations have had unsustainable impacts, suggesting altered conditions (Elliott et al. 2002, Farr et al. 2005).

Coastal Strand

Marine riparian systems of the Puget Basin are important habitat resources supporting a high diversity of coastal species, and the SAJH dunes represent one of less than five remaining native dune communities in the Puget Lowland (Brennan 2007, WDFW 2015). Several plant associations that occur in dune habitats are considered imperiled (Rocchio et al. 2012). For example, salt marshes associated with coastal lagoons host several species such as sharpfruited peppergrass (*Lepidium oxycarpum*), Nuttall's quillwort (*Isoetes nuttallii*), and erect pygmy-weed (*Crassula connata*) listed by the Washington Natural Heritage Program as sensitive. A noteworthy vegetation assemblage found along the SAJH shoreline is dominated by pickleweed (*Salicornia virginica*), saltgrass (*Distichlis spicata*), arrowgrass (*Triglochin maritima*) and jaumea (*Jaumea carnosa*).

The SAJH dunes are noteworthy for still being active, meaning that sand transport processes are still somewhat intact, and are likely one of the last remaining active dune systems in the Puget Lowland. The relative abundance and in some cases dominance of the native coastal sand verbena (*Abronia latifolia*) in the dunes and strand is indicative of a substantial degree of substrate instability and sand movement, which are critical ecosystem features for these systems which are easily lost via succession in the presence of stable sand. Geomorphic changes related to future sea level rise are a concern for the strand and spit communities.

Fire

Fire plays a critical role in structuring vegetation communities of the Pacific Northwest (Spurbeck and Keenum 2003, Gray and Daniels 2006, Storm and Shebitz 2006, Sprenger and Dunwiddie 2011). Fire regime parameters commonly described include periods between fires (fire return interval-FRI), severity, extent, and seasonality.

Prairies/Oak Woodlands

Fires were deliberately set by native people on SJI to create conditions favoring the growth of species that could be used for food or medicine. For example, camas (*Camassia quamash* and *C. leichtlinii*), strawberries (*Fragaria species*), bracken (*Pteridium aquilinum*), yampah (*Perideridia gairdneri*) and chocolate lily (*Fritillaria affinis*) are examples of species that thrive in recently burned-over areas and that were harvested extensively (Avery 2004). It is not known how long the practice of burning prairies was maintained, and few clues are available for reconstructing historical fire regimes at either American or English Camp. What evidence exists suggests that in the oak savanna/woodlands of Young Hill, fire-return intervals were relatively frequent, on the order of 7–10 years (Sprenger and

Dunwiddie 2011). On the exposed, south-facing slopes of American Camp, grasslands may have persisted historically with fires less frequent than the 3–5 years suggested for other Puget Sound grasslands (Hamman et al. 2011).

The historic fire regime in oak woodlands is easier to reconstruct. On Vancouver Island FRI was estimated at between 26–41 years (Pellat et al. 2015), while at a site on Waldron Island that has been intensively studied, Sprenger and Dunwiddie (2011) documented a pre-settlement mean fire return interval of 7.4 years (range 2–31 years). The rapid establishment of Douglas-fir in recent decades at both sites in the absence of fire strongly suggests that historic fires were an important factor in keeping coniferous tree invasion in check (Agee 1984).

Forests

Natural fire return intervals for stand-replacement fires in the region's lowland conifer forests were probably relatively long, at least 200 years and perhaps longer (Agee 1996). Although there is strong evidence of underburning in old-growth forest fragments in the Puget Lowland (McDadi and Hebda 2008), it is difficult to determine what the historical FRI at SAJH sites might have been, though it was likely in the range of 5–30 years (Agee 1996). A widespread, stand-replacement fire occurred somewhere between 1715–1725 (Agee 1984). Another stand-replacement fire may have occurred around 1775 in the northeast portion of English Camp.

Threats to Vegetation Communities

Invasive Plants

The introduction of non-native plant and animal species that accompanied the arrival of Europeans and the establishment of ranching has had profound impacts on vegetation diversity and community structure in SAJH (Avery 2004, Rochefort et al. 2012). The greatest impacts have occurred in prairie vegetation types where introduced herbs and grasses compete strongly with native species, and non-native grasses and herbs are now dominant in many areas (Rochefort and Bivin 2010, Rocchio et al. 2012). Species of most concern are discussed in many sources including Stanley et al. (2011) and Dennehy et al. (2011). Non-native species are generally less competitive in forested than in non-forested areas, but are of concern in all communities including dune and coastal strand/spit communities (Rochefort and Bivin 2010, Rocchio et al. 2012). A particular threat to dune communities is European searocket (*Cakile maritima*), which is common on South Beach and other strand habitats where it dominates sparsely vegetated areas (Wiedemann 1984). European beachgrass (*Ammophila arenaria*) is a highly invasive species in dune habitats but is fortunately currently absent from the park.

Herbivory

Populations of Columbia black-tailed deer (*Odocoileus hemionus columbianus*) and European rabbit (*Oryctolagus cuniculus*; Section 4.9) are high enough in some years to exert measureable negative impacts on native plant populations (Stevens 1975, Rochefort and Bivin 2010). Deer preferentially browse on deciduous shrubs and young trees (often planted in restoration programs; Clements et al. 2011), impacting not only the understory composition of native forests but also successional trajectories (Milestone 1986, Agee 1987, Rolph and Agee 1993, Martin et al. 2011). Increased grazing and browsing has locally reduced the cover of low vegetation and perhaps the diversity of native forbs (Bassett-Touchell 2008, Martin et al. 2011). Such damage to shrubs and ground cover occurs in places where deer densities are greater than 0.04/acre (Thiemann et al. 2009, Martin et al. 2011). Rabbits not only graze vegetation but their extensive underground warrens disturb the soil, facilitating the establishment of non-native species (Rochefort and Bivin 2010).

Direct Human Impacts

One state-listed imperiled community type—*Camassia quamash – Triteleia hyacinthina* Herbaceous Bald—has been impacted by trampling by humans on top of Young Hill. This unusual plant association occurs in vernal (seasonally flooded) seeps that occur on rocky balds, making it highly vulnerable to direct trampling or alteration of runoff patterns by visitors (Rocchio et al. 2012).

Disease

In addition to the fungus mentioned previously for madrone, another non-native fungus, *Phytophthora ramorum*, causes sudden oak death. This species was first recorded in Washington in 2003 and can also affect other species including Oregon white oak, Douglas-fir, and bigleaf maple. Spores of this species spread easily in the atmosphere and on physical carriers, and sporangia are produced on several non-host woody species, particularly California bay laurel (*Umbellularia californica*; Rizzo et al. 2005). As far as is known this fungus has not yet affected trees in SAJH (http://www.fs.usda.gov/ccrc/topics/regional-example-pacific-northwest).

Climate Change

Predictions are that climate change will result in overall conditions of reduced summer and increased winter rainfall in the PNW (Section 4.2). In this scenario increased summer drought accompanied by greater incidence of disease may actually favor the persistence of prairies over forest types (Bachelet et al. 2011). Geomorphic changes related to future sea level rise are a concern for the strand and spit communities (Section 4.5).

4.7.3. Reference Conditions

Prairies

Composition and Structure

As far as is known there are no studies that have reconstructed the number and composition of species that existed in prairies or oak woodlands prior to Euro-American contact in SAJH or elsewhere in the region. Some investigators (Dunwiddie 2002, Dunwiddie et al. 2014) have suggested that the combination of frequent burning and the use of digging sticks (with churning and turning of the soil) by Native Americans on the Puget Lowland prairies may have favored a significantly greater abundance of annual and perennial forbs, and a concomitant lower abundance of perennial graminoids than is seen in present-day good-condition prairies and remnants. However, with no intact reference communities, it is difficult to identify specific reference conditions for native species diversity in prairies.

Speculation exists that there could have been areas of oak savanna on more level, mesic portions of the American Camp prairie prior to EuroAmerican settlement and that the oaks were removed entirely by early settlers (Agee 1987). The extent of oak woodland was likely greater than at present as evidenced by large oaks in what is otherwise mostly young Douglas-fir forest (Chappell, pers. obs. 2014).

Though it is not possible to ascertain a reliable list of historical species and relative abundance, research cited herein and expert observation suggest that the current desired (reference) condition for PNW prairies should include the following:

- Native species are dominant and occupy >75% of relative cover.
- Woody shrub cover is approximately 10% or less (Altman and Stevens 2012).
- Relative cover of non-native species is declining, indicating recovery of native plant populations.
- Few if any aggressive invasive species are present.
- Areas that include oak woodlands have approximately 25% tree canopy cover with up to five large and/or ten young trees/acre (Altman and Stevens 2012).
- Prairie-dependent butterfly, bird, and pollinator species are present and populations stable if not increasing (Neame et al. 2013).
- At least 200 ac/81 ha of prairie at American Camp are maintained, even though historic records suggest there may have been nearly 600 ac/243 ha (Agee 1984, Rolph and Agee 1993).

For prairies, more specific criteria would include combinations of three types of measures: 1) areal extent and configuration, 2) native floristic diversity and/or integrity, e.g., FQI – floristic quality index and mean C, the coefficient of conservatism, for each plant species (Rocchio and Crawford 2013), and 3) relative cover of native versus non-native species. The Prairie Vegetation Monitoring Protocol for the park (Rochefort et al. 2012) identifies "Ecological Integrity Ratings" for three types of measures that are similar to those described above. However, they are rated using somewhat different criteria, or have not yet been assigned quantitative values. For this assessment, specific values for these measures based on limited data from the park, other prairies in the ecoregion (Dunwiddie et al. 2013), and personal experience are proposed (Table 4.7-3).

Table 4.7-3. Specific values for reference conditions measures for prairies at SAJH.

Condition	Value of Reference Conditions Measures			
	Areal extent and configuration	mean Coefficient of Conservation	# native species	Relative cover of native species
Good	> 200 acres	> 3.9	>50	> 75%
Moderate Concern	60–200 acres	3.7–3.9	25–50	> 15%
Significant Concern	< 60 acres	< 3.7	<25	<15%

Oak Woodlands

Composition and Structure

Historical accounts provide more information for oak woodland structure than for prairie composition. It appears that the Young Hill oak woodland was more open than at present with less woody vegetation in the understory (Agee 1987). The pre-settlement woodland/savanna likely had few to no conifers in the understory/subcanopy layers due to relatively frequent fires (Gedalof et al. 2006, Sprenger and Dunwiddie 2011). Measurable reference conditions for oak woodlands would include the following:

- Generally sparse canopy densities (e.g., savanna-like).
- Less than 15% shrub cover.
- Fewer oak trees than at present but with some regeneration (Gould et al. 2011).
- Approximately 175/ha Douglas-fir individuals (Dunwiddie et al. 2011).
- Self-sustaining bird populations that require relatively open canopies with snags and trees large enough to provide cavity habitat (Altman and Stevens 2012).
- Invasive non-native species should be absent (Dennehy et al. 2011).

Forests

Forest Age and Composition

Stand age classes can be used as a surrogate for stand structural feature, though differences in site productivity can strongly impact the rate at which late-successional features are created in a stand. Still, even relatively unproductive sites will develop greater structural features with age. Forests in good condition will have age classes similar to the presumed pre-EuroAmerican settlement distribution as presented in Table 4.7-4. The more different forest structure and composition is from historic measures the less it can be considered to be in good condition.

Significant Concern. Distribution of age class and dominance type is very different (<20% similarity) than the presumed pre-EuroAmerican settlement distribution.

Table 4.7-4. Common combinations of vegetation dominance type and stand age expected to occur in SAJH forests (various sources). X = stand age expected to occur.

Vegetation	Very Young	Young	Mature	Old-growth
Pseudotsuga menziesii (Douglas fir)	X	X	X	–
Pseudotsuga menziesii – Abies grandis (Douglas fir – grand fir)	–	X	X	–
Pseudotsuga menziesii – Arbutus menziesii (Douglas fir – Pacific madrone)	–	X	X	–
Pseudotsuga menziesii – Pinus contorta (Douglas fir – lodgepole pine)	X	X	–	–
Abies grandis (grand fir)	–	X	–	–

Table 4.7-4 (continued). Common combinations of vegetation dominance type and stand age expected to occur in SAJH forests (various sources). X = stand age expected to occur.

Vegetation	Very Young	Young	Mature	Old-growth
Abies grandis – Thuja plicata (grand fir – western red cedar)	–	X	–	–
Alnus rubra (red alder)	X	X	–	–
Alnus rubra – Pseudotsuga menziesii (red alder – Douglas fir)	X	X	–	–

Rocchio et al. (2012) and Agee (1987) provide further detail on stand compositional types. Douglas-fir, grand fir, western hemlock, western redcedar, lodgepole pine, red alder, and Pacific madrone will appear relatively frequently as canopy dominants or co-dominants (defined as the 1–3 most abundant species in the main and upper canopy layers, wherein dominant or co-dominant species occupy at least 25% of the total canopy cover). Based on published information and expert observations suggested forest reference conditions for SAJH include:

- All existing areas of old growth should remain.
- Distribution of all forest age classes similar to conditions prior to pre-EuroAmerican settlement.
- A minimum of two tree canopy layers for western hemlock old growth.
- A minimum of eight to ten standing live Douglas fir trees at least 24–37 in/61–94 cm dbh and >200 years old per acre (varying by site class).
- Standing decadent trees (dead or with broken tops) at sizes of 20 in/51 cm dbh or greater present in densities of approximately 4 snags/acre.
- At least one snag at least 13–17 in/33–43 cm dbh/acre and at least four logs at least 24 in/61 cm dbh

<u>Coastal Strand</u>

For strand and dune communities, criteria for evaluating condition would include extent, species diversity, relative abundance of native versus non-native species, and dune dynamics (sand transport, etc.). Very little information exists to suggest what the historical extent and species composition of the coastal strand, spit, and dune communities within the park should be. Consequently, reference conditions for these sites focus on the overall absence of invasive and non-native species (Brennan 2007, Rocchio et al. 2012).

4.7.4. Data and Methods

Much of the information on current vegetation conditions comes from the recent vegetation mapping effort conducted by Rocchio et al. (2012) who mapped the park's forests using Alliances from the National Vegetation Classification. Prior to that effort, Rochefort and Bivin (2010) compiled a vascular plant species inventory for the park. As part of this assessment an analysis of LiDAR fine-resolution data for the entire park produced a comprehensive profile of the vegetation canopy heights, and those data (in GIS/shapefile format) are available from the authors.

<u>Prairies/Oak Woodlands</u>

Extensive research has been conducted on the prairies and oak woodlands of the PNW, investigating both historic conditions and restoration targets and methods. Many of those efforts are cited herein, in particular Sinclair et al. (2006), Stanley et al. (2008), Dunwiddie and Bakker (2011), and Trowbridge et al. (2017). Data are also available from the North Pacific/ Columbia Basin (NPCB) Fire Ecology program (e.g. Kopper and Drake 2016), though the data were unavailable for this assessment.

<u>Forests</u>

Reference conditions for forests are based primarily on the work of Agee (1984, 1987), who reviewed available historical records and photographs, soil surveys, and research from regionally comparable sites to construct a description of historical landscape cover. Reference conditions are also informed by extensive field surveys of existing and relatively undisturbed forest stands throughout the Puget Lowland completed by the Washington Natural Heritage Program (Chappell 2006b). Early photographs suggest that much of the Douglas-fir on site was much older (some of it evidently >200 years) than at present, however, the photographic record covers only a small portion of current park lands.

<u>Coastal Strand</u>

Aside from the Rocchio et al. (2012) mapping effort, very little is known regarding the current condition of coastal strand vegetation in the park.

4.7.5. Resource Conditions and Trends

The overall vegetation resource of SAJH is described extensively in Rocchio et al. (2012), who reported that the most common vegetation type across the two park sites is the forest and woodland alliance dominated by Douglas fir and madrone (784 acres/317 ha). Shrub communities are dominated by snowberry, and several species of non-native grasses dominate herbaceous sites (Rocchio et al. 2012). Vegetation communities mapped at American Camp and English Camp are taken from Rocchio et al. (2012) and presented in Figures 4.7-1 and 4.7-2, respectively.

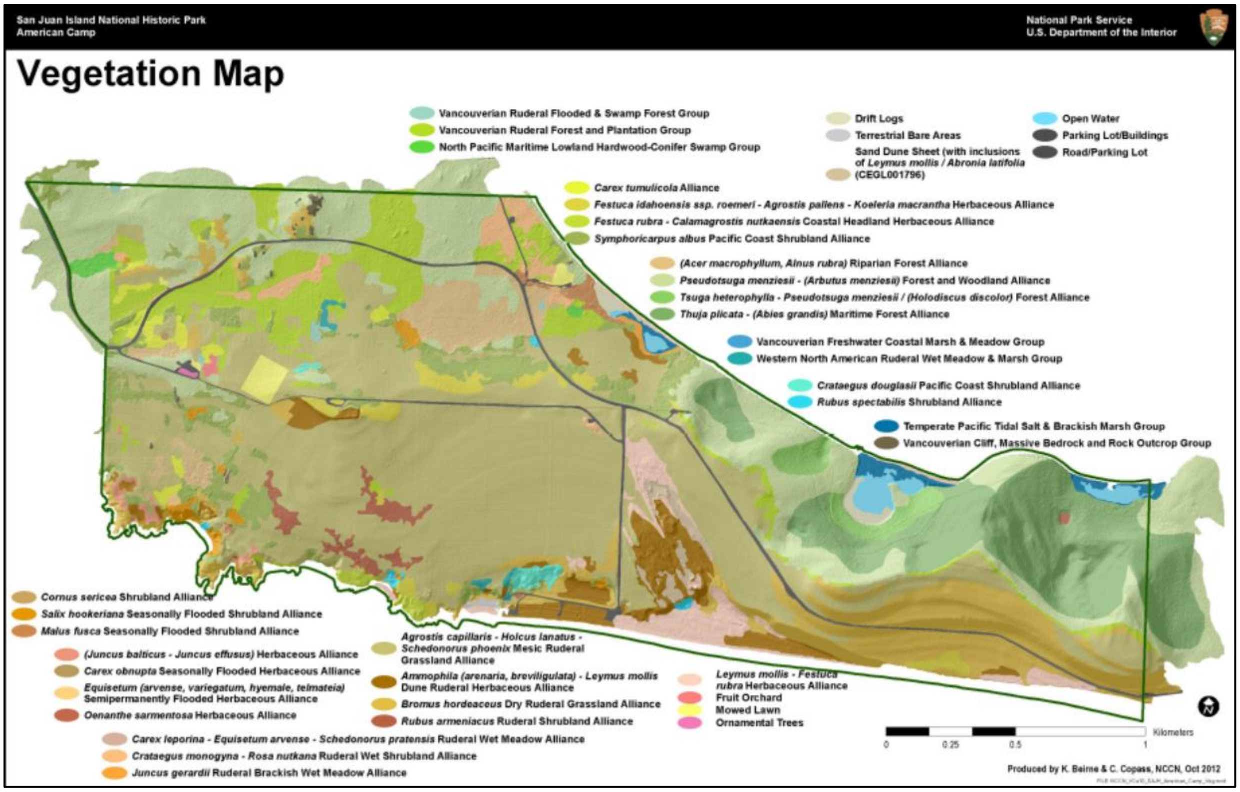


Figure 4.7-1. Vegetation map of American Camp from Rocchio et al. 2012.

