National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

North Coast and Cascades Network Climate Monitoring Report

Ebey's Landing National Historical Reserve and San Juan Island National Historical Park; Water Year 2010

Natural Resource Data Series NPS/NCCN/NRDS—2012/327

ON THE COVER
The Coupeville wharf and warehouse, built in 1905. The wharf is one of many historic buildings in downtown Coupeville, part of the Ebey's Landing National Historical Reserve.
Photograph by: Bill Baccus

North Coast and Cascades Network Climate Monitoring Report

Ebey's Landing National Historical Reserve and San Juan Island National Historical Park; Water Year 2010

Natural Resource Data Series NPS/NCCN/NRDS—2012/327

William Baccus

National Park Service
North Coast and Cascades Network
Olympic National Park
600 E. Park Ave
Port Angeles, WA 98362

Mark Huff

National Park Service
North Coast and Cascades Network
Mount Rainier National Park
55210 238th Ave E.
Ashford, WA 98304

June 2012

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado publishes a range of reports that address natural resource topics of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

Views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government.

This report is available from The North Coast and Cascades Network Inventory and Monitoring website (http://science.nature.nps.gov/im/units/nccn/reportpubs.cfm) and the Natural Resource Publications Management website (http://www.nature.nps.gov/publications/nrpm).

Please cite this publication as:

Baccus, W. D., and M. Huff. 2012. North Coast and Cascades Network climate monitoring report: Ebey's Landing National Historical Reserve and San Juan Island National Historical Park; Water Year 2010. Natural Resource Data Series NPS/NCCN/NRDS—2012/327. National Park Service, Fort Collins, Colorado.

NPS 484/115032, 438/115032, June 2012

Contents

Figures

Page

Tables

Page

Executive Summary

Climate and weather events define the ecological characteristics found in national parks and are key to understanding and interpreting changes in natural resources. Everyday park operations including fire management, natural resource activities, maintenance of park infrastructure, and visitor use are influenced by weather. Monitoring weather and maintaining climate records provides essential information to support park operations and monitor park resources

This report summarizes climate data collected within and adjacent to Ebey's Landing National Historical Reserve and San Juan Island National Historical Park from the 2010 water year. It is part of a set of climate summary reports from seven national and Historical parks in the North Coast and Cascades Network. Published in the National Park Service's Natural Resource Data Series, annual climate summary reports are intended to provide basic data sets and data summaries in a timely manner, with minimal interpretation and analyses. We envision National Park staff, especially planners, scientists, interpreters, partners, and interested public as the primary audience for these reports.

Temperature and precipitation data are presented from four weather stations located on three islands in the northwest corner of Washington State. Data from San Juan Island were recorded using automated instruments operated by the National Park Service and the Federal Aviation Administration. Data from Orcas and Whidbey Island are provided by the National Weather Service. For two stations with long term records, the Olga Cooperative Observer Station (COOP) Station on Orcas Island and the Coupeville COOP Station on Whidbey Island, monthly average temperatures and monthly total precipitation are reported and compared to the 30-year normal. For all stations, daily and monthly air temperature and precipitation data are displayed, including comparisons to period of record and highlights of important weather events from each site.

Weather data collected in water year 2010 indicated that this year was generally warmer and wetter than normal. Of particular interest is the major departure from normal in temperature during the months of January and February and an unusually dry month of July.

Acknowledgments

The National Park Service relies on several cooperating agencies to help support and maintain a long-term climate monitoring program as part of the North Coast and Cascades Network climate monitoring program. These agencies include:

- Federal Aviation Administration and Department of Defense – Automated Surface Observing Systems
- National Interagency Fire Center – Remote Automated Weather Stations Program
- National Weather Service – National Weather Service Cooperative Observer Program

Data management is critical to provide for the availability and analysis of climate data. We rely on the North Coast and Cascade Network Data Managers, specifically John Boetsch, Bret Christoe and Ruth Jenkins, the Western Regional Climate Center, and the National Climate Data Center for climate data management.

We thank the following park staff for their assistance: Ken Arzarian, Maintenance Supervisor and Rob Palmer, Park Ranger at San Juan Island National Historical Park, for emergency maintenance of the English Camp weather station.

The authors appreciate the careful review by Dr. Catharine Copass, North Coast and Cascades Network and Jerald Weaver, San Juan Island National Historical Park.

Acronyms

ASOS	Automated Surface Observing Systems
COOP	Cooperative Observer Station
EBLA	Ebey's Landing National Historical Reserve
FAA	Federal Aviation Administration
GDD	Growing Degree Days
I&M	Inventory and Monitoring
NCCN	North Coast and Cascades Network
NCDC	National Climatic Data Center
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NWS	National Weather Service
PNW	Pacific Northwest
RAWS	Remote Automated Weather Stations
SAJH	San Juan Island National Historical Park
USDA	United States Department of Agriculture
WRCC	Western Regional Climate Center

Glossary

ASOS: The Automated Surface Observing Systems program is a joint effort of the National Weather Service, the Federal Aviation Administration, and the Department of Defense. The program operates a network of automated weather stations at airports nationwide, for the purpose of supporting weather forecast activities and aviation operations.

Climate: Complete and entire ensemble of statistical descriptors of temporal and spatial properties comprising the behavior of the atmosphere. These descriptors include means, variances, frequency distributions, autocorrelations, spatial correlations and other patterns of association, temporal lags, and element-to-element relationships. The descriptors have a physical basis in flows and reservoirs of energy and mass. Climate and weather phenomena shade gradually into each other and are ultimately inseparable (Davey et al. 2006).

Climate Normals: A long-term average value of a meteorological parameter (i.e. temperature) for a certain area. For example, "temperatures are normal for this time of year" means that temperatures are at or near the average climatological value for a given time period. Normals are usually taken from data averaged over a 30-year period (e.g., 1971-2000 average), and are concerned with the distribution of data within limits of common occurrence.

Degree Days: A measure of the departure of the mean daily temperature from a given standard (e.g. one degree-day for each degree (°F) of departure above (or below) the standard during one day. Degree-days are accumulated over a "season" at any point during which the total can be used as an index of past temperature effect upon some quantity, such as plant growth, snow accumulation, etc.)

Growing Degree Days (GDD): A measure of heat accumulation over time, which is derived from the cumulative sum of daily air temperatures above a baseline value (e.g. 40°F is a common baseline value) over a specified time period. GDD is commonly used to understand rates of plant growth and the timing of plant and animal life cycles.

Fall: The season of the year which is the transition period from summer to winter occurring as the sun approaches the winter solstice. Fall includes the months of September, October, and November.

NWS-COOP: An extensive network of manually operated weather stations overseen by the National Weather Service. Many Cooperative Observer Program weather sites were established in the late 1800's and as such, provide the best long term data for understanding local climates. At each station, an observer records daily maximum and minimum temperature, as well as total rain and snowfall.

Period of Record: The total span of time that climate data have been collected at a specific location. The longer the period of record, the more likely the climate data will not be biased by singular weather events or cyclic climate anomalies such as those associated with the Pacific Decadal Oscillation.

RAWS: A network of remote automated weather stations that provide real-time weather data to assist land management agencies in monitoring fuels, rating fire danger and predicting fire behavior. RAWS stations are all operational during summer months, but many at lower elevations operate on a year round basis.

Spring: The season of the year comprising the transition period from winter to summer occurring when the sun is approaching the summer solstice. Spring includes the months of March, April and May.

Summer: The warmest season of the year during which the sun is most nearly overhead. Summer includes the months of June, July, and August.

Water Year: The Water Year (or Hydrologic Year) is most often defined as the period from October 1st to September 30 of the following year. It is called by the calendar year in which it ends. Thus, Water Year 2010 is the 12-month period beginning October 1st, 2009 and ending September 30th, 2010. The period is chosen so as to encompass a full cycle of precipitation accumulation.

Weather: Instantaneous state of the atmosphere at any given time, mainly with respect to its effects on biological activities. As distinguished from climate, weather consists of the short-term (minutes to days) variations in the atmosphere. Popularly, weather is thought of in terms of temperature, precipitation, humidity, wind, sky condition, visibility, and cloud conditions (Davey et al. 2006).

Winter: Typically the coldest season of the year during which the sun is farthest from overhead. Winter includes the months of December, January and February.

Introduction

Climate is a dominant factor driving the physical and ecologic processes affecting the North Coast and Cascades Inventory and Monitoring Network (NCCN) (Davey et al. 2006). Trends in precipitation and temperature influence how an ecosystem and its organisms function. The quantity and timing of rainfall and snow can affect the productivity and health of forests (Nakawatase and Peterson 2006), the amount of water flowing in streams (Hamlet et al. 2007) or inundating wetlands. Likewise, temperature can influence many aspects of ecosystems, such as the quantity and timing of plant growth in forests and prairies (Cayan et al. 2001). Through direct and indirect methods, climate affects the behavior and reproduction of terrestrial and aquatic animal species (Crozier et al. 2008), such as the distribution and migratory behavior of bird communities (Marra et al. 2005) or the thermal stress experienced by intertidal organisms along areas of rocky coastline (Tomanek and Helmuth 2002). Disturbance events such as forest fires, windstorms, and floods are strongly related to climate (Littell and Gwozdz 2011). These events have a major impact on park landscapes and their associated ecosystems.

Given the importance of climate, it has been identified as a primary vital sign by all 32 Inventory and Monitoring (I&M) networks within the National Park Service (Gray 2008). The NCCN monitors climate in order to: understand variations in other park resources being monitored, compare current and historic data to understand long-term trends, and provide data for modeling impacts to park facilities and resources in the future (Lofgren et al. 2010). Climate data derived from the NCCN climate network will play an important role in understanding and interpreting the physical and ecological Vital Signs monitored within NCCN parks.

The NCCN climate monitoring program capitalizes on weather stations operated by partnering agencies. The NCCN climate monitoring program compiles data from over 60 weather stations in and adjacent to the parks, 15 of which are operated by the National Park Service. Although a wide variety of climate parameters are measured as part of the NCCN climate program, this report focuses on two key parameters: precipitation and air temperature.

The report summarizes climate data collected at four weather stations located in and adjacent to Ebey's Landing National Historical Reserve and San Juan Island National Historical Park during the 2010 water year, and is part of a set of climate summary reports from seven national and historical parks in the NCCN (see Figure 1). Annual climate summary reports are intended to provide basic data sets and data summaries in a timely manner, with minimal interpretation and analyses. National Park staff, especially park managers, scientists, and interpreters, partners, and interested public are the primary audience.

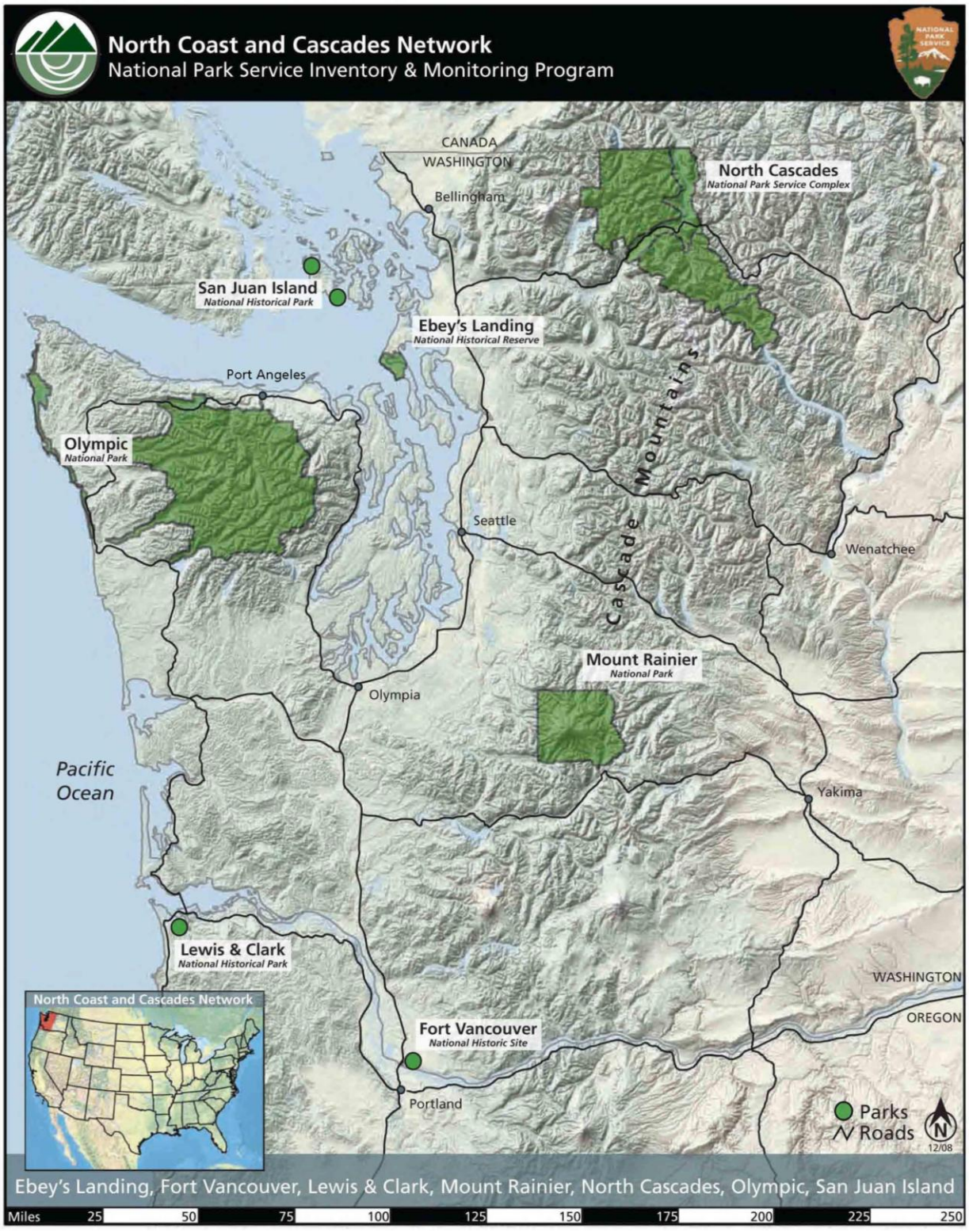

Figure 1. North Coast and Cascades Network National Parks (NCCN).

Methods

Station Locations

This report incorporates data collected from weather stations operated by the NPS, the Federal Aviation Administration and the National Weather Service (Table 1).

Table 1. Weather stations referenced in this report.

Station Name	Station Type	Location	Elevation (ft)	Forest Zone	Period of Record
Coupeville 1S	COOP	Whidbey Island	50	Lowland Prairie	1895 to Present
English Camp	NPS	San Juan Island	60	Lowland Forest	2008 to Present
Friday Harbor	ASOS	San Juan Island	108	Lowland Prairie	1999 to Present
Olga 2 SE	COOP	Orcas Island	80	Lowland Forest	1891 to Present

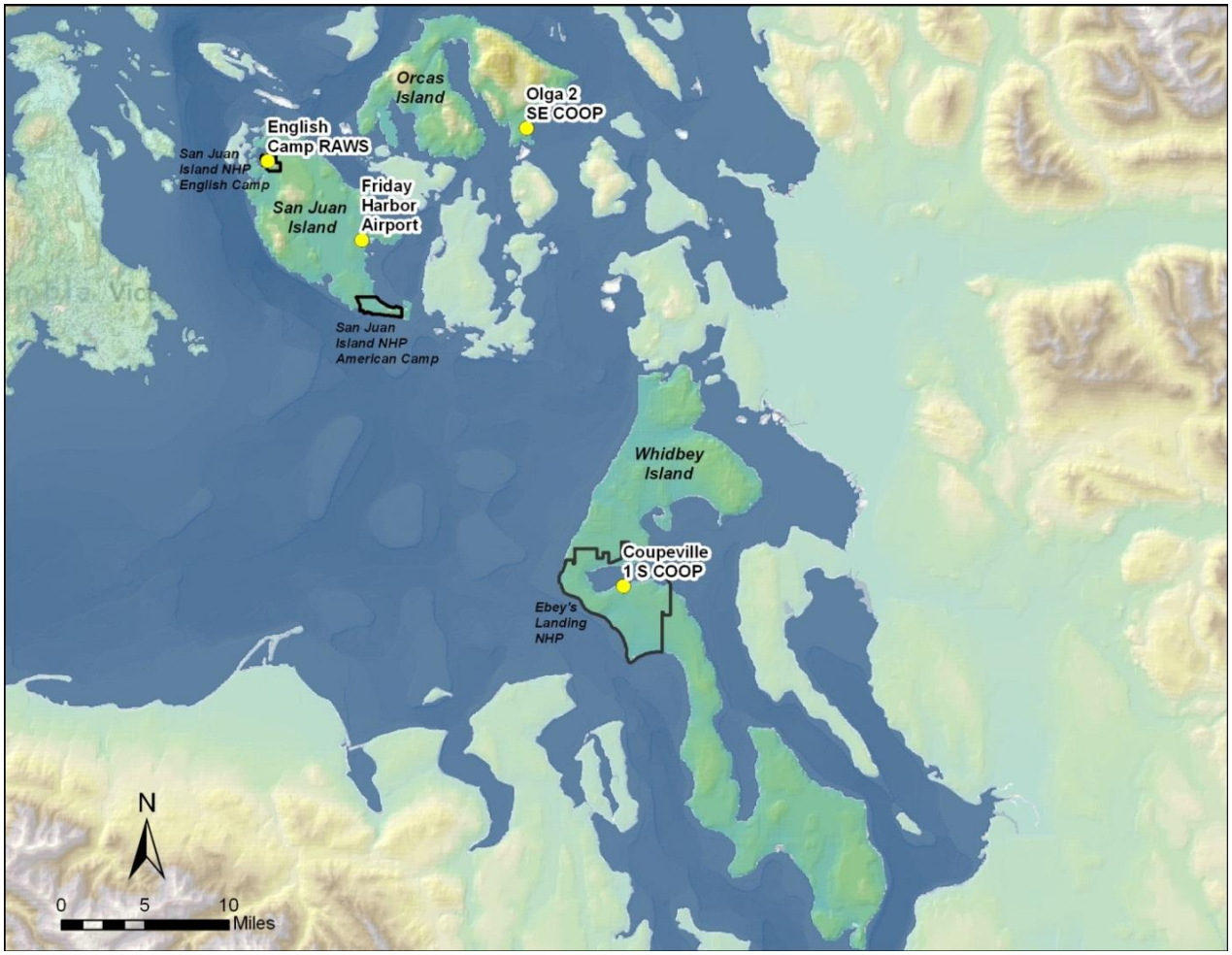

Figure 2. Location of weather stations referenced in this report.