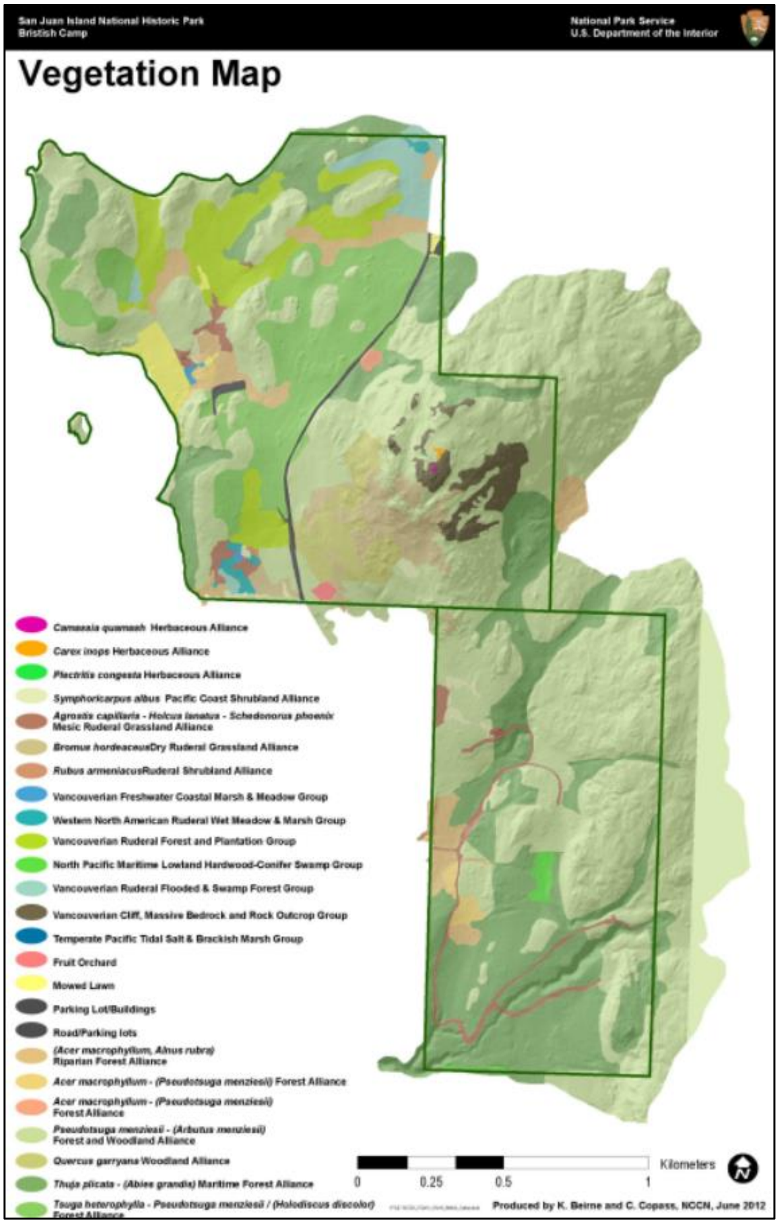


Figure 4.7-2. Vegetation map of English Camp and Mitchell Hill from Rocchio et al. 2012.

<u>Prairies/Oak Woodlands</u>

Extent

Only small remnants of native prairie now exist at American and English camps (Rochefort and Bivin 2010, Rocchio et al. 2012). The total acreage of all imperiled prairie/oak woodland associations at the park is currently 30.5 ac/12.3 ha, with the majority being fragments of the dry prairie community known as *Festuca roemeri – Camassia quamash – Cerastium arvense* Herbaceous Vegetation. This community is considered a historical occurrence (functionally extirpated) in Washington because all known occurrences are considered too small to be viable. Native herbaceous and nonvascular prairie alliances comprise 8.2% of the areal extent of prairie-associated vegetation mapped by Rocchio et al. (2012). An additional 2.9% is oak woodland (with a mostly non-native understory) and 9.6% is native shrubland that occupies mostly what was formerly prairie. The remaining approximately 80% is ruderal, non-native vegetation, with additional portions dominated by native mosses (Rocchio et al. 2012; Figure 4.7-3).

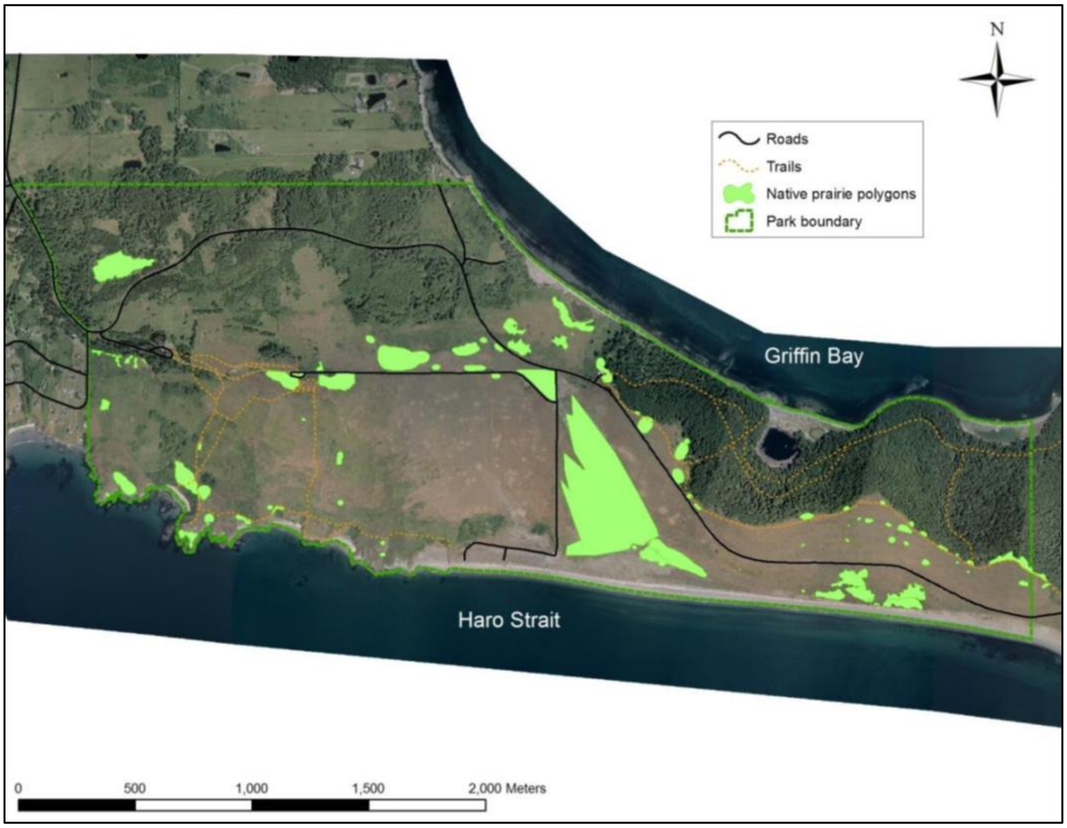


Figure 4.7-3. Prairie areas still dominated by native plants as delineated by field surveys at American Camp. From Rochefort and Bivin 2010. Note: the largest of these colored polygons in the central portion of the map is primarily occupied by dunes, which herein are considered separately from prairies as part of other less common plant communities.

While the conversion of some grassland areas back to forests at American Camp may appear to be of concern, these changes are occurring primarily on historically forested areas with forest soils. In the absence of significant, aggressive restoration actions, the current trend in the areal extent of actual native prairie is likely to be a gradual loss. The extent of grass-dominated vegetation that is structurally akin to the original prairie has likely not declined substantially from pre-EuroAmerican settlement times at American Camp.

It does not appear that large-scale conversion of oak woodland has occurred within the park. At Young Hill, soil surveys and the presence of scattered old oak trees in some forested areas indicate that there has been a small reduction in areal extent of the oak woodland/savanna in that area. Areal extent appears to be relatively stable based on the work of McCoy and Dalby (2009).

Composition/Species Diversity

The proportion of native species in prairie communities continues to decline as invasive grasses and forbs become increasingly dominant in the herbaceous layer. Orchardgrass (*Dactylis glomerata*) and tall oatgrass (*Arrhenatherum elatius*) are common in the oak woodland on Young Hill (Rocchio et al. 2012). The latter is of special note due to its well-documented capacity to rapidly overwhelm and dominate the native prairies of the Northwest (Dennehy et al. 2011). The majority of the American Camp prairie is classified as ruderal, meaning that early successional alliances are dominated primarily by non-native grasses. At English Camp, the areal extent of prairie was relatively stable during the period 1997–2007 (McCoy and Dalby 2009, Rochefort et al. 2012). The analysis by McCoy and Dalby, however, included open oak woodland as part of prairie, as well as degraded non-native grasslands that were mostly not grassland in the pre-EuroAmerican settlement era.

Woody cover is also increasing as shrubs and trees – particularly Douglas fir – expand into grasslands. Patches of former prairie, especially near forest margins and on more mesic sites in the northern section of American Camp, are currently dominated by native shrubs, mostly common snowberry (*Symphoricarpos albus*) and Nootka rose (*Rosa nutkana*) that have likely increased in abundance with fire suppression. Recruitment of alders and conifers into prairie sites has increased since the 1980s when there was a decline in rabbit abundance that reduced herbivory (McCoy and Dalby 2009, Rocchio et al. 2012).

From 1997–2007 approximately 75 ac/30 ha have seen an increase in woody species cover (McCoy and Dalby 2009), however, the American Camp prairie is still largely an open grassland. Oak woodland stand structure has mostly been improved following mechanical treatments and prescribed fires that have reduced conifer (mostly Douglas fir) abundance. The vast majority of the prairie soils (assumed to be the pre-settlement prairie/oak woodland extent) at American Camp remain in herbaceous dominance and have not converted to conifer forest.

Ecology/Fire

Fire is again being applied as a management tool to protect and restore prairies and grasslands, specifically to reduce non-native grasses and limit woody species recruitment (Dunwiddie and Baker 2011, Rochefort et al. 2012, Kopper and Drake 2016). Initial monitoring data associated with these management treatments show a large post-treatment decrease in Douglas-fir density (mean 107 trees/ac down to 10.5/ac), with a virtual elimination of pole-size and sapling trees, and no apparent change in shrub cover, with a mean of 30–40% and much variability (K. Kopper, pers. comm. 2014).

<u>Forests</u>

There are at present no true old-growth stands in the park (Figures 4-7.4 and 4-7.5). Most of the existing forest stands are young, though many are verging on mature or have just recently become mature (Agee 1984, 1987). On the north slopes of Mount Finlayson at American Camp there is a stand of mature conifer forest that includes individual trees that are approximately 120–130 years old. This stand is the result of regeneration following a late 19th-century timber harvest. In the 1950s, portions of the forest in this area were logged and high-graded (the largest trees were removed), but small patches of old trees remain (Agee 1987). Mature stands are now quite rare in the Puget Lowland making this forest stand of particular value.

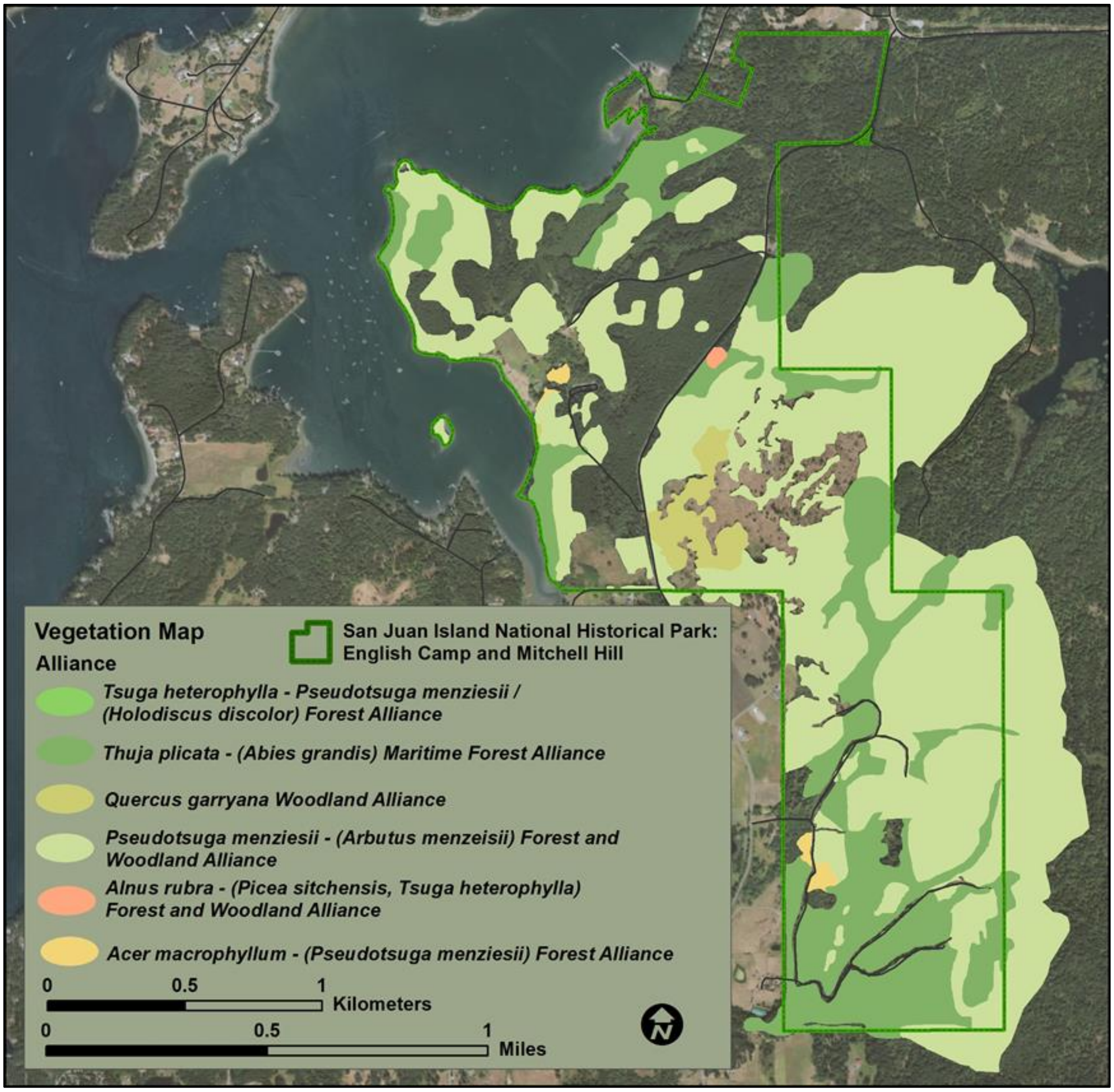


Figure 4.7-4. Location of native upland forest alliances at English Camp and Mitchell Hill. From Rocchio et al. 2012.

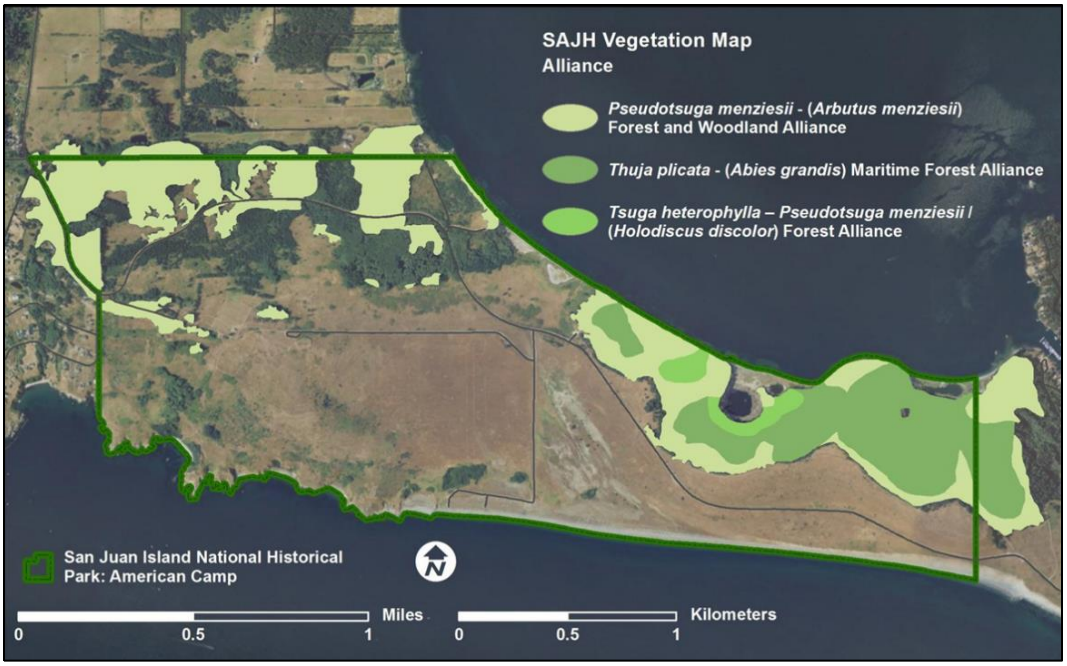


Figure 4.7-5. Location of native upland forest alliances at American Camp. From Rocchio et al. 2012.