Weather Station Measurements

Weather stations within the NCCN are managed by a variety of different agencies, each with a specific purpose. For this reason, instrumentation, method and period of collection may vary between sites. Table 2 describes the parameters measured at each station, highlights the data which are presented in this report, and indicates which data are available by request from the NCCN.

Table 2. Parameters measured at weather stations included in this report. **X** indicates the parameter is measured and data are presented in this report; X indicates parameter is measured and data are available on request.

Station Name	Managing Agency-Station Type	Air Temp	Rh	Precipitation	Snow fall	Sky Condition	Solar Radiation	Wind Speed & Direction	Fuel Temperature	Fuel Moisture
Coupeville 1S	NWS COOP[1]	**X**		**X**	**X**					
English Camp RAWS	NPS[2]	**X**	X	**X**			X	X	X	X
Friday Harbor Airport	ASOS[3]	**X**	X	**X**	X	X		X		
Olga 2 SE	NWS COOP[1]	**X**		**X**	**X**					

[1] National Weather Service Cooperative Stations (NWS COOP) stations rely on a standard array of manually operated weather instruments. Parameters are measured and recorded daily.

[2] National Park Service (NPS) stations utilize a standard array of automated weather instruments which are measured at 5 minute intervals and output as hourly averages.

[3] ASOS utilize a standard array of automated weather instruments in support of weather forecasting and aviation operations. Parameters are measured every 60 seconds, and output as hourly averages. These stations are managed and operated by the Federal Aviation Administration, National Weather Service and United States Department of Defense.

Data Quality

Data were compromised at English Camp, SAJH station when the tipping bucket rain gage malfunctioned on September 26, 2010. Consequently, five days of data for Water Year 2010 were lost. For the purposes of providing annual and monthly totals in this report, data from the lost days were replaced with data from the Friday Harbor Airport.

Precipitation data from the Coupeville COOP weather station during the month of March appeared suspect when compared to other stations referenced in this report. Weather stations on San Juan and Orcas Island, which normally correlate well with Coupeville, reported significantly more rainfall during the month of March (2.8, 2.5 and 2.3 inches, compared to 1.4 inches at Coupeville) (Table 5). When daily precipitation data were compared between sites, Coupeville indicated five days in March with no precipitation while other sites received significant rainfall. Precipitation in this area is highly variable, however not usually to this degree. These data are

provided by the National Weather Service and are derived from volunteer observations. In climate summaries, these precipitation data were used as reported.

Data Management

The NWS COOP station and ASOS station data used in this report are acquired directly from the managing agencies. Quality assurance and control is provided by these agencies and is described in the NCCN Climate Monitoring Protocol (Lofgren et al. 2010).

The daily data used in this report from the English Camp RAWS station are derived from hourly data which have been evaluated through automated queries and manual display and graphing. Hourly data flagged or identified as suspect are omitted from daily summaries. If more than two hours of data are missing on a given day, no daily values are presented.

Monthly values are generated and presented for stations where five or fewer daily values are missing. In the case of missing precipitation values, daily quantities may be substituted from another nearby weather station for the purposes of reporting monthly and annual totals. This will only occur when nearby data are available and a known correlation exists between these sites. In these cases where estimates are generated from nearby stations, data are footnoted and a description of the quantity and source of data replacement is given.

Data Reporting

Data in this report are based on the hydrologic or water year and organized by month and seasons. Ecosystems in the Pacific Northwest are dominated by two distinct hydrological periods, a wet season generally beginning in late October and ending in June, and a drought season which extends from July to September. While a calendar year divides the wet winter season, the use of a water year (October 1 to September 30) closely reflects the timing and seasonality of many physical and ecological processes that are driven by climate, such as soil saturation, forest evapotranspiration, emergence and flowering of plants, and the migratory timing of bird species.

Seasons in this report are distinguished based on National Weather Service standards for the Northern Hemisphere which defines December, January, and February as winter; March, April, and May as spring; June, July, and August as summer; and September, October, and November as fall.

This report provides monthly averages of daily average temperatures and monthly total precipitation for four stations listed in Table 2. The data are presented in Fahrenheit and inches to easily facilitate use and interpretation by the public and park staff. Two stations with long term records, the Olga COOP on Orcas Island and the Coupeville COOP in Ebey's Landing, are compared to the 30-year climate normal.

More detailed daily data are presented for three sites: 1) the park-operated weather station at English Camp on the west side of San Juan Island, 2) Friday Harbor ASOS, located near American Camp on the east side of San Juan Island, and 3) the Coupeville COOP in Ebey's Landing. Daily data include precipitation, temperature, and growing degree days, which is a measure of accumulated heat commonly used to predict plant development rates.

Results

Temperature

Mean annual temperatures were well above normal at weather stations within or adjacent to EBLA and SAJH. Coupeville, at 50.2°F, was 1.3° above normal, and Olga, at 49.5°F, was 1.4° above normal for the 2010 water year (Table 3). This deviation was driven in a large part by an unusually warm late winter and early spring.

Following a colder than normal December (departures of -2.3° and -3.9°F at Coupeville and Olga, respectively), warmer than normal temperatures dominated for the remainder of winter and the early spring (Figures 3 and 4). January had the highest observed deviation with departures of +5.6° and +6.2°F at Coupeville and Olga, respectively. The months of January through March averaged 4.0° above normal at both stations.

Temperatures during late spring and early summer months on the islands contrasted greatly to those from other parks in the NCCN. Whereas mainland parks experienced large negative departures, such as -2.4°F at Marblemount, (Larrabee et al. 2012) and -3.1°F at Elwha Ranger Station (Baccus et al. 2012), the islands experienced slightly above normal temperatures (+0.3°F) at both Coupeville and Olga (Figures 3 and 4). Late summer and early fall months continued with above normal temperatures, with the exception of August at Coupeville where mean monthly temperature was normal. This is consistent with many nearby sites which were affected by a persistent marine layer during August.

During a prolonged cold period in early December, notably low daily temperatures were recorded. Coupeville recorded an absolute low of 18.0°F on December 8. On the same day, English Camp recorded a low of 22.7°F (Table 4).

Table 3. Average monthly air temperatures (°F) from weather stations within or adjacent to EBLA and SAJH in Water Year 2010.

Season	Month & Year	Coupeville	English Camp	Friday Harbor	Olga
Fall	October 2009	51.4	49.9	50.6	49.6
	November 2009	45.9	45.4	46.2	45.4
Winter	December 2009	37.8	37.3	38.3	35.9
	January 2010	45.7	45.3	45.8	45.4
	February 2010	46.3	44.9	46.0	46.0
Spring	March 2010	47.3	44.8	45.8	46.0
	April 2010	50.0	48.0	48.8	49.0
	May 2010	53.4	51.4	51.2	52.5
Summer	June 2010	57.8	56.5	56.3	57.3
	July 2010	62.4	60.8	59.3	62.2
	August 2010	61.6	60.3	60.0	61.9
Fall	September 2010	58.2	54.0	57.2	59.5
Water Year		51.5	49.9	50.5	50.9
Normal (1971 to 2000)		50.2	-----	-----	49.5

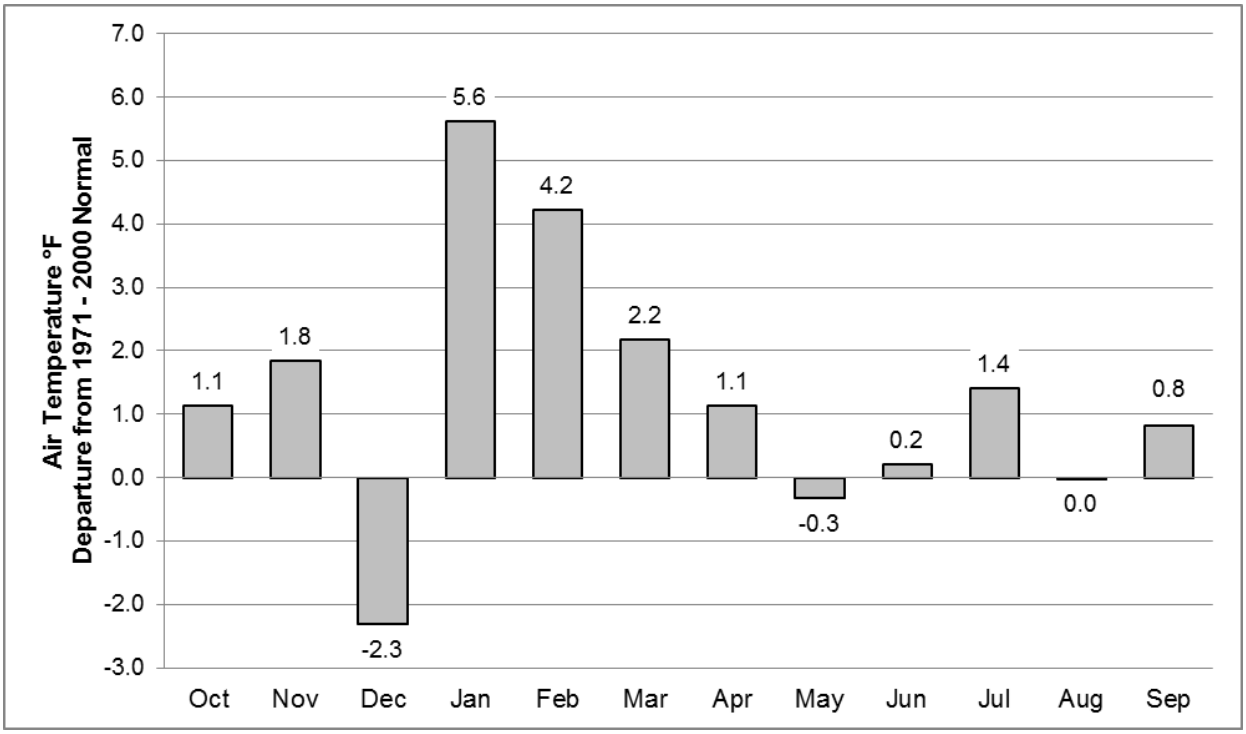

Figure 3. Comparison of average monthly temperature (°F) for Coupeville, WA COOP (EBLA) in Water Year 2010 against monthly averages for the climatological normal 1971-2000.

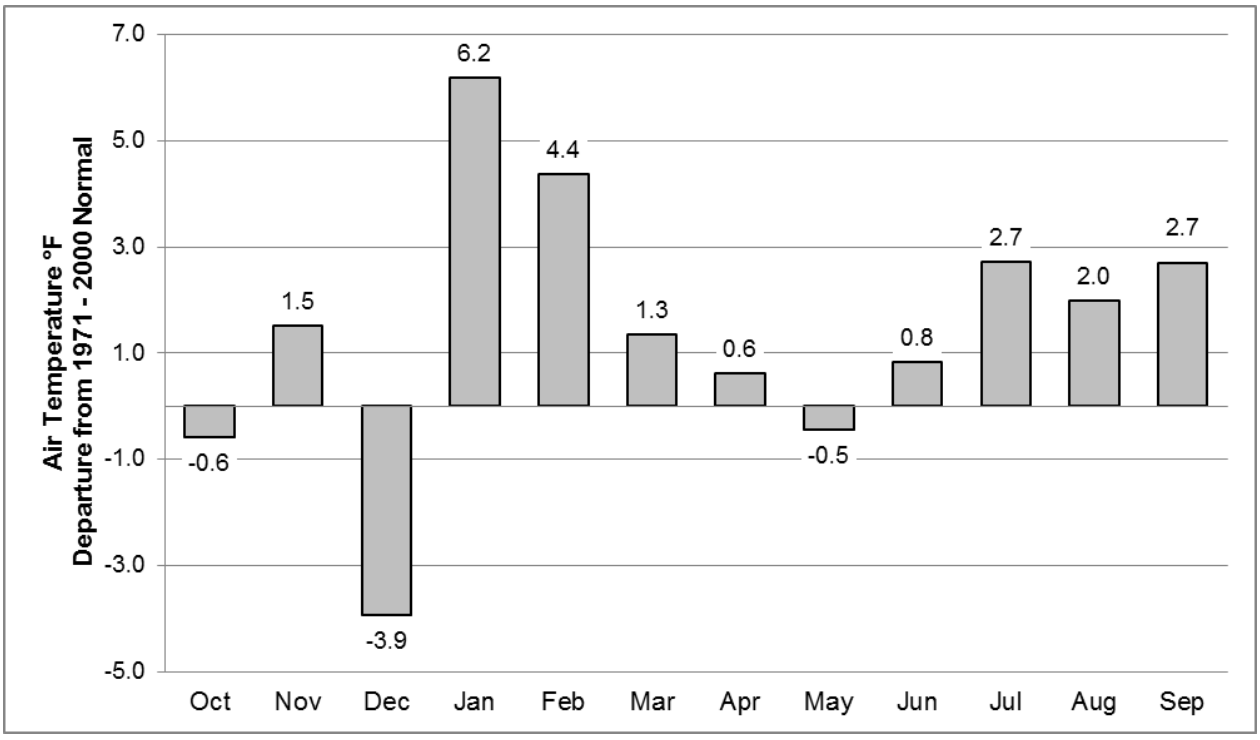

Figure 4. Comparison of average monthly temperature (°F) for Olga, WA COOP (Orcas Island) in Water Year 2010 against monthly averages for the climatological normal 1971-2000.

Table 4. Maximum and minimum daily temperature for each month from weather stations within or adjacent to EBLA and SAJH in Water Year 2010.

Season		Coupeville COOP Ebey's Landing		English Camp San Juan Island		Friday Harbor San Juan Island	
		Max Daily Air Temp °F	Min Daily Air Temp °F	Max Daily Air Temp °F	Min Daily Air Temp °F	Max Daily Air Temp °F	Min Daily Air Temp °F
Fall	October 2009	66.0	34.0	64.7	32.2	64.4	32.0
	November 2009	57.0	35.0	54.9	33.5	55.4	33.8
Winter	December 2009	55.0	18.0	50.7	22.7	51.8	19.4
	January 2010	57.0	34.0	59.3	32.3	57.2	32.0
	February 2010	58.0	31.0	54.7	32.4	55.4	30.2
Spring	March 2010	62.0	30.0	57.8	29.3	60.8	28.4
	April 2010	70.0	32.0	67.3	32.9	66.2	33.8
	May 2010	71.0	39.0	68.9	35.7	66.2	35.6
Summer	June 2010	73.0	45.0	74.0	43.2	71.6	42.8
	July 2010	90.0	47.0	90.3	46.7	89.6	44.6
	August 2010	92.0	46.0	91.0	43.1	91.4	44.6
Fall	September 2010	71.0	44.0	77.3	42.6	71.6	44.6
Water Year Max and Min		92.0	18.0	91.0	22.7	91.4	19.4

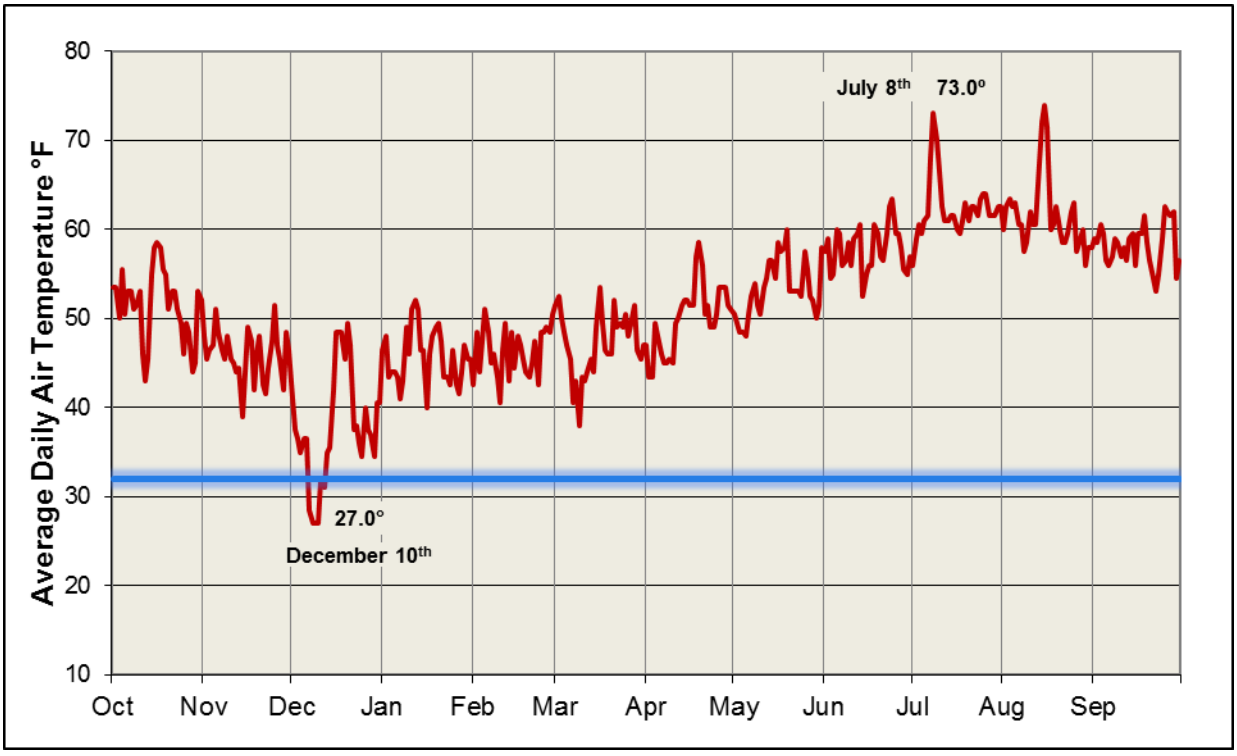

Figure 5. Daily average air temperature (°F) at Coupeville, WA, Water Year 2010.