Despite the absence of old-growth, natural succession is allowing mature conifer trees that are protected from logging and fire to become dominant, and the forest canopy at American Camp has been increasing as a result of fire suppression and natural succession. It should be noted, however, that these are observational assessments only as there are no data available on actual tree ages in this stand. A tree canopy higher than 100 ft occupies only 13.6% of English Camp. The distribution of age classes appears to be atypical for lowland environments similar to those in the park, and from what can be inferred from historical accounts. The current distribution of forest age classes in the English Camp unit is strongly weighted toward the "young" (50–100 ft/15–31 m) age class. Locations of the tallest tree stands in the English Camp and American Camp units can be seen in the maps generated from the LiDAR data (Figures 4.7-6 and 4.7-7). Very little is known regarding bird or mammal diversity in forest habitat at SAJH.

Coastal Strand

In general, coastal strand vegetation types in the park are in fair to good condition. Most sites are dominated by native species though non-natives can be co-dominant. The spits containing the lagoons on the north side of American Camp are undeveloped and in relatively good condition, particularly Third Lagoon.

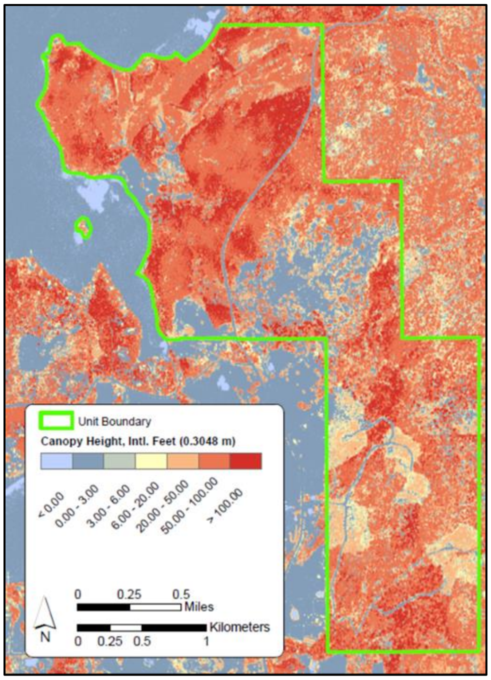


Figure 4.7-6. Canopy heights in English Camp and Mitchell Hill from LiDAR image analysis (this study).

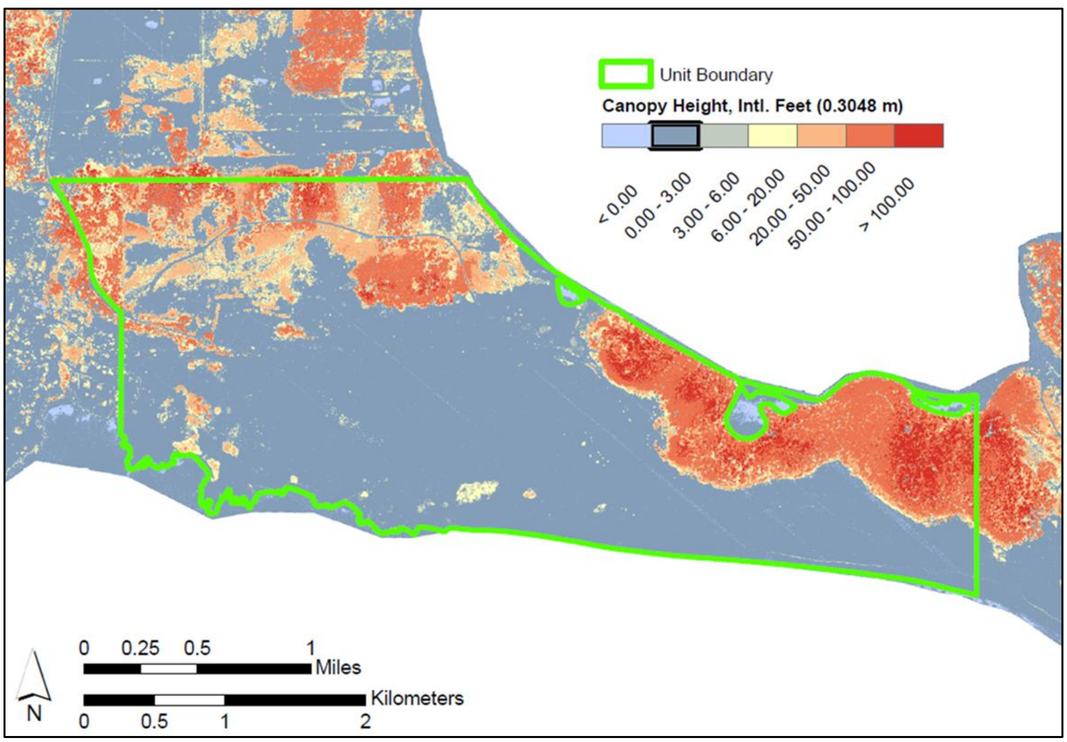


Figure 4.7-7. Canopy heights in American Camp from LiDAR image analysis (this study).

4.7.6. Level of Confidence
Confidence in the exact magnitude of historical changes in forest age, composition, and particularly structure is low given the absence of data to evaluate recent trends within the park. Confidence in prairie and oak woodland condition is high given published information and professional experience.

Given the availability of data, ongoing vegetation restoration efforts, and level of expertise of the authors, the confidence in this assessment is high.

4.7.7. Data Gaps and Research Recommendations
<u>Prairies</u>
Park planning documents highlight prairie restoration as a priority natural resource management goal (NPS 2008). While great efforts have been made to date to restore prairie and oak woodland ecosystems and some success has been achieved, additional research and management efforts would provide important information on prairie ecology to aid in successful restoration (Pellatt et al. 2015). Several suggestions for future work and investigation are provided below.

- Information is needed on minimal functional size for prairie sites, ecological relationships between rare species and prairie habitats, the relative effectiveness of mechanical treatments, active restoration, and prescribed fire, and the potential effects of climate change (Holling 1978, Walters and Holling 1990, Rolph and Agee 1993. Floberg et al. 2004, Dunwiddie et al. 2006, Allen and Gunderson 2011, Bachelet et al. 2011, Delvin 2013).

- Additional research is needed on ways to overcome the enormous restoration challenge presented by the high proportion of non-native seed in prairie seed banks (Rochefort and Bivin 2010), especially in relation to the application of prescribed fire as a restoration tool (Sinclair et al. 2006, Stanley et al. 2008, Stanley et al. 2011).

- Surveys of invertebrates, particularly obligate butterflies and pollinators, are needed.

- The overall costs/benefits of outplanting ("plugs") versus seeding should be further investigated.

- The NPS Fire Management Plan should be updated following the completion of a parkwide Vegetation Management Plan (S. Dolan pers. comm. 2019).

- Bryophytes and lichens are important contributors to overall biodiversity and ecosystem functions and should be comprehensively inventoried on park sites. Additionally, the effects of recreation, controlled burns, and other park management activities on these taxa should be investigated.

- Noxious weeds should be the object of careful, regular searches in likely habitat.

- Additional efforts should be made to inventory and monitor prairie-oak bird populations.

- Monitoring of restoration efforts is critical for success and should be continued.

- Measures that limit weeds, woody vegetation, and damage from herbivores (primarily deer and exotic rabbits) will speed the recovery of soils and native flora and fauna.

Forests

- Data are lacking on forest demographics and stand age structures throughout the park, including locations of any remnant stands of mature trees. The LiDAR data and the maps and descriptions in Rocchio et al. (2012) would be logical starting points for attempting to fill these gaps. In the process, consideration might also be given to modifying the Forest Service old-growth definitions so they better fit the environment of the San Juan Islands.

- For the park's forests, animal and plant diversity will benefit the most from management that encourages a diversity of age classes.

Coastal Strand

- Additional data are needed describing the condition and areal extent of strand, spit, and dune plant communities in the park, and in particular the effects of rabbits on these communities.

- Efforts to monitor for the potential introduction of European beachgrass (Ammophila arenaria) should be initiated and plans be in place to eradicate it if/when it should arrive.

- General studies of marine riparian vegetation communities of the San Juan Islands are lacking (Brennan 2007).

Current Fire Management

- Although naturally-occurring fires were probably infrequent, decades of wildland fire suppression have affected the types of vegetation and thus the types of habitat available to wildlife. Reduced fire frequency can result in less shrub cover (as trees grow taller and close out light and fewer fire-killed snags, which are necessary for many bats, woodpeckers, and other wildlife (Cahall and Hayes 2009). Fire suppression also facilitates the invasion of naturally-occurring oak woodlands by conifers, with subsequent change toward wildlife species that are more common throughout the Pacific Northwest than those that prefer oak woodlands.

- An active fire management program is in place at SAJH (NPS 2005). In addition to other goals, fire is used to help restore prairies by increasing relative cover of native grasses and herbaceous species while decreasing abundance of non-native species (NPS 2005). Fire treatments have generally been successful in meeting those goals, however, non-native herbaceous species, particularly annual grasses, have increased at some sites following burns (Lambert 2006, NPS 2008, K. Kopper, unpubl. data, pers. comm. 2014). Additional research is needed to understand when the ecological effects of fire will be more negative than positive and adjust management practices accordingly (Hamman et al. 2011).

Genetic Concerns and Restoration

- Genetic considerations are important when restoring plant communities as well as individual rare plant species. Whenever possible, using locally and regionally-derived native seed is good practice to ensure that local genotypes are not swamped by genes from other regions, which might not be well-adapted to local conditions. However, there is considerable debate within the restoration community regarding what is an acceptable distance to define appropriate source areas. This debate has intensified as considerations of assisted migration and enhancing resilience to climate change has caused some to argue for considerably larger potential source areas.

- The authors have seen no evidence of uniquely-adapted island genotypes, and consider native seed sources within the North Puget Sound region to be acceptable for restoration efforts. In some cases, particularly where sources within this region are unavailable, it may be entirely appropriate to use more distant sources, including from South Sound and even the Willamette Valley. It may be especially important to include genetic material from non-local (e.g., outside the park or San Juan Island) when the local source populations are extremely small, and may have very limited genetic diversity.

- Potential hybridization with closely related taxa is another genetic consideration with some species. The very rare Castilleja levisecta is known to hybridize with Castilleja hispida, and efforts should be made to avoid introducing both taxa in close proximity to one another in restoration plantings. Hybridization is also a concern with the locally rare Ranunculus californicus, as it is known to cross with the much more common Ranunculus occidentalis. Again, avoiding planting the two species in close proximity is advised to avoid possible genetic contamination and creation of hybrids. To avoid perpetuating or creating hybrids in restoration plantings, care should be taken to collect seed only from known “pure” parental stock, and avoid planting the two species in close proximity.

4.7.8. Sources of Expertise

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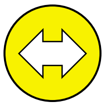
4.8. Birds

By Paul Adamus and Catherin Schwemm

4.8.1. Condition Summary

Bird diversity is high, supported by multiple habitat types in a relatively small area, though several bird species have been extirpated and others are at risk due primariy to habitat loss and degradation. Seabirds face numerous threats, many originating off-island. Overall bird diversity appears stable while the population trend for some species is declining. Confidence in this assessment is medium.



4.8.2. Background

The bird fauna of the San Juan Islands is diverse, owing to the combination of marine and terrestrial habitats and a relatively mild climate (Altman 2011, Holmgren et al. 2016), though several species have been extirpated since historical surveys began (Miller et al. 1935). This section will focus primarily on bird species of concern that are known residents in SAJH, but will also include species that may travel from other locations within the archipelago. The assessment focuses primarily on landbirds and shorebirds; seabirds are discussed in general terms only.

The certified park bird list, published in 2004, includes 172 bird species (114 listed as Present in Park and the rest as Probably Present). However, the actual number may be 218 if records published since the park list was certified in 2004 are included, which would add records but also exclude 11 species included in the NPS list as occurring in the park but for which no published records could be found. (Additional records were obtained by searching eBird (www.ebird.org) for locations within both of the park's units and extracting those data. Species found by the NPS North Cascades Network systematic surveys from 2006 through 2012 were also added as were species from a checklist for Cattle Point.) A comprehensive list of all bird species recorded from SAJH is provided in Appendix A.

<u>Landbirds</u>

Landbirds are defined here as species that do not require marine-associated resources or habitats. Of most interest from a conservation perspective at SAJH are species dependent on or strongly associated with prairie and oak woodland habitats (Altman 2011, Section 4.6). Of particular concern are species that require open grassland habitats with scattered trees and shrubs, and several that require nesting cavities in oak or other tall trees, given the increasing scarcity of these critical habitat resources across the region (Altman and Stephens 2012). 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; eight species no longer nest in San Juan County (Altman 2011).

A subspecies of horned lark, the streaked horned lark (*Eremophila alpestris strigata*) is federally designated as a Candidate Species (Pearson et al. 2016). This species historically bred in the park but was extirpated by the 1970's (MacLaren and Cummins 2000). Regional estimates are that there are <2,000 individuals remaining (Altman 2011).

Peregrine falcons (*Falco peregrinus*) and bald eagles (*Haliaeetus leucocephalus*) were both previously listed as federally Threatened and are designated Threatened by the Washington Department of Fish and Wildlife (WDFW). Both species occur regularly in the park but only bald eagles are known to nest here. 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).

Oregon Vesper sparrows (*Pooecetes gramineus affinis*) are a Federal Subspecies of Conservation Concern and a Washington species of Greatest Conservation Need/Candidate Species (Altman 2013, WDFW 2015). Vesper sparrows were common residents on SJI up until about the 1990s, but numbers in the grasslands on SJI and in SAJH are presently low; regional estimates suggest less than 3,000 total individuals remaining (Altman 2011, WDFW 2013).

Western Bluebirds (*Sialia mexicana*) were reintroduced to SJI 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), and several boxes have been installed in SAJH at both camps (J. Shrum pers. comm. 2019).

<u>Shorebirds</u>
Shorebirds ("waders") are generally considered those species that require shallow saltwater sites for feeding. ("Waterbirds" often refers to species that utilize freshwater sites, and while waterbird species present in SAJH are presented in Table A.1.d. they are not discussed specifically in this assessment.) Shorebird species typically have long legs relative to body size to facilitate foraging, and many shorebird species also have extremely long migrations that include freshwater or nearshore feeding locations that may be many hundreds if not thousands of miles apart (Skagen and Knopf 1993).

Three species that occupy important niches within Puget Sound food webs and that are of conservation concern due to declining populations and/or habitat threats are surf scoters (*Melanitta perspicillata*), dunlin (*Calidris alpine*) and black oystercatchers (*Haematopus bachmani*; Drut and Buchanan 2000, Brown et al. 2001, Buchanan 2006). Black oystercatchers are also identified by WDFW as a species of conservation concern due to the relatively high numbers of nesting pairs on SJI (in some years over 200; Golumbia et al. 2009). Great blue herons (*Ardea herodias*) are common around the island, particularly in False Bay.

<u>Seabirds</u>
A large variety of bird species depend on Salish Sea food webs and are commonly observed around SJI (Gaydos and Pearson 2011, SJC 2012). Regionally, many wintering seabird species have been in

decline apparently for several decades (Vilchis et al. 2014). Only one seabird species that is regularly present in the park is federally listed. The marbled murrelet (*Brachyramphus marmoratus*) is a small seabird that nests in old growth forests (critical habitat that is not found in the park) but forages regularly in marine waters adjoining both park units (FWS 1997). The waters of the San Juan Archipelago support a relatively high concentration of marbled murrelets and large groups (up to 100 individuals) occur in Griffin Bay adjoining American Camp. Marbled murrelets continue to exhibit small but consistent declining trends in Washington state waters (Pearson et al. 2014, Falxa and Raphael 2016). The brown pelican (*Pelecanus occidentalis*) was listed as endangered in the 1970s due to the significant negative effects of DDT on productivity, but was de-listed in 2009 (FWS 2009). Brown pelicans occur only sporadically in the San Juan Islands and are rarely observed in waters adjacent to the park.

<u>Priority Species and Habitats</u>

Species in the park that WDFW considers to be conservation candidates, are noted in Appendix A. The WDFW also has priority designations for habitats or groups of species that are at risk or rare. For SAJH those concentrations of species, including maximum numbers recorded, are:

- Alcids (small seabirds): ancient murrelets (~200), marbled murrelets (~100), rhinoceros auklets (~100), and pigeon guillemots (~40).
- Loons and grebes: Pacific loon (~250), horned grebe (~80), red-necked grebe (~60), and western grebe (~15).
- Waterfowl: surf scoter (~700), bufflehead (~353), red-breasted merganser (~100), white-winged scoter (~60), and harlequin duck (~25).
- Shorebirds: dunlin (~100) and black turnstone (~20).
- A historic (1992) record of a nesting colony of great blue herons at English Camp.

<u>Threats – Landbirds</u>

Human-initiated fires historically maintained habitat for prairie-associated species by limiting woody species expansion into grassland (Section 4.6). 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 loss of shrubs and small trees on the SJIs to deer browsing has been correlated with lower landbird diversity where deer densities are high (Martin et al. 2011, Arcese et al. 2014). West Nile virus (WNV) was introduced to North America relatively recently but has spread quickly with significant impacts on many wildlife populations including landbirds (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). As of 2017 WNV had been detected in mosquitos in Washington State but not in birds or humans and not at all on the SJI (https://www.doh.wa.gov/DataandStatisticalReports/DiseasesandChronicConditions/WestNileVirus).

Although native to North America, brown-headed cowbirds (*Molothrus ater*) parasitize the nests of many other bird species with often significant population impacts. Survey data indicate that brown-headed cowbirds are increasing within SAJH for unknown reasons (Siegel et al. 2007, Wilkerson et al. 2010, Holmgren et al. 2017, Vilchis et al. 2014). A non-native bird whose North American range is expanding rapidly is the Eurasian collared dove (*Streptopelia decaocto*) which arrived in the Pacific Northwest sometime during the 2000s (Fujisaki et al. 2010). Numbers of collared doves have increased on SJI and in the park since about 2010. Impacts on the native mourning dove or other species are undetermined. Other birds not native to the Pacific Northwest that occur regularly in parts of the park with unknown impacts are identified in Tables A-1 to A-4.

<u>Threats – Shorebirds and Seabirds</u>
Numerous direct and indirect effects of human activities can impact shorebirds (Carney and Sydeman 1999). Sea level rise associated with climate change could have the most significant impacts on coastal species such as shorebirds (Glick et al. 2007, Galbraith et al. 2014). Lost or abandoned fishing gear and other marine debris, including plastics, are a particular threat to seabirds (Good et al. 2009, Hamel et al. 2009, Vegter et al. 2014). For example, since 2002 over 870 unattached gillnets have been removed from the Salish Sea; 505 (58%) of those were removed in the San Juan Islands, and 14% held dead seabirds (Good et al. 2009). 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).

More difficult to quantify than direct impacts at colonies are population-level impacts to seabirds that occur at-sea such as from oil spills and leaks (Wiese and Robertson 2004, O'Hara and Morandin 2010) and fishing by-catch and impacts from anthropogenic light at night both on vessels and land-based (Zydelis et al. 2013, Krüger et al. 2017, Rodriguez et al. 2017).

<u>Climate Change</u>
Considering the life history and habitat needs of all bird species and geographic distribution of habitat, scientists at the National Audubon Society identified 189 Washington bird species that are most vulnerable to climate change (Table A-1). Shorebirds are especially vulnerable to sea level rise changes and other nearshore impacts related to climate change (Veloz et al. 2013, Galbraith et al. 2014). Changes in ocean conditions, particularly increases in sea surface temperatures and multiple impacts to forage fish populations, may be having multiple and related impacts on seabird productivity (Hayward et al. 2014, Vilchis et al. 2014, Grémillet et al. 2015, Alava et al. 2017).

4.8.3. 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 on SJI. Critical habitats should be maintained at present sizes, including in particular prairies/oak woodlands and intertidal/coastal habitats and resources.

4.8.4. Data and Methods

The NPS NCCN landbird monitoring program samples landbirds at SAJH every other year using point count surveys as described in Siegel et al. (2007). There are 38 sample points at American Camp and 16 at English Camp. Breeding-season surveys (mainly of songbirds) have been conducted repeatedly at the same points in both park units in 2005, 2007, 2009, 2011, 2013, and 2015 (Holmgren et al. 2016). The monitoring protocol is intended to survey mainly passerines and gulls (Seigel et al. 2007).

Though difficult to translate directly from existing monitoring data (point count methods are intended to estimate population abundance and density of species, not to assess community structure; Farnsworth et al. 2005, Schmidt et al. 2013), and not an objective of the NCCN landbird monitoring program (Siegel et al. 2007), diversity indices can be compared over time using point-count data (Melles et al. 2003). Saracco et al. (2014) analyzed the NCCN monitoring data from 2007, 2009 and 2011 to detect species trends.

An intensive data analysis was conducted by Vilchis et al. (2014) using annual aerial surveys and Christmas Bird Count data for the period 1994 to 2010. Results of these trend studies of the Salish Sea region are included in Appendix A. EBird data (www.ebird.org) were retrieved in December, 2014 for locations within both of the park's units for this report and updated in October, 2017 for the two park eBird "hotspots", American Camp and English Camp.

Cassidy and Grue (2006) analyzed wildlife information statewide for the purpose of recommending additional species in each county that might not meet WDFW criteria for Priority Species status, but for which land managers might wish to take additional steps to protect. Bower (2009) utilized survey results from several monitoring efforts within the Salish Sea region, including SJI, to analyze overall seabird abundance and trends for selected species from 1975–2007. Though not directly inclusive of SJI, 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. 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://wdfw.wa.gov/conservation/phs/list/.

4.8.5. Resource Condition and Trend

Bird species identified from monitoring as well as current WDFW Candidates are noted in Tables A-1 to A-4 for Landbirds, Raptors, Shorebirds, and Seabirds, respectively. The large number of species identified from park lands, which represent only about 5% of the land area of SJI, represent approximately 94% of all bird species found across all the San Juan Islands (Adamus 2011). There are only about 18 species that have been recorded elsewhere on San Juan Island but as far as is known not on park lands and many species are found in higher abundance at American Camp than anywhere else on the island; of 218 species with records from either American Camp or English Camp, 187 (86%) have been recorded at American Camp and 114 (52%) from English Camp. Of the 58 species for which there were sufficient data to determine trends, Crewe et al. (2012) reported 57% (33) of species declining in estimated abundance, 38% (22) with no change, and 5% (3) increasing.

In 2015 Holmgren et al. (2016) found that overall detections of species had remained high from 2013–2015. No substantial changes were noted in detections of either species of concern or non-native species. Saracco et al. (2014) found, though, that several species (Cassin's Vireo [*Vireo cassinii*], Swainson's Thrush [*Catharus ustulatus*], and Townsend's Warbler [*Setophaga townsendi*]) declined and none increased. Between 2007–2012, fecundity and survival estimates of western bluebirds were similar to reference populations (Slater and Altman 2013), however, the bluebird reintroduction program has been very successful with increasing numbers of breeding pairs on the island in recent years (https://sjpt.org/a-banner-year-for-bluebirds/). Data for breeding within SAJH by bluebirds were unavailable for this report, but it is likely that boxes within park habitats have supported productive nests (J. Shrum pers. comm. 2019).

Crewe et al. (2012) found bald eagles in decline by 1.8% per year while peregrine falcons showed no change. Crewe et al. (2012) found dunlins in decline by 8.9% per year while black oystercatchers and marbled murrelets showed no change. Overall Bower (2009) found 14 of the 37 seabird species he analyzed showing significant declines from 1975–2007 and declines of 11 of those species exceeded 50%.

Causes of regional seabird declines vary across species and are often undetermined. Suspected contributors to the declines (or shifts in geographic range) include entrapment in fishing gear, oil spills, contaminants, and habitat loss both locally and in other parts of these species' ranges (Gaydos and Pearson 2011). For many of the region's wintering alcids and grebes, the more recent and comprehensive analysis of Vilchis et al. (2014) has implicated changes in the availability of low-trophic prey such as forage fish as the major driver of the decline.

4.8.6. Level of Confidence

Medium.

4.8.7. Data Gaps and Research Recommendations

- No systematic data have been collected over the long term from within the park that would allow valid calculation of trends for any of the park'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 park. 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 park. In particular human activities in the nearshore area should be monitored for effects on shorebird species.

- Effects of contaminants on the park's wildlife species have not been investigated.

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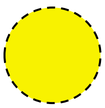
4.9. Non-avian Vertebrates

By Catherin Schwemm and Paul Adamus

4.9.1. Condition Summary

Almost nothing is known regarding the population size or dynamics of any native vertebrate species. Several native species are extirpated from San Juan Island, while non-native rabbits are invasive. Population trends are unknown for any native vertebrate species other than deer, though there are no indications that any native species is declining. Bats are at high risk from white-nose syndrome. Confidence in this assessment is low.



4.9.2. Background

For this Section the term “vertebrates” includes reptiles, amphibians, land mammals, and bats. (Birds are discussed in Section 4.8 and marine mammals that haul-out on SAJH beaches in Section 4.5.) Tables B-1 through B-4 in Appendix B present all terrestrial vertebrate species confirmed from park sites or presumed/potentially present given available habitat.

Amphibians/Reptiles

Amphibians as a group have no external coverings (such as hair or feathers) and absorb water and gases directly through their skin. Consequently, they 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 (O'Regan et al. 2014). The relatively dry environment of SAJH coupled with island isolation does not support high amphibian diversity, and compared to much of the Pacific Northwest, relatively few species are known to be present (Samora et al. 2013; Table B-1 in Appendix B).

Amphibians are declining globally due to threats from climate change, habitat loss, disease, and the presence of toxics in their environment, to which they are particularly susceptible (Gardner et al. 2007, Kilpatrick et al. 2010, Li et al. 2013). Particularly in the PNW, the dense, complex rainforests and associated riparian habitats upon which many amphibian species depend have been much degraded or completely lost (Grialou et al. 2000, Olson et al. 2007, Hodgson 2008).

Reptilian faunal diversity of the PNW is relatively low compared to other areas with more mesic conditions and compared with the number of native amphibian species (Meserve and Jaksic 1991, Blaustein et al. 1995). Other than the observations cited in Table B-2 in Appendix B almost nothing is reported regarding reptiles on SJI.

Land Mammals

Islands generally support a lower diversity of non-avian vertebrates than do mainland areas of comparable size (Lomolino et al. 2006). Fossil bison (*Bison antiquus*) bones found in the San Juan Islands indicate a brief and early postglacial land mammal dispersal corridor which, combined with over water immigration, served to populate the fauna of the San Juan Islands from the nearby mainland following retreat of the ice nearly 12,000 years ago (Kurle et al. 2013). In addition, the relatively small sizes of the two SAJH sites naturally limits the available terrestrial habitat for vertebrates within park boundaries.

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 many ecosystems rodents are the largest group of primary consumers, and as seed eaters, Howe and Brown (2001) have suggested that, "…plant communities reflect what small vertebrates fail to eat…". 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).

Only three native small mammals are present in SAJH, two rodents (deer mice-*Peromyscus maniculatus*) and Townsend's voles-*Microtus townsendii*), and one insectivore (vagrant shrews-Sorex vagrans). 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).

Herbivores

Non-native European rabbits (*Oryctolagus cuniculus*; "rabbits") were first documented on San Juan Island in 1929 but were probably present for several decades prior (Couch 1929; Stevens 1975). This species of rabbit is medium-sized (adults are about 3–6 lbs/1.3–2.7 kgs), and like all rabbits is completely herbivorous. In the absence of most predators rabbits quickly increased in abundance, specifically in the prairie area of American Camp (Hall 1977, West and Agee 2009).

Columbian black-tailed deer (*Odocoileus hemionus columbianus*), a small subspecies of mule deer, are native to the SJI. The elimination of predators such as wolves and mountain lions by settlers allowed deer populations to increase to where they now often have measurable negative impacts on vegetation and other species (Schoen 1972, USFWS 2010, Martin et al. 2011).

Carnivores

Mustelids are the largest group of carnivores, so-named because of the anal scent glands all mustelids possess. River otters (*Lontra canadensis*) are smaller than sea otters but can be found in brackish water areas such as Garrison Bay and Jake's Lagoon. Mink (*Neovison vison*) are common on the SJI, foraging mostly along the intertidal zone. Mink are native but have likely interbred with farm-raised mink (Carlton and Hodder 2003). Mid-sized carnivores found on SJI include raccoons (*Procyon lotor*) and red foxes (*Vulpes Vulpes*). No large carnivores are currently present on SJI.

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).

Two bat species of conservation concern whose occurrence in the park has not been confirmed but that are likely here are Townsend's big-eared bat (*Corynorhinus townsendii*) and Keen's myotis (*Myotis keenii*). These species are considered by the Washington Department of Fish and Wildlife (WDFW) to be Candidate species for listing as Priority Species (Hayes and Wiles 2013). Roosting concentrations of big brown bats (*Eptesicus fuscus*) are listed by the WDFW as a Priority Species/Habitat (WDFW 2015).

Extirpated Species

Western toads (Bufo [Anaxyrus] boreas), a Washington State Candidate species and a Federal Species of Concern, were historically present on SJI but have not been documented in the past 15 years (Samora et al. 2013). Likewise, western pond turtles (*Actinemys marmorata*) have not been seen on SJI for several decades. For this assessment, it is assumed that both western toads and western pond turtles have been extirpated from SJI, though as far as is known there have been no targeted surveys for these species on the island for several decades. Other species that may have once been present on SJI and in SAJH but have never been recorded are the Oregon spotted frog (*Rana pretiosa*) and Pacific giant salamander (*Dicamptodon tenebrosusis*).

The loss of forests that resulted from logging and clearing land for agriculture likely led to the extirpation of several large mammal species from the San Juan Islands including elk (*Cervus canadensis roosevelti*), gray or timber wolves (*Canis lupus* or *C. gigas*; Miller et al. 1935), and cougar (*Felis concolor*). Beaver (*Castor canadensis*) were once present on San Juan Island but there are no recent observations, though they are still present on several other of the SJI. Miller et al. (1935) provide a particularly enlightening summary of historical changes in vertebrate diversity on the SJI.

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).

Non-native Species

In addition to rabbits and deer (discussed above), several amphibians have been intentionally or accidentally introduced from the mainland to the SJI, including bullfrogs (*Lithobates catesbeianus*), western painted turtles (*Chrysemys picta*), and red-eared sliders (*Trachemys scripta elegans*). The presence of free-ranging domestic cats and dogs in the park, some of which are likely feral, is a serious threat to native small carnivore populations (Vanak and Gompper 2010) as well as native prey populations (Doherty et al. 2015).

Norway (*Rattus norvegicus*) and black (*Rattus rattus*) rats are also likely present in the park (Miller et al. 1935, Schoen 1972, FWS 2010). Norway rats and house mice were documented on San Juan Island in 1928 but a small mammal survey covering a limited area in 1974 found neither species (Nordquist 1975). House mice (*Mus musculus*) may be present (Miller et al. 1935, Schoen 1972). Muskrats (*Ondrata zibethica*), native to Washington but not the SJI, are also likely present (Miller et al. 1935, Carlton and Hodder 2003). Red foxes were introduced to the islands for fur and hunting in the early 20th century, and without competition from larger species and an abundant supply of rabbits, have increased in abundance over time (Schoen 1972).

Disease

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. Though one bat with WNS was detected in Washington State, it was found along a transportation corridor and was possibly brought to the state in a vehicle rather than arriving independently (E. Gasser, NPS, pers. comm. 2017) The means of contamination and a cure are not yet identified and many researchers anticipate further spread in coming years (https://www.whitenosesyndrome.org).

Climate Change

The degree to which climate change will alter a particular species distribution or abundance depends on that organisms' ability to adapt to changing resource and environmental conditions (Rowe et al. 2015). Predicting which species will be most affected by impacts of climate change is beyond the scope of this assessment. In many cases areas like National Parks will be disproportionately affected because they protect some of the last remaining contiguous habitats in the country (Hansen and DeFries 2007, Hansen et al. 2014).

4.9.3. 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 park. Minimally there should be no reduction in species diversity on park lands. Non-native species should be absent.

Land 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 such as when predators are intentionally removed (Rowe et al. 2011). Measureable 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 SAJH habitats in patterns observed historically. Diversity should remain high.

4.9.4. 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/); descriptions of how map source data were acquired are available at https://wdfw.wa.gov/conservation/phs/list/.

Amphibians/Reptiles

Samora et al. (2013) conducted amphibian surveys at SAJH in 2002 at both park 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).

Land Mammals

As far as is known, no comprehensive surveys for land mammals have been conducted either on SJI or within SAJH sites.

Bats

A survey of bat species on SJI was conducted in 2004, mostly at English Camp (Christophersen 2006). The conservation organization Kwiaht conducts periodic visual and acoustical surveys to compile a list of bats on San Juan Island in an effort to learn more about species diversity and distribution, and those efforts are ongoing (http://www.kwiaht.org/documents/Bats_of_SJI_2015.pdf), though results from those surveys are not publicly available.

4.9.5. Resource Condition and Trend

<u>Amphibians/Reptiles</u>

Samora et al. (2013) found only two of eight amphibian species potentially present at SAJH. Pacific tree-frogs (*Hyla regilla*) and northern red-legged frogs (*Rana aurora*) were found at English Camp, and tree-frogs were found at American Camp. Two other amphibians, American bullfrogs (*Rana catesbeiana*) and rough-skinned newts, have been found on San Juan Island but never documented from SAJH sites. Long-toed and northwestern salamanders (*Ambystoma macrodactylum* and *A. gracile*) may be present at a few locations on San Juan Island but likewise have never been observed in the park. Red-legged frogs (*Rana aurora*) are common in Washington but are becoming rare in other areas, and Samora et al. (2013) only found one in SAJH. Sharp-tailed snakes (*Contia tenuis*) were found in the park on Young Hill in 2018 (S. Dolan pers. comm. 2019). Rubber boa snakes (*Charina bottae*) have occasionally been reported from SJI but the State shows no documented records from the SJI. Northern alligator lizards (*Elgaria coerulea*) were not detected by Samora et al. (2013) but are listed as present according to North Coast Cascades Inventory and Monitoring species list.

<u>Land Mammals</u>

Populations of deer and rabbits have apparently prospered in the park and throughout SJI, largely in response to the elimination of carnivores from the county during early settlement and the reverting of prairie to intermediate successional stages in the absence of fire (Chamberlain et al. 2007). Numerous large, well-developed rabbit warrens exist at American Camp, and the core rabbit colony area there is virtually devoid of grassland nesting birds and small mammals due to a lack of native vegetation and cover (Lees and Bell 2008). The rabbit population has fluctuated since monitoring began in the early 1970s (Figure 4.9-1; West and Agee 2009).

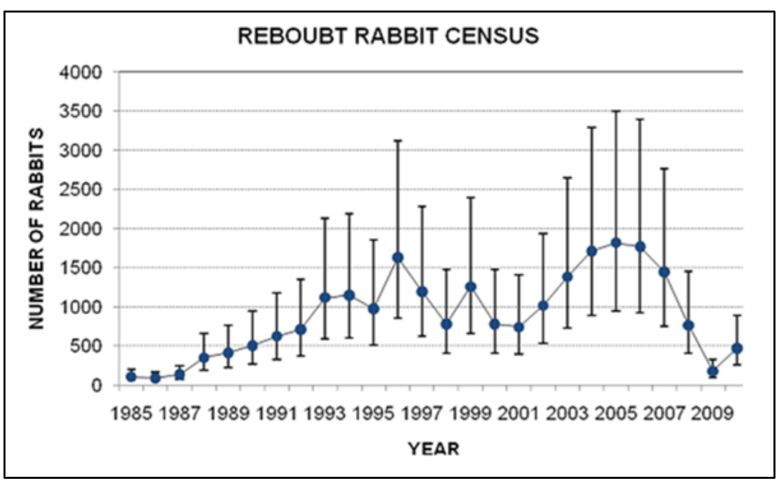


Figure 4.9-1. European rabbit population estimate at American Camp from 1985–2010 with 95% confidence intervals. From West and Agee 2009.

Efforts to control rabbits by the park have included construction of a rabbit-proof barrier fence in 2003 along the western boundary of American Camp adjacent to the Eagle Cove subdivision to prevent colonization into the park. In 2004, two north-south barrier fences were erected west of the Grandma's Cove trail to prevent rabbits from colonizing the western portion of the prairie from the main rabbit colony area. In 2005 the park constructed a barrier fence through the center of the core rabbit colony to split the area into smaller management zones. The rabbit-proof fence along the western boundary and the two fence sections west of Grandma's Cove trail appear to be effective at preventing rabbit colonization of the western portion of the prairie.