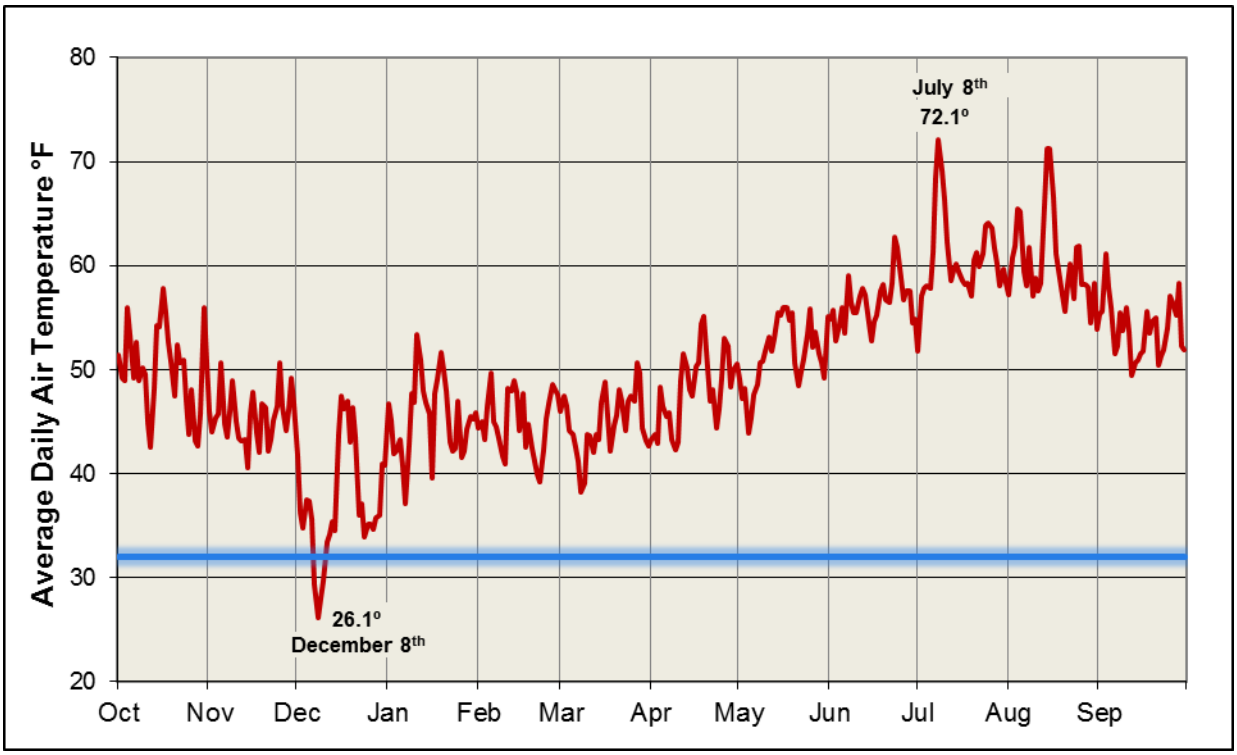

Figure 6. Daily average air temperature (°F) at English Camp, WA, Water Year 2010.

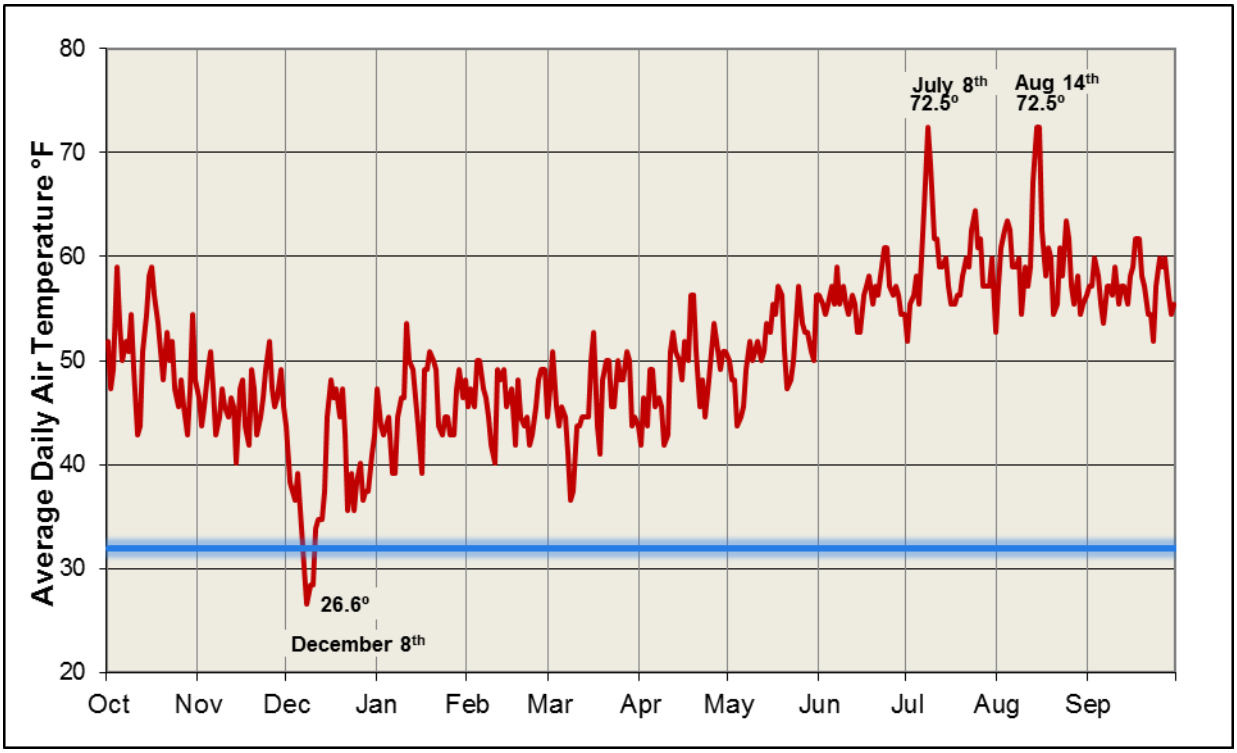

Figure 7. Daily average air temperature (°F) at Friday Harbor, WA, Water Year 2010.

Growing Degree Days

Growing degrees days (GDD) are a measure of heat accumulation, derived from the cumulative sum of daily air temperatures over a specified time period. GDD is commonly used to understand rates of plant growth and the timing of plant and animal life cycles. Spring and early summer of 2010 exhibited the highest amount of heat units available for plant growth in the last four years. The year 2010 especially stands out when compared to the previous two years (2008 and 2009), which exhibited unusually cool spring growing conditions (Figure 8).

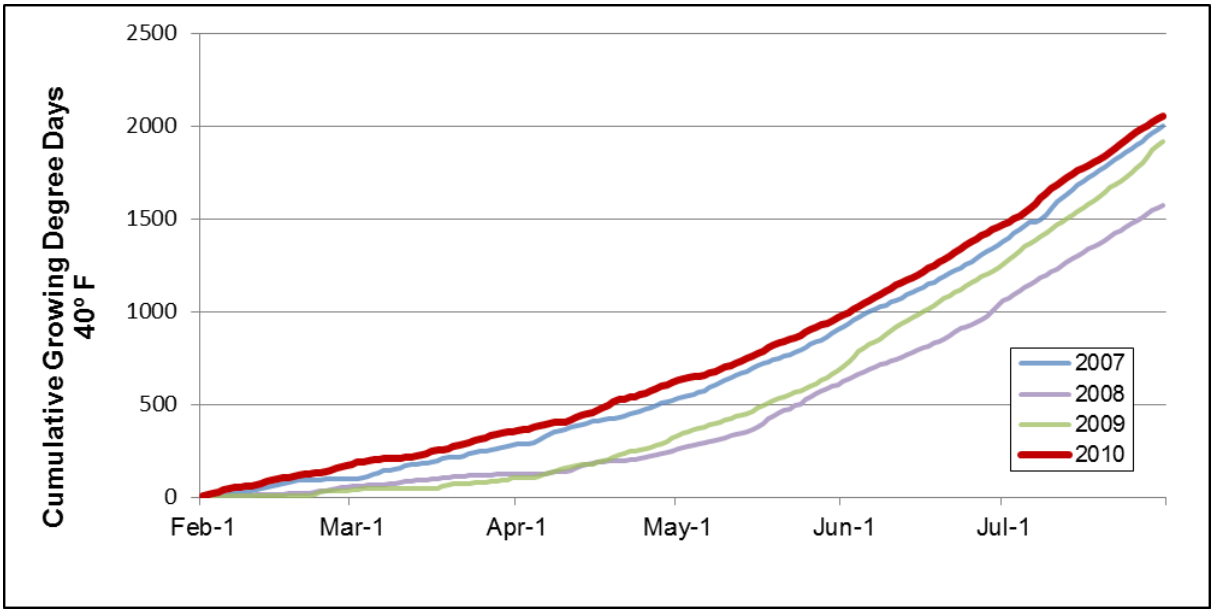

Figure 8. Cumulative Growing Degree Days (40°F) from February 1 to July 31, at Friday Harbor, WA, Water Year 2010.