Bats

Seven bat species have been confirmed from SAJH, but very little else is known regarding bat diversity or the status of rare species. A mixed colony of Yuma myotis (*Myotis yumanensis*) and big brown (*Eptesicus fuscus*) bats established in an historical building called Crook House at English Camp sometime prior to the mid-2000s. Park management determined that occupation of the building by bats was not compatible with the preservation goals for the structure and instead developed a plan to relocate the bats. A bat box was installed in 2004, and in August of 2006 over 1,700 Yuma myotis and 80 big browns were observed utilizing the box (R. Christopherson memo to file; https://irma.nps.gov/DataStore/DownloadFile/489046). At the time observers noted that the number of Yuma myotis had increased while the number of big browns had decreased, in both cases for unknown reasons. More recent data were unavailable for this assessment, though the PHS database includes records of big brown and Yuma myotis from across SJI.

4.9.6. 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 certainly nearly nothing is known regarding the population status of any native mammal species other than deer.

4.9.7. 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 SAJH would provide early indications of any new species and allow time for response (Kurle et al. 2013).
- Surveys and monitoring are also needed for native mammals to assess possible responses to climate change and continued habitat alterations in and near the park. 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 park.

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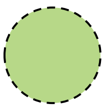
4.10. Habitat Integrity

By Catherin Schwemm and Paul Adamus

4.10.1. Condition Summary

Habitat connectivity has likely improved with efforts to purchase and protect additional lands adjacent to the park. Very little data exist regarding natural night skies and natural quiet, though it is unlikely that either of these indicators are improving. Overall concern is warranted for park habitats, particularly during summer months when visitation to the island and the park sites is high. No trends are detectible and confidence is low.



4.10.2. Background

Habitat Connectivity and Fragmentation

Habitat fragmentation can be described as an alteration of large areas (relative to specific taxa) of continuous wild space into smaller parts by the presence of human impacts. 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). A reduction in available habitat eliminates resources necessary for 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 (Fahrig and Merriam 1994, Berger 2004, Krauss et al. 2010), even for avian species and bats (Frey-Ehrenbold et al. 2013). Habitat can also be functionally fragmented, for example if human inputs prevent the transfer of genetic material between plant populations and/or reduce or prevent pollination (Hadley and Betts 2012, Rudnick et al. 2012, Newman et al. 2013).

The existence of metapopulation dynamics, where populations that are separate spatially actually require the exchange of genetic information via dispersal to sustain the population overall (Hanski 1999), largely explains why the loss of habitat connectivity has had such dramatic effects on many species (Hanski 2011). Recolonization after local extinctions (e.g. following severe disturbance), is impossible if animals are unable to physically travel between sites (Beier 1993, Crooks 2002, Berger 2004). Consequently, maintaining metapopulation dynamics is also the reason why protecting the ecological connections between large, natural areas such as national parks is critical for conservation of numerous species (Hansen and DeFries 2007, Rudnick et al. 2012, Bauer and Swallow 2013, Hansen et al 2014).

Ecologically, park sites are influenced strongly by processes that isolate islands from mainland communities and that limit the number of species that might otherwise be present. On the San Juan Islands specifically, movements of mammals, birds, and plant propagules can further be hindered by wide expanses of land that contain little or no vegetative cover. Whether naturally-occurring or mediated by humans, the absence of connections between habitat patches creates fragments of habitat that indirectly limits the abundance and genetic diversity of many species (Fahrig and Merriam 1994, Belisle and Desrochers 2002, Tremblay and St. Clair 2011, Rudnick et al. 2012).

Because this is a relatively small island, connectivity concerns for NPS at SAJH are primarily related to those that affect birds, small vertebrates, amphibians and plants (Bennett 1990, Noss 1991, Atobe et al. 2014, Lechner et al. 2015). The impacts of rural development on vegetation and land cover began with EuroAmerican settlement, as San Juan Island's forests and prairies were first converted to agriculture, and then increasingly to roads, buildings, and other infrastructure. By the 1930s virtually all of the virgin forest remaining in the San Juans had been cut. Within the past 50 years, rural development (i.e., building of homes, roads, conversion of native vegetation to cropland or pasture) has increased significantly near the park and throughout San Juan Island.

Natural Night Skies

The importance of maintaining dark night skies 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, Gaston et al. 2012). 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 terms 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 park 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).

Less often addressed are the ecological impacts of artificial light (ecological light pollution) during diurnal dark periods. Artificial light at night has very different impacts on wildlife and ecological processes than it does on humans (Longcore and Rich 2004, Rich and Longcore 2005, Horvath et al. 2009). Evolutionarily the moon provided the only source of light at night, and organisms adapted their biology and behaviors to the light patterns of lunar cycles (Duriscoe et al. 2007). Consequently the dark night sky is considered the natural condition to which biotic components of ecosystems have evolved (Gaston et al. 2013).

Research has examined the impacts of artificial night light on many groups of organisms, including plant populations (Lewanzik and Voight 2014, Somers-Yeates et al. 2016), insects (Geffen et al. 2014, Perkin et al. 2014, Luarte et al. 2016), birds (songbirds, owls, shorebirds, seabirds; Kempenaers et al. 2010, Rodriguez et al. 2012), 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. 2014 for reviews). For example, 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). Cumulatively these impacts can affect population dynamics, successional processes and biodiversity (Kyba and Hölker 2013, Gaston and Bennie 2014, Lewanzik and Voigt 2014).

Natural Quiet

Soundscapes are generally defined as the total amount of ambient noise in an area measured in terms of frequency and amplitude (decibels; Ambrose and Burson 2004). Because national parks are often (perhaps wistfully) considered "islands" of quiet (Lynch et al. 2011, Miller 2008), NPS has been working for several decades to establish baseline conditions and develop measuring and monitoring methods for soundscapes in national parks (Miller 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).

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, Traux 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), and invertebrates (Morley et al. 2014). 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). In some cases research indicates that recreational activities such as hiking and cross-country skiing may in fact have greater impacts on wildlife than motorized activities (Larson et al. 2016).

The presence of roads and associated uses (e.g. vehicles, construction), has some of the strongest impacts on wildlife (as opposed to inputs such as overflights, which are generally considered as a visitor-impact issue; Barber et al. 2011, Buxton et al. 2017). Road noise can alter animal behavior, movement patterns, ability to find prey, and breeding processes (Bee and Swanson 2007, Barber et al. 2011, Kociolek et al. 2011, Siemers and Schaub 2011). 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), and ecological systems in protected areas such as natural parks may be particularly at risk from noise impacts (Buxton et al. 2017).

4.10.3. Reference Conditions

<u>Habitat Connectivity</u>
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 SAJH 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 species.

<u>Natural Night Skies</u>
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. Ecologically the reference condition on park lands should be the absence of artificial light at night that negatively affects organisms and natural processes.

<u>Natural Quiet</u>
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 2011). Given the relative absence of information on the effects of noise on wildlife, measurements of anything over natural sounds may be considered undesirable (however measured).

4.10.4. Data and Methods

<u>Connectivity</u>
Because very little is known regarding dispersal and habitat needs of any native species in the park, sources such as vegetation maps and remotely sensed data could be consulted to suggest which areas might be utilized, but at this point there is no information on movement patterns of park animals or plant propagules.

<u>Natural Night Skies</u>
One assessment of night sky brightness was conducted at SAJH in 2012. Two sites were measured, one at Young Hill and one at the Redoubt at American Camp, both in mid-August. The methods used are described in Duriscoe et al. (2007) and Duriscoe (2013), but basically measure the total amount of light in the sky compared to natural nighttime levels ("All-sky Light Pollution Ratio"-ALR). As far as is known these were point-in-time measures only with no subsequent assessments made (Wood 2015a).

<u>Natural Quiet</u>
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; Wood 2015b). The "maximum sound level" is the loudest sound level generated during a noise event. Evaluating the condition of the ecologically relevant soundscape,

however, is problematic. As far as is known there have been no studies focused specifically on the impacts of anthropogenic noise on wildlife in SAJH.

4.10.5. Resource Condition

Connectivity

A survey in 2007 of the San Juan County shoreline reported an average 25 percent loss of marine riparian forest cover between 1977 and 2006 (MacLennan and Johannessen 2008). Such loss and resulting fragmentation is likely to have adversely altered the movements of some forest-associated bird and mammal species. However, at least within the American Camp unit, the forest canopy has been increasing as result of fire suppression and natural succession, and in the process, it may be causing prairie habitat to become more isolated from other patches of grassland on San Juan Island.

Habitat connectivity has likely improved with the acquisition of the Mitchell Hill property and protected open space adjacent to English Camp. The eastern boundary of English Camp is contiguous to a block of mostly continuous forest at least 8 mi^2 (259 ha) in extent. Within the unit, the 25 ft (8 m) wide West Valley Road bisects the unit and creates the only linear opening of significant extent in the forest canopy. The closest large patch of oak woodland outside the park is approximately 1.3 mi (2.1 km) to the southeast, but nearly all of the connecting land is forest. The Washington State database of Priority Habitats and Species (PHS) identifies all of English Camp as a Biodiversity Area and Corridor (http://apps.wdfw.wa.gov/phsontheweb/).

At American Camp, wooded habitat both within and immediately outside the park is unfragmented by land uses, but the expanding woodlands threaten to separate the park's prairie habitat from grasslands outside the park. A narrow road runs the length of the American Camp unit but traffic is relatively light and speeds are fairly slow. Nearly all land adjoining the unit's east end is managed for conservation by the Washington Department of Natural Resources and the San Juan County Land Bank. Beyond that, in the Cattle Point settlement, subdivisions contain about 150 lots and a few undeveloped lots remain. At the unit's west end, the Eagle Cove settlement contains about 43 lots with an average size of one acre (0.4 ha), and about half have been developed. At the park's northwest corner there are narrow wooded corridors, part owned by the San Juan County Land Bank, that connect the park's woodland to a patchwork of other woodlands totaling about 500 acres (202 ha), until a gap of 3.281 ft (~1,000 m) in width is reached about 1.7 mi (2.7 km) northwest of the park boundary.

Natural Night Skies

Light pollution from Victoria, British Columbia, is considerable and appears to be increasing. However, no measurements have been taken and trends are unquantified. NPS data collected in one sampling session show an ALR of 1.87 at Young Hill and 1.46 at Redoubt-American Camp (Wood 2015a). (An ALR of 0.0 would indicate pristine natural conditions, while a ratio of 1.0 would indicate that anthropogenic light was 100% brighter than the average natural light from the night sky.) It is unknown how well the methods used to measure light pollution in relation to what humans see measure elements that have ecological consequences for wildlife (Rich and Longcore 2005). A meta-study on anthropogenic impacts in the California Current (Andrews et al. 2015) found that in general light pollution is not a relatively strong stressor though the impact of light is increasing slightly.

Natural Quiet

Though there are no data or studies from SAJH to quantify recent increases or decreases in anthropogenic sound levels, other data suggest that noise levels are increasing in most natural areas, and that in very few places are noise levels decreasing (Buxton et al. 2017). Sound level monitoring efforts that include the area of SAJH suggest a day-night average sound level[1] of about 65 decibels (DNL, A-weighted) at ground level during aircraft practice periods from the U.S. Navy's Outlying Landing Field at Coupeville, mainly in the part of the Reserve between Crockett Lake northward to just south of Coupeville (https://www.nepa.navy.mil/growler/). As of 2011 there were 6,166 total flight operations per year at that location. Flight schedules vary from several times per week to once a month. The time of day and length of practice sessions also vary erratically. The erratic schedule implies that significant noise impacts can occur on a regular, but inconsistent basis. About 94% of the flights occur during daylight hours (Bremer 2004).

4.10.6. Level of Confidence

Low.

4.10.7. Data Gaps and Research Recommendations Connectivity

Connectivity

It is important to work with partners to protect areas outside park boundaries to reconnect habitat patches with corridors of vegetation outside of areas already set aside as natural preserves. The WDFW (2009) recognizes "Biodiversity Areas and Corridors" as a Priority Habitat and suggests jurisdictions consider using systematic approaches for identifying and protecting them.

Natural Night Skies

- Repeat measurement of All-sky Light Pollution Ratio – ALR is necessary to determine trends.
- A lighting plan for the park should be developed, and natural night sky goals incorporated in park planning documents.

Natural Quiet

- A study of current noise conditions should be conducted.
- New methods for modeling potential noise impacts from proposed developments and activities may be useful for planning purposes (Keyel et al. 2017).

[1] Day-night average sound level (DNL) averages noise events that occur over a 24 hour period, weighting noise events that occur from 10:00 pm – 7:00 am with an additional 10 dB to account for sensitivity of noise receptors during this time.

4.10.8. Sources of Expertise

- Emma Brown, NPS Natural Sounds and Night Skies Division

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Chapter 5. Discussion

By Catherin Schwemm and Paul Adamus

5.1. Assessment Summary

This assessment serves as a review and summary of available data and literature for focal natural resources in San Juan National Historical Park. The park is noted for its spectacular ocean views and three of the rarest habitat types in Puget Sound: prairies, oak woodlands, and ocean spits. The prolonged absence of fire, combined with locally severe grazing by deer and introduced rabbits, as well as isolation from the mainland and similar habitats elsewhere in Puget Sound, has altered the composition and structure of these habitats as well as the park's forests. Those changes have resulted in the loss or decline of several plant and animal species found in only a few other places within Puget Sound.

The marine waters that adjoin the park support an outstanding array of seabirds, marine mammals, and fish, but those resources are at risk from many factors, most of which are beyond the park's control. At Westcott Bay, the causes of an apparent decline in eelgrass—an exceptionally productive habitat for marine life—have never been conclusively determined. In the immediate vicinity of the park, mean annual air temperature has increased and precipitation decreased during recent decades, increasing the risks to the park's groundwater and mostly ephemeral surface waters. Freshwater resources are also highly vulnerable to impacts from residential development in areas adjoining the park and saltwater intrusion.

The information presented here provides a partial baseline against which changes in condition of components in the future may be compared. Table 5.1 summarizes the condition and trend of each of the resources addressed in this assessment, however, current condition and trends from recent historical conditions could not be determined for many components due to lack of sufficient well-documented data sets.

A synthesis of the information provided herein leads to a few areas of concern that natural resource managers may want to give particular attention to for future management efforts: the nearshore ecosystem, potential changes in ocean systems resulting from climate change. Finally, the authors present three areas where additional management actions might provide much needed information on resources, potentially improve restoration outcomes, and aid in future assessment efforts.

Table 5-1. Summary of Resources, Indicators, and graphic representations of Condition and Trend evaluated for SAJH and placed within the NPS Ecological Monitoring Framework (Fancy et al. 2009). See individual sections of Chapter 4 for discussion of the methods and data used for each determination.

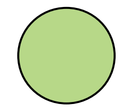
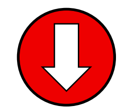
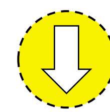
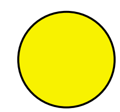
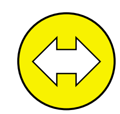
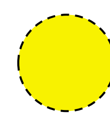
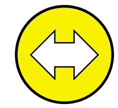
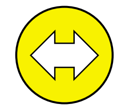
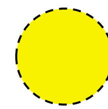
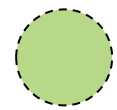
Level 1 Category	**SAJH Resource**	**Indicators**	**Condition and Trend**
Air and Climate	Air Quality (Section 4.1)	• Visibility • Nitrogen and Sulfur Deposition • Ozone	
	Climate (4.2)	• Temperature • Precipitation	
Geology and Soils	–	–	
Water	Freshwater (4.3)	• Surface Water Quality • Surface Water Quantity (Flow) • Groundwater Quality • Groundwater Quantity (Levels)	
Biological Integrity	Wetlands (4.4)	• Plant Species Composition	
	Nearshore (4.5)	• Physical Shoreline Processes – Erosion • Extent of Kelp and Aquatic Plants (Seagrasses) • Intertidal Invertebrate Diversity • Forage Fish and Juvenile Salmon Abundance • Presence/Absence of Marine Mammals	
	Rare Plants (4.6)	• Abundance and Extent by Species	

Table 5-1 (continued). Summary of Resources, Indicators, and graphic representations of Condition and Trend evaluated for SAJH and placed within the NPS Ecological Monitoring Framework (Fancy et al. 2009. See individual sections of Chapter 4 for discussion of the methods and data used for each determination.

Level 1 Category	SAJH Resource	Indicators	Condition and Trend
Biological Integrity (continued)	Vegetation and Land Cover (4.7)	• Extent of Prairies • Plant Species Diversity in Prairies • Presence/Absence of Obligate Bird Species • Extent of Oak Woodlands • Coastal Strand Species Composition	
	Birds (4.8)	• Species Diversity by Habitat • Presence/Absence of Rare and At-risk Species	
	Vertebrates (4.9)	• Species Diversity of Amphibians and Reptiles • Species Diversity of Mammals • Presence/Absence of Invasive Species • Deer Abundance	
Ecosystem Pattern and Processes	Habitat Integrity (4.10)	• Connectivity • Dark Night Sky • Natural Quiet	

5.2. Threats to Nearshore Conditions

5.2.1. Artificial Structures and Shoreline Modifications

The presence of artificial structures such as docks and jetties constructed to reduce shoreline erosion and/or provide services often have secondary impacts of altering sediment transport processes by restricting the movement of material along the coast (MacLennan et al. 2010, Shipman et al. 2010, Dafforn et al. 2015). The presence of shoreline armoring can disrupt the connections between terrestrial and ocean process, alter beach and intertidal-dwelling invertebrate communities, and reduce habitat for spawning by forage fish (Toft et al. 2010, Krueger et al. 2010, Heerhartz et al. 2016).

A countywide survey of major shoreline modifications in 2007 found that 40 percent of shoreline parcels in San Juan County already have at least one beach structure (SSPS 2007). A subsequent study found that much of the new armoring occurring in the SJI is occurring without appropriate permitting in place (Windrope et al. 2016). Shoreline development that affects water clarity or introduces toxic material into the nearshore environment can negatively affect kelp and seagrasses (FSJ 2010, Thom et al. 2014), and the park may wish to pursue funding to conduct additional inventories of shoreline structures in and adjacent to the park for long reaches that share a prevailing coastal current.

5.2.2. Pollution and Toxics

Many human activities introduce materials into the nearshore environment that can negatively impact biological organisms. Activities such as commercial shipping, boat maintenance and operations, oil transport and refining, ferry traffic, and numerous mainland operations can all have direct and indirect effects on marine water quality and nearshore habitat quality (Flora and Fradkin 2004). Toxic materials such as PCBs and hydrocarbons are also present in the Puget Sound marine system (PSEMP 2017). Marine waters around SJI are potentially impacted by effluent from the city of Victoria, which does not treat its sewage and instead pumps waste directly into the ocean.

5.2.3. Marine Debris

Plastic and other solid debris enter marine waters from sources both near the SJI (e.g., recreational boats, ferries, creosote-covered driftwood) and at sea (e.g., fishing fleets, aquaculture, ocean dumping; Andrady 2011, Hirai et al. 2011, Hammer et al. 2012). Many studies have documented negative impacts of marine debris (especially microscopic-sized plastic particles) on marine mammals, seabirds, and entire marine ecosystems (e.g., Tanaka et al. 2013). In particular, ingestion of microplastics by forage fish is a growing concern (PSEMP 2017, Bertram et al. 2017). Derelict fishing nets and trawls – material abandoned or lost and left to float in the ocean – are serious threats to marine mammals and fish (Good et al. 2009).

5.2.4. Resource Extraction

Shellfish can be harvested legally in limited parts of SAJH in compliance with State regulations. For example, legal harvesting of clams and crabs occurs in Westcott and Garrison Bays, including on NPS property. Since 1973 harvesting has been prohibited in the area of the parade ground but is permitted year-round from the dinghy dock north around Bell Point up to the property line of the Westcott Bay. Although geoduck clams (*Panopea generosaare*) are an important economic species and are present around the islands, most of the county's intertidal shoreline is unsuitable for this species and no commercial geoduck clam fisheries have been designated in the county (DNR 2008). Aquaculture (including oyster, clam and salmon culturing) has the potential to increase nutrients and/or pathogens in surrounding waters, introduce exotic organisms, increase turbidity, and indirectly affect non-target species (Dethier and Ferguson 1998, Flora and Fradkin 2004). Commercial harvest has been identified as a partial driver of population declines for several forage fish species in Puget Sound (Greene et al. 2015).

5.2.5. Invasive Species
Invasive plants and invertebrates are significant threats to marine ecosystems around the world and in the Salish Sea (Gartner et al. 2016). Competitors of eelgrass in Puget Sound include the non-native brown seaweeds *Sargassum muticum* and *S. japonica* (Britton-Simmons 2004). *S. japonica* has been reported from Griffin Bay and Cattle Point at American Camp unit (Copello et al. 2004), and also likely occurs in Grandma's Cove. Non-native eelgrass species, in particular *Zostera japonica*, compete with native eelgrasses through multiple mechanisms (Mumford 2007, Mach et al. 2014, Shafer et al. 2014). *Z. japonica*, occurs in waters at both English Camp and American Camp.

Though numerous non-native invertebrate species have established in Puget Sound, relatively little is known regarding their impacts in park offshore waters. At English Camp, mahogany clams (*Nuttalia obscurata*/purple varnish clam) and Pacific oysters (*Crassostrea gigas*) have been documented (Dethier and Ferguson 1998), and mahogany clams are present in Griffin Bay (Copello et al. 2004, Klinger et al. 2006). A native of Japan, the solitary tunicate (*Ciona savignyi*) has been recorded from the northern San Juan Islands. The gallo mussel (*Mytilus galloprovincialis*) hybridizes with native mussels and is likely present in or near Westcott Bay. The non-native Atlantic oyster drill (*Urosalpinx cinerea*), Japanese oyster drill (*Ocinebrellus inornatus*), Northern quahog clam (*Mercenaria mercenaria*) and Japanese clam (*Neotrapezium liratum*) have all been found in the Georgia Strait region but not specifically in SAJH. European green crabs (*Carcinus maenas*) were recently found in Westcott Bay and are likely a significant threat to native crab populations (Mach and Chan 2014).

5.2.6. Marine Water Quality
The waters surrounding the San Juan Islands have been assigned a Class AA rating by WDOE, however, very little is known regarding conditions directly off the English Camp or American Camp shores. Samples collected by Wiseman et al. (2000) at the end of the boardwalk at English Camp revealed high quality waters characterized by relatively high dissolved oxygen and low nitrate and soluble phosphate, though obviously these data are now quite out of date. In sediments just north of the English Camp in Roche Harbor, elevated (but non-lethal) concentrations of lead, copper, and tributyl-tin were found in 2000 (Serdar et al. 2001), but since that time sampled sediments have shown no measurable change in the levels of toxic materials or beneficial benthic invertebrates (WDE 2014). In Westcott Bay, fecal coliforms are within safe limits for shellfish (WDH 2016). Levels of most metals were near natural levels, though average levels of cadmium were higher than at other SJI sites (Takesue et al. 2005).

Nitrate levels throughout Puget Sound increased at a rate of 3 µM per decade (Krembs 2014), most likely originating from human sources such as failing septic systems, livestock and agricultural runoff, and residential application of fertilizers (SJC-DHCS 2000 and 2004). Excessive algal growth triggered by elevated nitrate levels has caused fall/winter levels of dissolved oxygen to decline to levels harmful to marine life both regionally (Chan et al. 2008) and in Puget Sound (Krembs 2013). Also, nitrate-induced growth of filamentous green algae on shallow hard substrates, when excessive, can limit the diversity of other seaweeds and macroinvertebrates (Mumford 2007). The effects of nitrate loading are likely to be most noticeable in bays, lagoons, and other areas with restricted circulation and where upland flows are restricted (Barsh et al. 2010).

Data describing coastal water quality within park waters are scarce. The Washington Department of Health (WDOH) monitors water quality in the interest of protecting the shellfish resource. As part of that program fecal coliforms, temperature and salinity are monitored at important shellfish growing areas including Westcott Bay. One monitoring spot within Westcott is located just northwest of English Camp (www.doh.wa.gov/Portals/1/Documents/4400/westcott.pdf).

Klinger et al. (2006) summarized data collected by WDOH and the Washington Department of Ecology (WDOE). WDOE has a Marine Waters Monitoring Program (primarily targeted at detecting threats to human health) with three stations offshore of Cattle Point. At each of these stations samples are collected at three depths (0.5, 10, and 30m) to measure temperature, salinity, pH, fecal coliform bacteria, chlorophyll a, nitrate, nitrite, ammonium, Secchi disk depth and others. Data are currently collected at each of the three sites on a rotating annual basis (one site/year; www.ecy.wa.gov/programs/eap/mar_wat/data.html; Klinger et al. 2006).

San Juan County implemented a pilot program for stormwater monitoring that included one marine site each in Westcott, Garrison and False bays, though the data were not available for this report. As far as is known, aside from the WDOE/WDOH sampling mentioned above, no other water quality monitoring is conducted in nearshore environments around American Camp or English Camp.

5.2.7. Climate Change

All shoreline resources are 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).

5.3. Ocean Conditions

The condition of the ocean environment surrounding San Juan Island is of concern, and climate change is having increasingly measurable impacts on ocean processes (Halpern et al. 2009, Feely et al. 2012, Komar et al. 2013, Cheng et al. 2015). Specifically, sea surface temperatures (SST) are rising and the chemistry of ocean waters is changing (ocean acidification; OA), while toxic materials and ocean debris have multiple negative effects on marine organisms and sea levels are rising (SLR). Ocean dynamics along the coast interact with physical and biological resources of SAJH, therefore this section briefly assesses ongoing divergences from past oceanic conditions resulting from climate change that may affect those resources. There are minimal data for marine processes adjacent to SAJH, and very little NPS can do to alter marine conditions, however a discussion of the marine resource and likely climate change impacts is presented here to assist and support future research and monitoring efforts.

5.3.1. Sea Surface Temperatures

Nearshore marine systems are vulnerable to increasing ocean temperatures (Okey et al. 2012, Doney et al. 2012). Though the processes are complex, in general average sea surface temperatures around the globe are increasing coincident with atmospheric warming (Doney et al. 2012). Estimates are that from 1995–2008 the temperature of the upper 2,300 ft (700 m) of water in global oceans increased by approximately 0.4 °F/ 0.2 °C (Howard et al. 2013). Further increases in SST could exacerbate global climate change by adding more CO_2 to the atmosphere through evaporation (Howard et al. 2013). Increases in SST have the potential to alter existing ecosystems through numerous mechanisms (Klinger et al. 2006, Doney et al. 2012), and regional and local effects of SST increases will vary enormously across systems and species (Hazen et al. 2013, Greene et al. 2015).

The Pacific Northwest has experienced measurable increases in SST in recent years. Most notably, during the winter of 2013–2014 a large mass of warm water, eventually referred to as “the Blob”, formed in the northern Pacific (PSEMP 2016). During the spring and summer of 2014 this warm water spread across a large area, resulting in many areas where temperatures increased relative to historic averages by more than 7°F/4°C, surpassing previous high water temperature records (Eisenlord et al. 2016, Peterson et al. 2016, PSEMP 2016). Future predictions are that SST will continue to increase by 3–5°F/2–3°C (Moore et al. 2015).

Important ecological effects of warmer ocean temperatures are anticipated and in many cases have already been documented for the coastal regions of Puget Sound. Changes in prey availability for pinnipeds and seabirds and fish (Cury et al. 2011, Atcheson et al. 2012), survival, growth, and distribution of salmonids (Abdul-Aziz et al. 2011, Martins et al. 2012), reductions in shellfish productivity (Huppert et al. 2010), and more frequent harmful algal blooms (HAB; Moore et al. 2015, Gobler et al. 2017) have been correlated with or tied less strongly to increasing SST (TNC and CIG 2016).

5.3.2. Ocean Acidification/Water Quality

As CO_2 is added to the atmosphere, much of it is absorbed by seawater which causes pH levels of ocean waters to decline and waters to become more acidic (Byrne 2014). As acidity in the ocean increases and pH declines, fewer carbonate minerals are available to organisms for skeletal and shell development (Gruber et al. 2012, Hofmann et al. 2014). Because of their dependence on acid-soluble calcium carbonate for shell-building, species most threatened by acidification of their nearshore habitat include crabs, oysters, clams, barnacles, mussels, starfish, and even zooplankton (Busch et al. 2013). Anthropogenic ocean acidification also has direct physiological and behavioral effects on marine organisms, (Clements and Hunt 2015), for example increased CO2 has been shown to impair sensory abilities of both prey and predator marine fish species (Cripps et al. 2011, Leduc et al. 2013).

Current estimates are that oceanic waters have absorbed approximately one-third of the carbon that has been released into the atmosphere over the last two centuries (Berman et al. 2011, Hoegh-Guldberg et al. 2014). One model predicts a mean decrease in global surface ocean pH ranging from 0.1 to 0.2 units by 2050 (IPCC 2014). Other models suggest that the pH of surface oceans will decrease by 0.3 to 0.4 units by the end of the century (Feely et al. 2008). Regional upwelling dynamics driven by the California Current naturally bring more CO_2 to PNW coastal areas (Lachkar 2014, Reum et al. 2014), however, studies strongly indicate that human-caused increases in atmospheric CO_2 have had a large role in increasing pH above historic levels (Doney et al. 2012, Gruber et al. 2012, Reum et al. 2014).

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 (Wootton et al. 2008, Washington Blue Ribbon Panel on Ocean Acidification 2012). Reum et al. (2014) found that higher CO_2 levels in Puget Sound waters presently exist throughout the year. Specifically, minimum values of CO_2 at some Puget Sound sampling locations have increased by 1.8–1.9 ppm yr−1 (PSEMP 2016). In addition, this region of the northeastern Pacific is already CO_2-rich as a result of upwelling and other processes, so that uptake of additional atmospheric CO_2 will occur more rapidly near the continent than in the open ocean (Reum et al. 2014). Advanced modeling exercises predict complex Puget Sound food web responses to increasing ocean acidity based on general declines in all calcifiers with both direct and indirect effects on multiple trophic levels (Feely et al. 2010, Busch et al. 2013).

5.3.3. Sea Level Rise and Storm Dynamics

Current Conditions

Climate-driven sea-level rise is threatening shoreline resources worldwide and along the eastern Pacific coast (Huppert et al. 2010, Dalrymple et al. 2012, IPCC 2014). (Sea level rise also has great potential to damage and destroy cultural resources, however, possible impacts to cultural resources from sea level rise and changing storm/wave dynamics are not addressed here.) In the Puget Sound region, local factors that influence sea level include subduction of tectonic plates, residual isostatic rebound (rising of the continent following ice sheet retreat; Verdonck 2006), oceanic and coastal winds, and local atmospheric pressure patterns (Canning 2005, Johannessen and MacLennan 2007, Mote et al. 2008, MacLennan et al. 2013, Sweet and Park 2014).

Shoreline flooding is a periodic natural process that can originate from upland rainfall, storm surges and high tides, and that often provides important nutrients to riparian and coastal systems. Detrimental impacts of flooding and coastal storms include increased erosion, structural damage, impaired water quality, and loss of habitat and direct mortality to species that are already under stress or at low numbers (Erwin 2009. Atkinson et al. 2016). Of specific interest for this assessment is the potential for more frequent and/or intense flooding events on SJI due to climate change and rising sea levels.

Future Conditions

It is anticipated that the shoreline configuration of coastlines in Puget Sound will change as sea levels rise and storm events increase in frequency and intensity (Huppert et al. 2010). The extent of tidally-influenced areas will also change, and there may be an increase in some areas while other sites are lost (TNC and CIG 2016). Though rising sea levels are somewhat mediated in the PNW as this region continues to experience uplift following the release of glacial pressure during the ice age, predictions are strong that rising sea levels will be greater than increases in land elevation over the next century (Dalrymple et al. 2012, Komar et al. 2013). Rising sea levels will likely impact beaches through sand erosion, sea cliff retreat, increased flooding (FEMA 2016) and salinity intrusion (Craft et al. 2009, TNC and CIG 2016), and will affect lagoons and other nearshore systems where species have adapted to historic tidal processes and water levels (Johannessen and MacLennan et al. 2007, Cheng et al. 2015).

By the year 2100 estimates are that global sea levels will rise between 7–23 in/17–58 cm depending on emission scenario (Slangen et al. 2012) or perhaps even higher (Cayan et al. 2009). A report by the National Academy of Sciences (NAS 2012) projects sea level rise for the coasts of California, Oregon and Washington to be from 0.5 ft/0.2 m (IPCC A1B scenario – Moderate) to 1.6 ft/0.5 m (IPCC A1F1 scenario – High) by 2050. In Seattle sea level rose approximately 8 inches from 1900–2008 (TNC and CIG 2016), though sea level rise at the NOAA Friday Harbor sea level station from 1934 to 2006 averaged a relatively modest 0.05 in/1.13 mm per year (Canning 2005). If this trend continues at the same pace, the local increase over the coming 100 years may be just 4.54 inches (NOAA 2010).

5.4. Natural Resources Management

5.4.1. Adaptive Restoration

At least three major implications for management derive from this assessment. First, though restoration efforts have resulted in much success related to conserving and expanding rare and at-risk communities, more could be done to adapt restoration methods in response to new science. Focused efforts are currently underway to improve the ecological condition of the park's oak woodland and prairie habitat using a variety of hands-on management techniques. By removing invasive plants to establish weed-free connections with native herbaceous cover that exists both within and outside the park, managers will increase the chances of maintaining viable populations of rare species.

5.4.2. Increased Monitoring

Without expanding the monitoring of the condition of the park's resources—especially those with greatest potential to be affected by park policies and management—the risk of damaging the park's resources will increase, or at least, opportunities will be lost to understand many of the resources sufficiently to recover them to a more healthy and sustainable state.

5.4.3. Human Impacts

More research and management effort could be directed toward monitoring and measuring the effects of human activities on natural resources, particularly native wildlife species and sensitive plant communities. For example, avian nest predators (e.g. common raven, *Corvus corax*) are attracted to congregations of people such as at campgrounds, scenic pullouts, and picnic areas, resulting in greater raven abundance and reductions in productivity of other bird species (Marzluff and Neatherlin 2006). Unrestrained pets that inevitably accompany residential development near a park can dramatically increase predation on songbird and small mammal populations within the park (Calver et al. 2011). Additional attention to these activities and related impacts might increase the likelihood of success for interpretive efforts that strive to reduce human/resource conflicts.

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Appendix A. Birds of SAJH

Table A-1. Landbird species observed during 5 years of systematic breeding-season surveys in San Juan Island National Historical Park's American Camp (AC) and English Camp (EC) units, from Siegel et al. (2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2016).

Common Name	NPSpecies	Abundance/ Residency[A]	Conservation Status[B]	Trend/EBird records[C]	AC max count[D]	EC max count[D]	Oak/Prairie Associate[E]	Habitat Requirements
American Crow	Yes	Common/ Breeder	–	–	300	30	–	–
American Golden-Plover	No	–	–	–	4	0	–	–
American Goldfinch	Yes	Common/ Breeder	–	–	600	5	–	–
American Pipit	No	–	–	–	12	0	–	–
American Redstart	No	–	–	–	0	1	–	–
American Robin	Yes	Abundant/ Breeder	–	–	25	85	–	–
Anna's Hummingbird	No	/Unknown	–	–	1	1	–	–
Band-tailed Pigeon	Yes	Uncommon/ Resident	CC/	–	1	1	–	–
Barn Swallow	Yes	Common/ Breeder	–	–	90	6	–	–

[A] 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. (2011, 2012, 2013)

[B] CC – Climate Change Vulnerable (https://wa.audubon.org/conservation/climate); 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"

[C] Only trends that have been published for species that occur within the park or nearby waters are shown (V – Vilchis et al. 2014; C – Crewe et al. 2012; A-Altman 2011; B-Bower 2009;)

[D] Maximim/minimum count per survey point any year

[E] 1= obligate or near-obligate, 2= associated.

Table A-1 (continued). Landbird species observed during 5 years of systematic breeding-season surveys in San Juan Island National Historical Park's American Camp (AC) and English Camp (EC) units, from Siegel et al. (2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2016).

Common Name	NPSpecies	Abundance/ Residency[A]	Conservation Status[B]	Trend/EBird records[C]	AC max count[D]	EC max count[D]	Oak/Prairie Associate[E]	Habitat Requirements
Belted Kingfisher	Yes	Uncommon/ Resident	–	–	2	3	–	–
Bewick's Wren	Yes	Uncommon/ Breeder	–	–	7	1	1	Nesting cavities/shrub cover
Black Swift	Yes/ probable	NA/NA	–	–	1*	0	–	–
Black-billed Magpie	No	–	–	–	1*	0	–	–
Black-capped Chickadee	No	–	–	–	1	0	1	Nesting cavities
Black-headed Grosbeak	Yes	Rare/Breeder	–	–	1	1	1	–
Black-throated Gray Warbler	Yes	Uncommon/ Breeder	–	Declining (A)/None AC; Uncommon EC	1	8	1	Large patches
Bobolink	No	–	–	–	1	0	–	–
Brewer's Blackbird	Yes	Common/ Breeder	–	–	1	1	–	–
Brown Creeper	Yes	Common/ Breeder	CC/	–	4	9	–	–

[A] 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. (2011, 2012, 2013)

[B] CC – Climate Change Vulnerable (https://wa.audubon.org/conservation/climate); 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”

[C] Only trends that have been published for species that occur within the park or nearby waters are shown (V – Vilchis et al. 2014; C – Crewe et al. 2012; A-Altman 2011; B-Bower 2009;)

[D] Maximim/minimum count per survey point any year

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Table A-1 (continued). Landbird species observed during 5 years of systematic breeding-season surveys in San Juan Island National Historical Park's American Camp (AC) and English Camp (EC) units, from Siegel et al. (2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2016).