Precipitation

Annual precipitation in Water Year 2010 was above normal at weather stations within or adjacent to EBLA and SAJH. Coupeville received 24.8 inches, 116 percent of normal. Olga station on Orcas Island, a site further north and east of EBLA and SAJH, received 33.7 inches, 120 percent of normal (Table 5). Total precipitation is typically higher at Olga than SAJH or EBLA because it is farther from the rainshadow of the Olympic Mountains (Figures 2, 11 and 12).

The late fall months, especially October, were wetter than normal. At Coupeville, the month of October received 237 percent of normal rainfall, while Olga received 215 percent (Figures 9 and 10). November deviations were less, at 117 and 127 percent greater than normal, respectively. This contrasted with many other areas of western Washington, where November was one of the wettest months on record. Winter months were much drier than normal (73% of normal at both Coupeville and Olga). Wet conditions returned in the spring, with Coupeville averaging 127 percent of normal and Olga averaging 139 percent of normal for the period of March through May (Figures 9 and 10).

Late summer was quite dry, especially the month of July, receiving only 0.1 inch of rain at most stations on the first of the month. This was followed by 36 days without rain (Figures 13 and 14).

September was much wetter than normal, receiving 2.7 and 4.1 inches of rain (216% and 307% of normal) at Coupeville and Olga, respectively.

The wettest day of the year occurred on October 17, 2009, with Coupeville receiving 1.63 inches and English Camp receiving 1.45 inches.

Table 5. Total monthly precipitation (inches) from weather stations within or adjacent to SAJH and EBLA in Water Year 2010.

Season	Month & Year	Coupeville	English Camp	Friday Harbor	Olga
Fall	October 2009	4.0	4.1	4.1	5.2
	November 2009	3.4	6.6	4.8	5.6
	December 2009	1.3	2.0	1.1	2.0
Winter	January 2010	2.7	4.0	3.2	4.2
	February 2010	1.2	1.1	0.9	1.7
	March 2010	1.4[a]	2.5	2.3	2.8
Spring	April 2010	2.3	1.0	1.6	2.3
	May 2010	3.1	1.8	1.7	3.0
	June 2010	1.9	0.9	1.0	1.5
Summer	July 2010	0.1	0.1	0.3	0.1
	August 2010	0.8	1.0	1.1	1.2
Fall	September 2010	2.7	3.2[b]	2.9	4.1
Water Year		24.8	28.2[b]	24.8	33.7
Normal (1971 to 2000)		21.4	----	----	28.2

[a] Monthly total for Coupeville in the month of March is suspect due to poor correlation (both monthly and daily) with adjacent weather stations.

[b] Precipitation data are missing for five days from September 26th to September 30th, 2010. Daily data was substituted from Friday Harbor ASOS station to derive monthly and yearly totals.

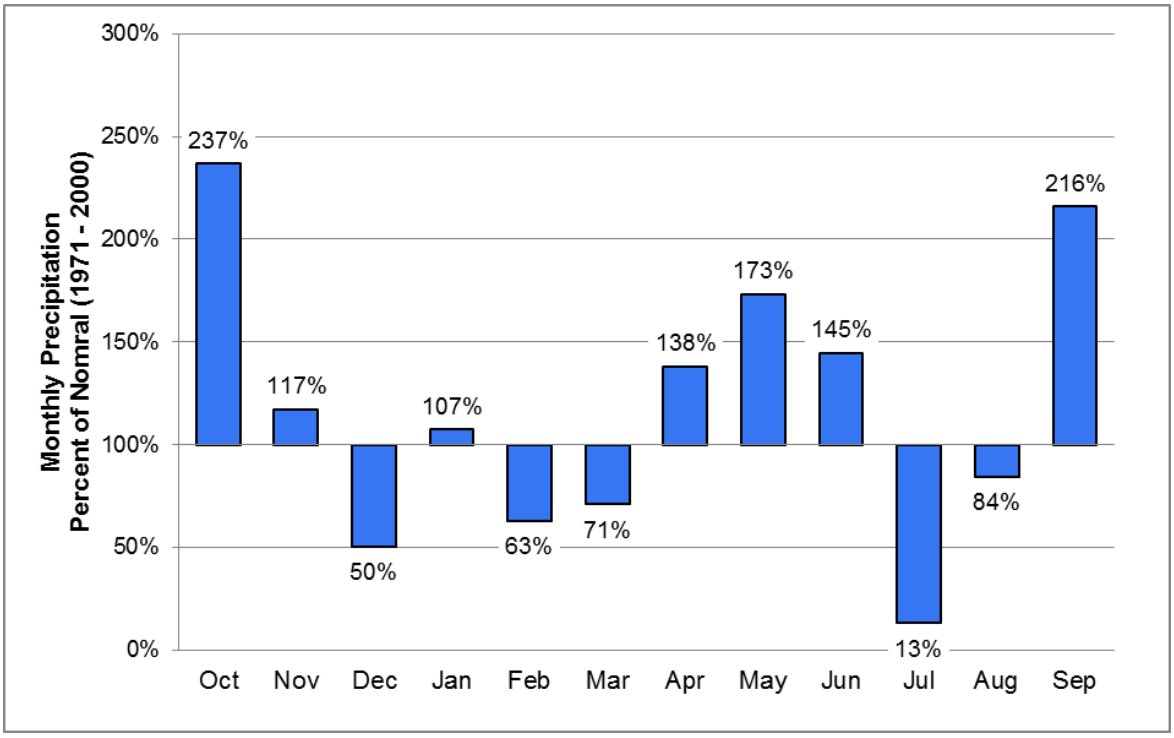

Figure 9. Comparison of total monthly precipitation (inches) at Coupeville, WA COOP in Water Year 2010 against the climatological normal 1971-2000.

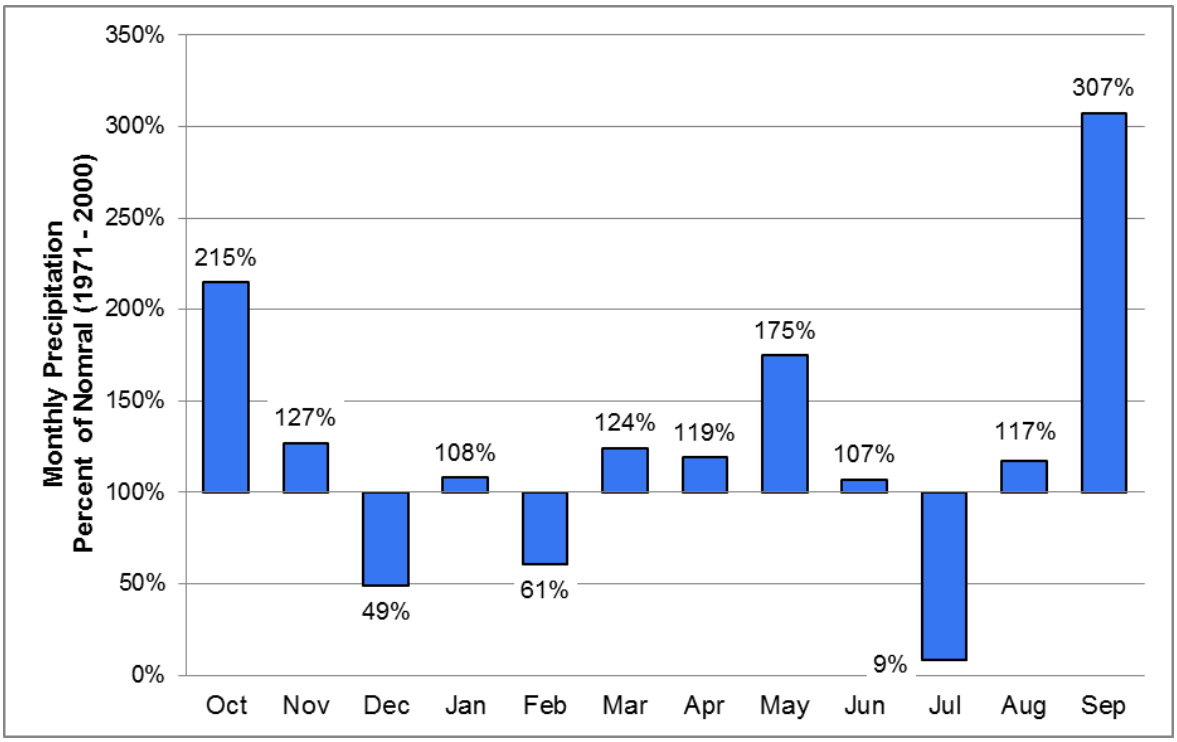

Figure 10. Comparison of total monthly precipitation (inches) at the Olga, WA COOP in Water Year 2010 against the climatological normal 1971-2000.