Common Name	NPSpecies	Abundance/ Residency[A]	Conservation Status[B]	Trend/EBird records[C]	AC max count[D]	EC max count[D]	Oak/Prairie Associate[E]	Habitat Requirements
Brown-headed Cowbird	Yes	Uncommon/ Breeder	–	-/Uncommon AC; Rare EC	25	6	–	–
Bushtit	Yes	Uncommon/ Breeder	–	Declining (A)/Uncommon AC; Rare EC	12	0	1	Shrub cover/large patches
California Quail	Yes	Uncommon/ Breeder	Not-native	–	31	1	–	–
Cassin's Vireo	Yes	Uncommon/ Breeder	–	–	0	4	1	–
Cedar Waxwing	Yes	Uncommon/ Resident	–	–	20	5	–	–
Chestnut-backed Chickadee	Yes	Common/ Breeder	–	–	28	31	–	–
Chipping Sparrow	Yes	Common/ Breeder	–	Declining (A)/Rare AC; Uncommon EC	1	2	1	Low-growing grasses
Clay-colored Sparrow	No	–	–	–	1	0	–	–
Cliff Swallow	Yes	Uncommon/ Migratory	CC/	–	30	2	–	–

[A] 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. (2011, 2012, 2013)

[B] CC – Climate Change Vulnerable (https://wa.audubon.org/conservation/climate); 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"

[C] Only trends that have been published for species that occur within the park or nearby waters are shown (V – Vilchis et al. 2014; C – Crewe et al. 2012; A-Altman 2011; B-Bower 2009;)

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Table A-1 (continued). Landbird species observed during 5 years of systematic breeding-season surveys in San Juan Island National Historical Park's American Camp (AC) and English Camp (EC) units, from Siegel et al. (2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2016).

Common Name	NPSpecies	Abundance/ Residency[A]	Conservation Status[B]	Trend/EBird records[C]	AC max count[D]	EC max count[D]	Oak/Prairie Associate[E]	Habitat Requirements
Common Nighthawk	Yes/ probable	/Unknown	–	Declining (A)/None AC; One record EC 1998	0	1	–	–
Common Raven	Yes	Uncommon/ Breeder	CC/	–	12	5	–	–
Common Yellowthroat	Yes	Common/ Breeder	–	–	4	1	–	–
Dark-eyed Junco	Yes	Common/ Breeder	–	–	20	35	–	–
Downy Woodpecker	Yes	Uncommon/ Breeder	–	Declining (A)/Uncommon AC; Rare EC	4	1	1	Nesting cavities
Dusky Flycatcher	No	–	–	–	0	1	–	–
Eurasian Collared-Dove	No	–	Not-native	–	12	0	–	–
European Starling	Yes	Common/ Breeder	Not-native	–	180	180	–	–
Evening Grosbeak	No	–	–	–	1*	1	–	–
Fox Sparrow	Yes	Common/ Resident	–	–	10	1	–	–

[A] 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. (2011, 2012, 2013)

[B] CC – Climate Change Vulnerable (https://wa.audubon.org/conservation/climate); 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"

[C] Only trends that have been published for species that occur within the park or nearby waters are shown (V – Vilchis et al. 2014; C – Crewe et al. 2012; A-Altman 2011; B-Bower 2009;)

[D] Maximim/minimum count per survey point any year

[E] 1= obligate or near-obligate, 2= associated.

Table A-1 (continued). Landbird species observed during 5 years of systematic breeding-season surveys in San Juan Island National Historical Park's American Camp (AC) and English Camp (EC) units, from Siegel et al. (2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2016).

Common Name	NPSpecies	Abundance/ Residency[A]	Conservation Status[B]	Trend/EBird records[C]	AC max count[D]	EC max count[D]	Oak/Prairie Associate[E]	Habitat Requirements
Golden-crowned Kinglet	Yes	Common/ Breeder	CC/	–	18	24	–	–
Golden-crowned Sparrow	Yes	Common/ Resident	–	–	45	1	–	–
Hairy Woodpecker	Yes	Uncommon/ Breeder	CC/	–	1	1	–	–
Hammond's Flycatcher	Yes	Rare/ Breeder	–	–	1	1	–	–
Hermit Thrush	No	–	–	–	4	1	–	–
Horned Lark	Yes	Rare/ Migratory; No longer nests in SJC	–	–	12	0	1	–
House Finch	Yes	Common/ Breeder	CC/	–	25	0	–	–
House Sparrow	Yes/ probable	NA/NA	Not-native	–	30	1	–	–
House Wren	Yes	Uncommon/ Breeder	–	Declining (A)/Uncommon AC&EC	7	9	1	Nesting cavities/shrub cover
Hutton's Vireo	Yes	Uncommon/ Breeder	–	–	1	1	1	Shrub cover/large patches

[A] 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. (2011, 2012, 2013)

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[C] Only trends that have been published for species that occur within the park or nearby waters are shown (V – Vilchis et al. 2014; C – Crewe et al. 2012; A-Altman 2011; B-Bower 2009;)

[D] Maximim/minimum count per survey point any year

[E] 1= obligate or near-obligate, 2= associated.

Table A-1 (continued). Landbird species observed during 5 years of systematic breeding-season surveys in San Juan Island National Historical Park's American Camp (AC) and English Camp (EC) units, from Siegel et al. (2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2016).

Common Name	NPSpecies	Abundance/ Residency[A]	Conservation Status[B]	Trend/EBird records[C]	AC max count[D]	EC max count[D]	Oak/Prairie Associate[E]	Habitat Requirements
Killdeer	Yes	Common/ Unknown	–	–	20	0	–	–
Lapland Longspur	No	–	–	–	20	0	–	–
Lewis' Woodpecker	No	No longer nests in SJC	–	-/None AC; Last record EC 2004	1*	0	1	Nesting cavities
Lincoln's Sparrow	No	–	–	–	25	0	–	–
MacGillivray's Warbler	Yes	Rare/ Breeder	–	–	1	1	–	–
Marsh Wren	Yes	Uncommon/ Breeder	CC/	–	10	0	–	–
Mountain Bluebird	No	–	–	–	1	1	–	–
Mourning Dove	Yes/ probable	NA/NA	–	Declining (A)/Rare AC	6	1	–	–
N. Rough-winged Swallow	Yes	Uncommon/ Breeder	–	–	12	2	–	–
Nashville Warbler	No	–	–	Declining (A)/None AC&EC	1	0	1	Shrub cover
Northern Flicker	Yes	Uncommon/ Breeder	–	–	6	3	–	–

[A] 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. (2011, 2012, 2013)

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[C] Only trends that have been published for species that occur within the park or nearby waters are shown (V – Vilchis et al. 2014; C – Crewe et al. 2012; A-Altman 2011; B-Bower 2009;)

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Table A-1 (continued). Landbird species observed during 5 years of systematic breeding-season surveys in San Juan Island National Historical Park's American Camp (AC) and English Camp (EC) units, from Siegel et al. (2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2016).

Common Name	NPSpecies	Abundance/ Residency[A]	Conservation Status[B]	Trend/EBird records[C]	AC max count[D]	EC max count[D]	Oak/Prairie Associate[E]	Habitat Requirements
Northern Shrike	Yes/ probable	NA/NA	–	–	6	0	–	–
Olive-sided Flycatcher	Yes	Uncommon/ Breeder	A	–	4	2	–	–
Orange-crowned Warbler	Yes	Common/ Breeder	–	–	25	15	–	–
Ovenbird	No	–	–	–	1	1	–	–
Pacific (Winter) Wren	Yes	Common/ Breeder	–	–	5	10	–	–
Pacific-slope Flycatcher	Yes	Common/ Breeder	CC/	–	4	15	–	–
Palm Warbler	No	–	–	–	1	0	–	–
Pileated Woodpecker	Yes	Uncommon/ Breeder	C	–	1	2	–	–
Pine Siskin	Yes	Common/ Breeder	CC/	–	135	25	–	–
Purple Finch	Yes	Uncommon/ Breeder	CC/	Declining (A)/Uncommon AC&EC	4	5	1	Large patches

[A] 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. (2011, 2012, 2013)

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Table A-1 (continued). Landbird species observed during 5 years of systematic breeding-season surveys in San Juan Island National Historical Park's American Camp (AC) and English Camp (EC) units, from Siegel et al. (2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2016).

Common Name	NPSpecies	Abundance/ Residency[A]	Conservation Status[B]	Trend/EBird records[C]	AC max count[D]	EC max count[D]	Oak/Prairie Associate[E]	Habitat Requirements
Purple Martin	Yes/ probable	NA/NA	C	–	4	1	–	–
Red Crossbill	Yes	Common/ Breeder	CC/	–	6	15	–	–
Red-breasted Nuthatch	Yes	Common/ Breeder	CC/	–	10	7	–	–
Red-breasted Sapsucker	Yes	Rare/ Migratory	–	–	1	0	–	–
Red-winged Blackbird	Yes	Common/ Breeder	–	–	35	2	–	–
Ring-necked Pheasant	Yes	Rare/ Resident	Not-native	–	1	0	–	–
Rock Pigeon (Feral Pigeon)	Yes/ probable	NA/NA	Not-native	–	1	1	–	–
Rock Wren	No	–	–	–	1	0	–	–
Ruby-crowned Kinglet	No	–	–	–	12	3	–	–
Rufous Hummingbird	Yes	Common/ Breeder	CC/	–	20	5	–	–
Savannah Sparrow	Yes	Common/ Breeder	–	–	30	1	–	–

[A] 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. (2011, 2012, 2013)

[B] CC – Climate Change Vulnerable (https://wa.audubon.org/conservation/climate); 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"

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Table A-1 (continued). Landbird species observed during 5 years of systematic breeding-season surveys in San Juan Island National Historical Park's American Camp (AC) and English Camp (EC) units, from Siegel et al. (2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2016).

Common Name	NPSpecies	Abundance/ Residency[A]	Conservation Status[B]	Trend/EBird records[C]	AC max count[D]	EC max count[D]	Oak/Prairie Associate[E]	Habitat Requirements
Say's Phoebe	No	No longer nests in SJC	–	–	0	0	–	–
Sky Lark	No	–	–	–	14	0	–	–
Song Sparrow	Yes	Common/ Breeder	–	–	15	8	–	–
Spotted Towhee	Yes	Common/ Breeder	–	–	15	10	1	Shrub cover
Steller's Jay	No	–	–	–	1	0	–	–
Swainson's Thrush	Yes	Common/ Breeder	–	–	2	5	–	–
Tennessee Warbler	Yes	Occasional/ Migratory	–	–	0	0	–	–
Townsend's Solitaire	Yes	Uncommon/ Migratory	–	–	0	1	–	–
Townsend's Warbler	Yes	Common/ Breeder	–	–	1	10	–	–
Tree Swallow	Yes	Common/ Breeder	CC	–	2	3	–	–

[A] 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. (2011, 2012, 2013)

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Table A-1 (continued). Landbird species observed during 5 years of systematic breeding-season surveys in San Juan Island National Historical Park's American Camp (AC) and English Camp (EC) units, from Siegel et al. (2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2016).

Common Name	NPSpecies	Abundance/ Residency[A]	Conservation Status[B]	Trend/EBird records[C]	AC max count[D]	EC max count[D]	Oak/Prairie Associate[E]	Habitat Requirements
Turkey Vulture	Yes	Uncommon/ Migratory	–	–	125	6	–	–
Varied Thrush	Yes	Uncommon/ Breeder	CC	–	2	100	–	–
Vaux's Swift	Yes	Uncommon/ Breeder	C	–	1	2	–	–
Vesper Sparrow	Yes	Uncommon/ Breeder	FWS-2/A	-/Very rare AC;None EC	3	0	2	–
Violet-green Swallow	Yes	Common/ Breeder	CC	–	16	10	–	–
Warbling Vireo	Yes	Common/ Breeder	–	–	1	3	–	–
Western Bluebird	Yes	Recently reintroduced to SJI	W	-/Very rare AC; None EC	3	0	1	Nesting cavities/low-growing grasses
Western Kingbird	No	No longer nests in SJC	–	–	1	0	2	–

[A] 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. (2011, 2012, 2013)

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Common Name	NPSpecies	Abundance/ Residency[A]	Conservation Status[B]	Trend/EBird records[C]	AC max count[D]	EC max count[D]	Oak/Prairie Associate[E]	Habitat Requirements
Western Meadowlark	Yes	Uncommon/ Breeder; No longer nests in SJC	–	Declining (A)/Uncommon AC;None EC	12	0	2	–
Western Tanager	Yes	Common/ Breeder	CC	–	1	2	1	Habitat edges
Western Wood-Pewee	Yes/ probable	Unknown breeding status;	–	–	2	1	1	Habitat edges
White-crowned Sparrow	Yes	Common/ Breeder	–	–	47	5	–	–
White-throated Sparrow	No	–	–	–	1	0	–	–
Wild Turkey	Yes	Uncommon/ Resident	Not-native	–	1	19	–	–
Willow Flycatcher	Yes	Uncommon/ Breeder	CC	–	1	0	–	–
Wilson's Warbler	Yes	Uncommon/ Breeder	–	–	4	3	–	–
Yellow Warbler	Yes	Uncommon/ Migratory	–	–	4	1	–	–

[A] 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. (2011, 2012, 2013)

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Table A-1 (continued). Landbird species observed during 5 years of systematic breeding-season surveys in San Juan Island National Historical Park's American Camp (AC) and English Camp (EC) units, from Siegel et al. (2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2016).

Common Name	NPSpecies	Abundance/ Residency[A]	Conservation Status[B]	Trend/EBird records[C]	AC max count[D]	EC max count[D]	Oak/Prairie Associate[E]	Habitat Requirements
Yellow-rumped Warbler	Yes	Common/ Breeder	–	–	4	5	–	–

[A] 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. (2011, 2012, 2013)

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Table A-2. Raptor species observed during 5 years of systematic breeding-season surveys in San Juan Island National Historical Park's American Camp (AC) and English Camp (EC) units, from Siegel et al. (2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2011, 2012, 2013).

Common Name	NPSpecies	Abundance/ Residency[A]	Conservation Status[B]	Trend (if known)[C]	AC max count[D]	EC max count[D]	Oak/Prairie Associate[E]
American Kestrel	Yes	Uncommon/ Breeder	CC/	Declining (A)	5	0	2
Bald Eagle	Yes	Common/ Breeder	CC/S	–	10	7	–
Barn Owl	Yes/ probable	NA/NA	–	–	1	0	–
Barred Owl	Yes	Unknown/ Unknown	–	–	0	1	–
Burrowing Owl	No	No longer nests in SJC	–	–	1	0	–
Cooper's Hawk	Yes/ probable	/Unknown	–	Increasing (A)	2	0	2
Golden Eagle	Yes	Rare/ Resident	C	–	1	0	–
Great Horned Owl	Yes/ probable	NA/NA	–	–	0	1	–
Gyrfalcon	No	–	–	–	1	0	–
Long-eared Owl	No	–	–	–	1	0	–
Merlin	No	–	–	–	1	1	–
Northern Fulmar	No	–	–	–	1*	0	–

[A] 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. (2011, 2012, 2013)

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[C] Only trends that have been published for species that occur within the park or nearby waters are shown (V – Vilchis et al. 2014; C – Crewe et al. 2012; A-Altman 2011; B-Bower 2009;)

[D] Maximim/minimum count per survey point any year

[E] 1= obligate or near-obligate, 2= associated.

Table A-2 (continued). Raptor species observed during 5 years of systematic breeding-season surveys in San Juan Island National Historical Park's American Camp (AC) and English Camp (EC) units, from Siegel et al. (2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2011, 2012, 2013).

Common Name	NPSpecies	Abundance/ Residency[A]	Conservation Status[B]	Trend (if known)[C]	AC max count[D]	EC max count[D]	Oak/Prairie Associate[E]
Northern Goshawk	No	–	–	–	0	0	–
Northern Harrier	Yes	Uncommon/ Resident; No longer nests in SJC	CC/	–	6	0	1
Northern Pygmy-Owl	No	–	–	–	0	0	–
Northern Saw-whet Owl	Yes/ probable	NA/NA	–	–	1*	0	–
Osprey	Yes	Rare/ Breeder	–	–	1	8	–
Peregrine Falcon	Yes	Rare/ Resident	CC/S	–	1	0	–
Red-tailed Hawk	Yes	Common/ Breeder	–	–	4	2	–
Rough-legged Hawk	No	–	–	–	1	0	–
Sharp-shinned Hawk	Yes/ probable	NA/NA	–	–	1	1	–
Short-eared Owl	Yes	Rare/ Unknown	–	–	3	0	1
Snowy Owl	Yes	Occasional/ Migratory	–	–	1*	0	–

[A] 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. (2011, 2012, 2013)

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[C] Only trends that have been published for species that occur within the park or nearby waters are shown (V – Vilchis et al. 2014; C – Crewe et al. 2012; A-Altman 2011; B-Bower 2009;)

[D] Maximim/minimum count per survey point any year

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Table A-2 (continued). Raptor species observed during 5 years of systematic breeding-season surveys in San Juan Island National Historical Park's American Camp (AC) and English Camp (EC) units, from Siegel et al. (2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2011, 2012, 2013).

Common Name	NPSpecies	Abundance/ Residency[A]	Conservation Status[B]	Trend (if known)[C]	AC max count[D]	EC max count[D]	Oak/Prairie Associate[E]
Swainson's Hawk	Yes	Occasional/ Vagrant	–	–	0	0	–
Western Screech-owl	Yes/ probable	Unknown breeding status;	–	Increasing (A)	0	0	2

[A] 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. (2011, 2012, 2013)

[B] CC – Climate Change Vulnerable (https://wa.audubon.org/conservation/climate); 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”

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Table A-3. Seabirds observed during 5 years of systematic breeding-season surveys in San Juan Island National Historical Park's American Camp (AC) and English Camp (EC) units, from Siegel et al. (2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2011, 2012, 2013).

Common Name	NPSpecies	Abundance/ Residency[A]	Conservation Status[B]	Trend (if known)[C]	AC max count[D]	EC max count[D]
Ancient Murrelet	No	–	G/2	-/Rare AC; None EC	200	0
Bonaparte's Gull	Yes/ probable	NA/NA	–	–	350	1
Brandt's Cormorant	Yes/ probable	NA/NA	C	–	1000	1
Brown Pelican	No	–	–	–	0	0
California Gull	Yes/ probable	NA/NA	CC/	–	50	3
Cassin's Auklet	No	–	–	–	1*	0
Common Murre	Yes	Uncommon/ Migratory	–	–	1000	1
Double-crested Cormorant	Yes	Common/ Resident	–	–	150	50
Glaucous Gull	No	–	CC/	–	1*	0
Glaucous-winged Gull	Yes	Common/ Resident	–	–	400	56
Heermann's Gull	Yes/ probable	NA/NA	–	–	250	1
Herring Gull	No	–	–	–	4	0
Long-tailed Jaeger	Yes	Occasional/ Migratory	–	–	0	0
Marbled Murrelet	No	–	T/2	-/Very rare AC, last record 2015; Only one record EC 1998	100	1
Mew Gull	Yes/ probable	NA/NA	–	–	500	25
Parasitic Jaeger	Yes/ probable	NA/NA	–	–	1	0

[A] 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. (2011, 2012, 2013)

[B] CC – Climate Change Vulnerable (https://wa.audubon.org/conservation/climate); 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"

[C] Only trends that have been published for species that occur within the park or nearby waters are shown (V – Vilchis et al. 2014; C – Crewe et al. 2012; A-Altman 2011; B-Bower 2009;)

[D] Maximim/minimum count per survey point any year

Table A-3 (continued). Seabirds observed during 5 years of systematic breeding-season surveys in San Juan Island National Historical Park's American Camp (AC) and English Camp (EC) units, from Siegel et al. (2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2011, 2012, 2013).

Common Name	NPSpecies	Abundance/ Residency[A]	Conservation Status[B]	Trend (if known)[C]	AC max count[D]	EC max count[D]
Pigeon Guillemot	Yes	Common/ Resident	CC/G/2	–	40	10
Rhinoceros Auklet	Yes	Common/ Resident	CC/G/2	–	100	1
Ring-billed Gull	Yes/ probable	NA/NA	–	–	20	3
Sooty Shearwater	No	–	–	–	1	0
Tufted Puffin	Yes/ probable	NA/NA	C	–	3	1
Western Gull	Yes/ probable	NA/NA	CC/	–	1	4
White-winged Scoter	Yes	Common/ Resident	G	–	60	2

[A] 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. (2011, 2012, 2013)

[B] CC – Climate Change Vulnerable (https://wa.audubon.org/conservation/climate); 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”

[C] Only trends that have been published for species that occur within the park or nearby waters are shown (V – Vilchis et al. 2014; C – Crewe et al. 2012; A-Altman 2011; B-Bower 2009;)

[D] Maximim/minimum count per survey point any year

Table A-4. Shorebirds and waterbirds observed during 5 years of systematic breeding-season surveys in San Juan Island National Historical Park's American Camp (AC) and English Camp (EC) units, from Siegel et al. (2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2011, 2012, 2013).

Common Name	NPSpecies	Abundance/ Residency[A]	Conservation Status[B]	Trend/ EBird records[C]	AC max count[D]	EC max count[D]
American Avocet	No	–	–	–	1*	0
American Bittern	No	–	–	–	1*	0
American Coot	Yes/ probable	NA/NA	–	–	1	0
American Dipper	No	–	–	–	1	0
American Wigeon	Yes/ probable	NA/NA	CC/	Increasing (V)	40	20
Baird's Sandpiper	Yes/ probable	NA/NA	–	–	1	0
Barrow's Goldeneye	Yes/ probable	NA/NA	G/1	Declining (C)/ None at AC&EC	1	0
Black Oystercatcher	Yes	Rare/ Resident	CC/S	Increasing (V)	28	5
Black Scoter	Yes	Rare/ Migratory	–	Declining (V/B/C)/ Very rare AC; None EC	2	0
Black Turnstone	Yes/ probable	NA/NA	G/5	Increasing (V)	20	0
Black-bellied Plover	No	–	–	–	45	0
Blue-winged Teal	Yes/ probable	NA/NA	–	Increasing (V)	0	0
Brant	No	–	–	Increasing (V)	2	0
Buff-breasted Sandpiper	Yes	Occasional/ Migratory	–	–	0	0
Bufflehead	Yes	Common/ Resident	CC/G/4	–	60	353

[A] 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. (2011, 2012, 2013)

[B] CC – Climate Change Vulnerable (https://wa.audubon.org/conservation/climate); 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"

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[D] Maximim/minimum count per survey point any year

Table A-4 (continued). Shorebirds and waterbirds observed during 5 years of systematic breeding-season surveys in San Juan Island National Historical Park's American Camp (AC) and English Camp (EC) units, from Siegel et al. (2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2011, 2012, 2013).

Common Name	NPSpecies	Abundance/ Residency[A]	Conservation Status[B]	Trend/ EBird records[C]	AC max count[D]	EC max count[D]
Cackling Goose	No	–	–	–	0	2
Canada Goose	Yes	Common/ Resident	G	Increasing (V/B/C)	75	50
Canvasback	Yes/ probable	NA/NA	–	Declining (C)/ None at AC&EC	0	0
Caspian Tern	No	–	–	–	3	0
Cinnamon Teal	Yes/ probable	NA/NA	–	–	0	0
Common Goldeneye	Yes	Common/ Resident	CC/G/1	Declining (B)/ Very rare AC&EC	10	1
Common Loon	Yes	Common/ Resident	CC/	Declining (C)/ Uncommon AC; Very rare EC	10	2
Common Merganser	Yes	Uncommon/ Resident	CC/	Increasing (V)	4	4
Common Tern	Yes	Rare/ Migratory	–	–	8	1
Dunlin	No	–	G/5	Increasing (V)	100	0
Eared Grebe	Yes	Rare/ Resident	–	–	1	3
Eurasian Wigeon	No	–	–	–	1*	0
Gadwall	Yes	Rare/ Resident	–	–	25	0
Great Blue Heron	Yes	Common/ Resident	–	Declining (C)/ Uncommon AC; Common EC	5	4

[A] 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. (2011, 2012, 2013)

[B] CC – Climate Change Vulnerable (https://wa.audubon.org/conservation/climate); 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”

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[D] Maximim/minimum count per survey point any year

Table A-4 (continued). Shorebirds and waterbirds observed during 5 years of systematic breeding-season surveys in San Juan Island National Historical Park's American Camp (AC) and English Camp (EC) units, from Siegel et al. (2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2011, 2012, 2013).

Common Name	NPSpecies	Abundance/ Residency[A]	Conservation Status[B]	Trend/ EBird records[C]	AC max count[D]	EC max count[D]
Greater Scaup	Yes	Common/ Resident	CC/	Declining (V/B/C)/ Only one record AC 2015; Rare EC	10	116
Greater White-fronted Goose	Yes	Rare/ Migratory	–	–	0	0
Greater Yellowlegs	Yes	Uncommon/ Migratory	CC/	–	4	0
Green Heron	No	–	–	–	0	0
Green-winged Teal	Yes/ probable	NA/NA	–	Declining (C)/ Very rare AC; Rare EC	5	5
Harlequin Duck	Yes	Uncommon/ Resident	G/4	Declining (C)/ Uncommon AC; Only one record EC 1998	26	0
Hooded Merganser	Yes	Uncommon/ Resident	CC/G/1	Increasing (V)	14	2
Horned Grebe	Yes	Uncommon/ Resident	CC/3	Declining (C)/Uncommon AC; Rare EC last record 2015	80	68
Least Sandpiper	Yes/ probable	NA/NA	–	–	12	0
Lesser Scaup	Yes/ probable	NA/NA	CC/	Declining (V/B/C)/Generally rare EC but many in 2016; None AC	0	6
Lesser Yellowlegs	Yes/ probable	NA/NA	–	–	11	0

[A] 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. (2011, 2012, 2013)

[B] CC – Climate Change Vulnerable (https://wa.audubon.org/conservation/climate); 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"

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[D] Maximim/minimum count per survey point any year

Table A-4 (continued). Shorebirds and waterbirds observed during 5 years of systematic breeding-season surveys in San Juan Island National Historical Park's American Camp (AC) and English Camp (EC) units, from Siegel et al. (2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2011, 2012, 2013).

Common Name	NPSpecies	Abundance/ Residency[A]	Conservation Status[B]	Trend/ EBird records[C]	AC max count[D]	EC max count[D]
Long-billed Curlew	No	–	–	–	1*	0
Long-billed Dowitcher	Yes/ probable	NA/NA	–	–	1*	0
Long-tailed Duck	Yes	Uncommon/ Resident	–	Declining (C)/Only one record EC 1998; Rare AC	10	4
Mallard	Yes	Common/ Breeder	CC/	Increasing (V)	30	15
Marbled Godwit	No	–	–	–	1*	0
Northern Pintail	Yes/ probable	NA/NA	–	Increasing (V)	250	0
Northern Shoveler	Yes/ probable	NA/NA	–	Increasing (C)	1*	2
Pacific Golden-Plover	No	–	–	–	2	0
Pacific Loon	Yes	Uncommon/ Resident	G/3	Declining (C)/Uncommon AC; One record only EC 2004	250	0
Pectoral Sandpiper	No	–	–	–	4	0
Pelagic Cormorant	Yes/ probable	NA/NA	–	–	80	10
Pied-billed Grebe	Yes/ probable	NA/NA	–	–	1	0
Red-breasted Merganser	Yes	Uncommon/ Resident	CC/G/4	Increasing (V)	100	30
Redhead	No	–	–	–	0	0
Red-necked Grebe	Yes/probable	NA/NA	CC/3	–	60	3

[A] 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. (2011, 2012, 2013)

[B] CC – Climate Change Vulnerable (https://wa.audubon.org/conservation/climate); 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”

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Table A-4 (continued). Shorebirds and waterbirds observed during 5 years of systematic breeding-season surveys in San Juan Island National Historical Park's American Camp (AC) and English Camp (EC) units, from Siegel et al. (2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2011, 2012, 2013).

Common Name	NPSpecies	Abundance/ Residency[A]	Conservation Status[B]	Trend/ EBird records[C]	AC max count[D]	EC max count[D]
Red-necked Phalarope	Yes/ probable	NA/NA	–	–	8	0
Red-throated Loon	Yes/ probable	NA/NA	–	Declining (C)/Very rare AC; None EC	1	0
Ring-necked Duck	Yes/ probable	NA/NA	CC/	–	1	6
Rock Sandpiper	No	–	–	–	3	0
Ruddy Duck	No	–	–	Declining (V&B)/None AC; Only one record EC 2016	1*	0
Ruddy Turnstone	No	–	–	–	1*	0
Sanderling	No	–	–	–	20	0
Sandhill Crane	No	No longer nests in SJC	–	–	0	0
Semipalmated Plover	Yes/ probable	NA/NA	–	–	1	0
Semipalmated Sandpiper	No	–	–	–	0	0
Short-billed Dowitcher	Yes/ probable	NA/NA	–	–	1*	0
Snow Goose	No	–	–	–	1	1
Solitary Sandpiper	No	–	–	–	0	0
Sora	Yes/ probable	NA/NA	–	–	0	0
Spotted Sandpiper	Yes/ probable	NA/NA	–	–	1	0

[A] 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. (2011, 2012, 2013)

[B] CC – Climate Change Vulnerable (https://wa.audubon.org/conservation/climate); 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"

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[D] Maximim/minimum count per survey point any year

Table A-4 (continued). Shorebirds and waterbirds observed during 5 years of systematic breeding-season surveys in San Juan Island National Historical Park's American Camp (AC) and English Camp (EC) units, from Siegel et al. (2008, 2009), Wilkerson et al. (2010) and Holmgren et al. (2011, 2012, 2013).

Common Name	NPSpecies	Abundance/ Residency[A]	Conservation Status[B]	Trend/ EBird records[C]	AC max count[D]	EC max count[D]
Surf Scoter	Yes	Common/ Resident	G/4	Declining (V)/ Common AC; Uncommon EC	700	65
Surfbird	Yes/ probable	NA/NA	CC/	–	15	0
Thayer's Gull	Yes/ probable	NA/NA	–	–	2	0
Trumpeter Swan	Yes/ probable	NA/NA	–	–	1*	0
Tundra Swan	No	–	–	–	0	0
Virginia Rail	Yes/ probable	NA/NA	–	–	0	0
Wandering Tattler	No	–	–	–	1	0
Western Grebe	Yes/ probable	NA/NA	CC/C/3	Declining (C)/Rare AC; Very rare EC, last record 2013	15	9
Western Sandpiper	Yes/ probable	NA/NA	–	–	50	0
Whimbrel	Yes/ probable	NA/NA	–	–	1	0
White-winged scoter	–	–	–	Declining (V/C)/Uncommon AC&EC	–	–
Wilson's Snipe	No	–	–	–	1	0
Wood Duck	Yes/ probable	NA/NA	G/1	–	0	1
Yellow-billed Loon	Yes/ probable	NA/NA	–	–	1*	0

[A] 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. (2011, 2012, 2013)

[B] CC – Climate Change Vulnerable (https://wa.audubon.org/conservation/climate); 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"

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[D] Maximim/minimum count per survey point any year

Appendix B. Vertebrates of SAJH

Table B-1. Amphibians documented from SAJH or potentially present, from various sources: (C – confirmed; P – likely or probably present; ? – occupancy unknown).

Common Name	Scientific Name	NPSpecies	Adamus et al. 2011 (island-wide)	Conservation Status	Notes
Pacific tree/chorus frog	*Hyla (Pseudacris) regilla*	Present	C	Common	Confirmed by Samora et al. (2013)
Northern red-legged frog	*Rana aurora*	–	P	–	Confirmed by Samora et al. (2013), but they only found one individual
Oregon spotted frog	*R. pretiosa*	–	–	Federally threatened	Identified as possible by Samora et al. (2013) but not found
Western toad	*Bufo boreas*	Probably present	?	State candidate species and federal species of concern;	Locally extinct?
Rough-skinned newt	*Taricha granulosa*	Unconfirmed	C	–	Common in small lakes and ponds on the larger SJI; high seasonal dispersal activity when they are at risk on roads; identified as possible by Samora et al. (2013) but not found
Ensatina	*Ensatina eschscholtzii*	–	–	–	Identified as possible by Samora et al. (2013) but not found
Western red-backed salamander	*Plethodon vehiculum*	–	–	–	Identified as possible by Samora et al. (2013) but not found
Northwestern salamander	*Ambystoma gracile*	–	P	–	–
Bullfrog	*Rana catesbeiana*	Unconfirmed	C	–	Identified as possible by Samora et al. (2013) but not found

Table B-2. Reptiles documented from SAJH or potentially present, from various sources: (C – confirmed; P – likely or probably present; ? – occupancy unknown).

Common Name	Scientific Name	NPSpecies	Adamus et al. 2011 (island-wide)	Conservation Status	Notes
W. terrestrial garter snake	*Thamnophis elegans*	Present	P	–	–
Northwestern garter snake	*T. ordinoides*	Present	P	–	Confirmed by Samora et al. 2013;
Common garter snake	*T. sirtalis*	Probably present	C	–	–
Northern alligator lizard	*Elgaria coerulea*	Present	C	–	–
Western fence lizard	*Sceloporus occidentalis*	–	C	–	–
Sharp-tailed snake	*Contia tenuis*	–	C	–	Limited distribution in Washington and hard to detect, could be more common than survey data suggest (WDFW 2015);
Rubber boa	*Charina bottae*	–	C	–	–
Western painted turtle	*Chrysemys picta*	–	C	–	–

Table B-3. Mammals (other than bats) documented from SAJH or potentially present, from various sources: (C – Confirmed; P – likely or probably present).

Common Name	Scientific Name	NPSpecies	Adamus et al. 2011 (island-wide)	Conservation Status	Notes
Vagrant shrew	*Sorex vagrans*	Present	C	–	–
Townsend's vole	*Microtus townsendii*	Present	C	–	–
Deer mouse	*Peromyscus maniculatus*	Present	C	–	–
Norway rat	*Rattus norvegicus*	Unconfirmed	C	–	Non-native
Black rat	*R. rattus*	Unconfirmed	C	–	Non-native
European Rabbit	*Oryctolagus cuniculus*	Present	C	–	Not native/ invasive
Columbia black-tailed deer	*Odocoileus*	Present	–	–	–
Red fox	*Vulpes vulpes*	Present	C	–	Introduced?
River otter	*Lontra canadensis*	Present	C	–	–
American mink	*Mustela vison*	Present	P	–	–
Raccoon	*Procyon lotor*	Present	P	–	–
Feral cat	*Felis catus*	Present	–	–	Non-native
Common muskrat	*Ondatra zibethicus*	Unconfirmed	C	–	–
Steller's sea lion	–	–	–	–	–
Harbor seal	–	–	–	–	–

Table B-4. Bats documented from SAJH or potentially present, from various sources: (C – Confirmed; P – likely or probably present).

Common Name	Scientific Name	NPSpecies	Adamus et al. 2011 (island-wide)	www.kwiaht.org/bats.htm (SJI)	Conservation Status	Notes
Big brown	*Eptesicus fuscus*	Present	P	X	–	–
Silver-haired	*Lasionycteris noctivagans*	Present	P	–	–	–
California myotis	*Myotis californicus*	Present	C	X	–	First confirmed in the park 2006
Little brown	*M. lucifugus*	Present	C	X	–	–
Long-legged myotis	*M. volans*	Present	C	–	–	–
Long-eared myotis	*M. evotis*	Present	P	X	–	–
Yuma myotis	*M. yumanensis*	Present	P	X	–	–
Hoary	*Lasiurus cinereus*	Probably Present	P	–	–	–
Keen's myotis	*M. keenii*	Probably Present	P	–	–	–
Townsend's big-eared	*Corynorhinus townsendii*	Unconfirmed	P	X	Species of Concern	–

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National Park Service
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