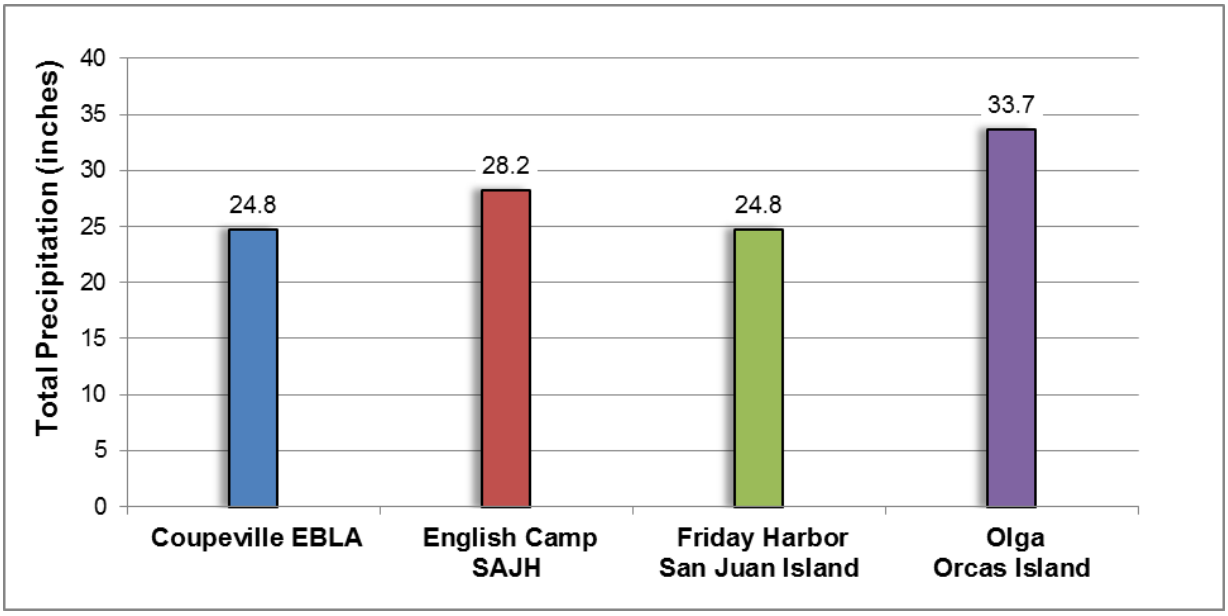

Figure 11. Total precipitation (inches) recorded at weather stations within or adjacent to SAJH and EBLA in Water Year 2010.

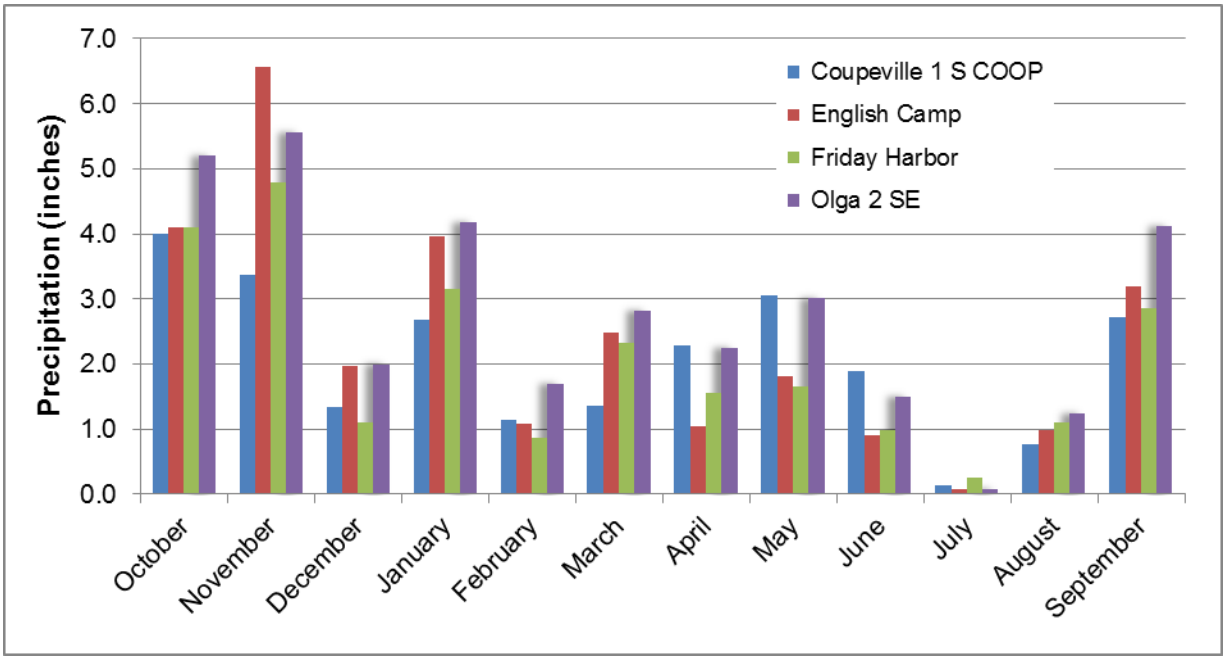

Figure 12. Comparison of monthly precipitation values for four stations within or adjacent to SAJH and EBLA in Water Year 2010.

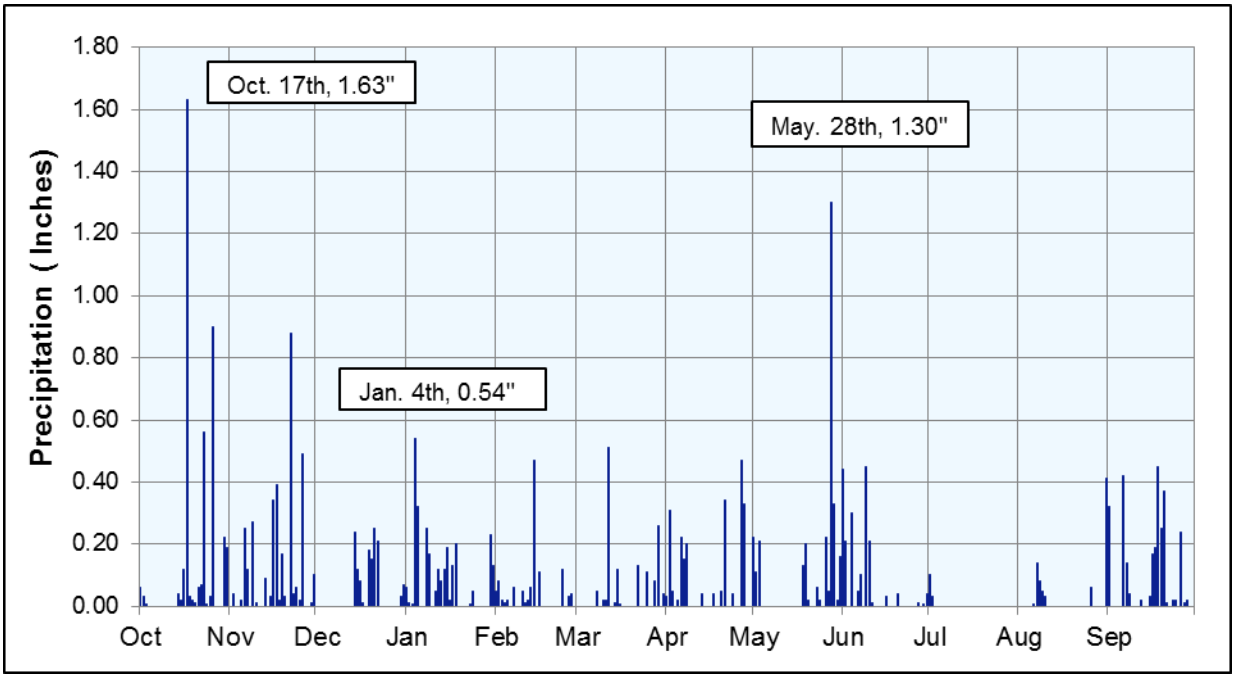

Figure 13. Daily precipitation (inches) at Coupeville, WA, Water Year 2010.

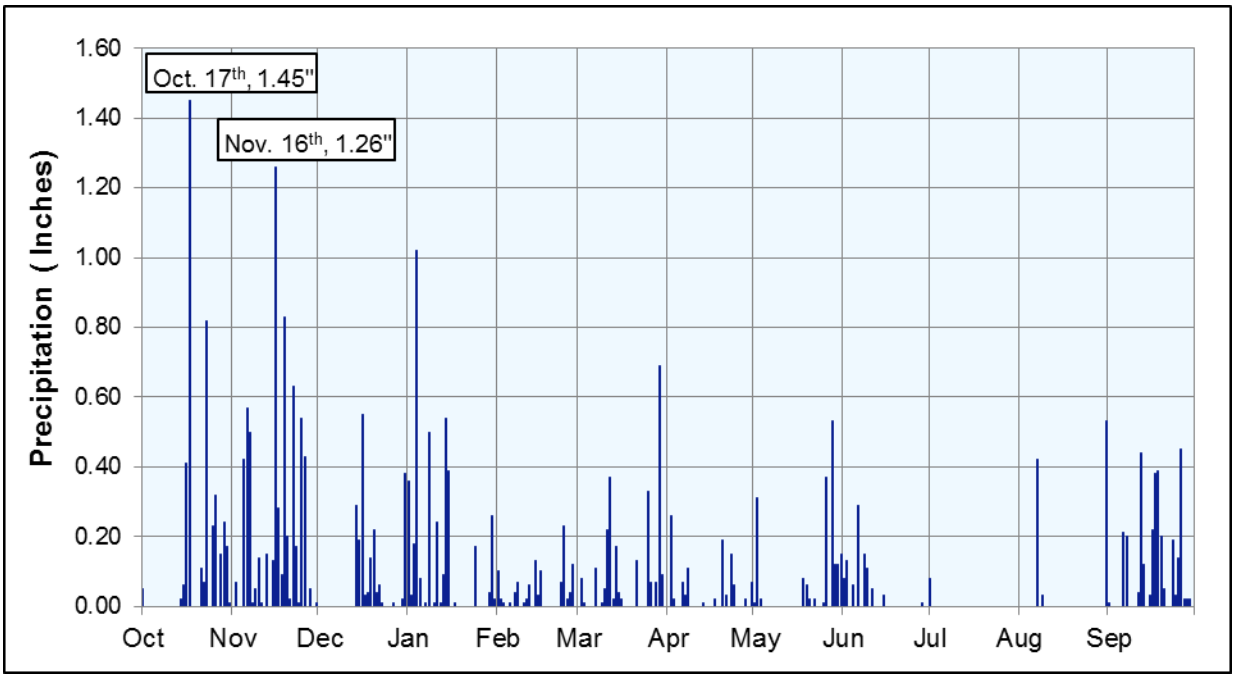

Figure 14. Daily precipitation (inches) at English Camp, WA (SAJH), Water Year 2010.

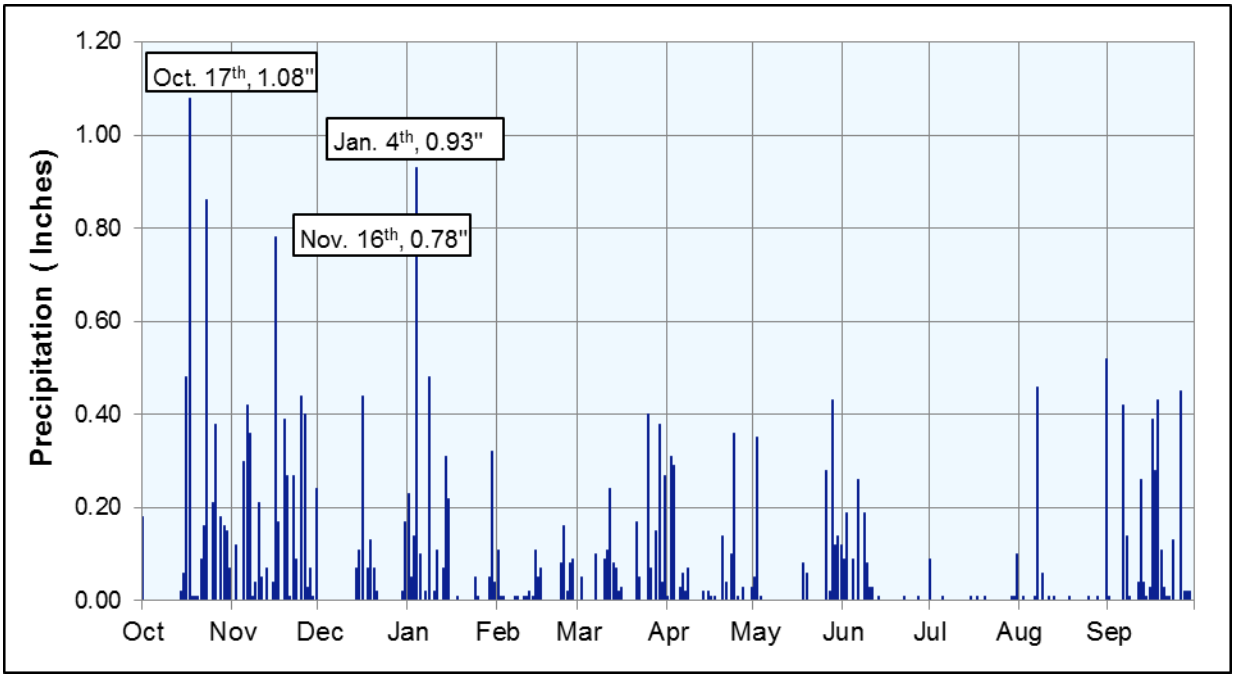

Figure 15. Daily precipitation (inches) at Friday Harbor, WA, Water Year 2010.

Literature Cited

Baccus, W. D., M. Larrabee, R. Lofgren, and M. Huff. 2012. North Coast and Cascades Network climate monitoring report: Olympic National Park; water year 2010. Natural Resource Data Series NPS/NCCN/NRDS—2012/262. National Park Service, Fort Collins, Colorado.

Cayan, D. R., S. A. Kammerdiener, M. D. Dettinger, J. M. Caprio and D. H. Peterson. 2001. Changes in the onset of spring in the western United States. Bulletin of the American Meteorological Society 82(3):399-415.

Crozier, L. G., A. P. Hendry, P. W. Lawson, T. P. Quinn, N. J. Mantua, J. Battin, R. G. Shaw, and R. B. Huey. 2008. Potential responses to climate change in organisms with complex life histories: Evolution and plasticity in Pacific salmon. Evolutionary Applications 1(2):252–270.

Davey, C. A., K. T. Redmond, and D. B. Simeral. 2006. Weather and climate inventory National Park Service North Coast and Cascades Network. Natural Resource Technical Report NPS/NCCN/NRTR—2006/010. National Park Service, Fort Collins, Colorado. Available online: https://irma.nps.gov/App/Reference/DownloadDigitalFile?code=429033&file=2006_10_23_nccninventory_final.pdf (accessed 14 March 2012).

Gray, S. 2008. Framework for linking climate, resource inventories and ecosystem monitoring. Natural Resource Technical Report NPS/GRYN/NRTR-2008/110. National Park Service, Fort Collins, Colorado.

Hamlet, A. F., P. W. Mote, M. P. Clark, and D. P. Lettenmaier. 2007. 20th century trends in runoff, evapotranspiration, and soil moisture in the Western U.S. Journal of Climate 20(8):1468-1486.

Johnstone, J. 2011. A review of a 'San Francisco Summer' for the Pacific Northwest. Presentation at the Pacific Northwest Weather Workshop, 2011. Available online: http://www.wrh.noaa.gov/sew/2011pnwww/Johnstone.pdf (accessed 24 October 2011).

Larrabee, M. A., B. Baccus, R. Lofgren, and M. Huff. 2011. North Coast and Cascades Network climate monitoring report: North Cascades National Park Complex; water year 2010. Natural Resource Data Series NPS/NCCN/NRDS—2012/261. National Park Service, Fort Collins, Colorado.

Littell, J. S., and R. Gwozdz. 2011. Climatic water balance and regional fire years in the Pacific Northwest, USA: Linking regional climate and fire at landscape scales. Chapter 5, pp. 117-139 *in* McKenzie, D., C.M. Miller, and D.A. Falk (eds.), The Landscape Ecology of Fire, Ecological Studies 213, Springer, Dordrecht, The Netherlands.

Lofgren, R., B. Samora, B. Baccus, and B. Christoe. 2010. Climate monitoring protocol for the North Coast and Cascades Network (Mount Rainier National Park, Olympic National Park, North Cascades National Park, Lewis and Clark National Historical Park, Ebey's Landing

National Historical Reserve, San Juan Islands National Historical Park, Fort Vancouver National Historic Site): volume 1. narrative and appendices, version 5/26/2010. Natural Resource Report NPS/NCCN/NRR—2010/240. National Park Service, Fort Collins, Colorado.

Mantua, N. 2010. The Pacific Decadal Oscillation. The Joint Institute for the Study of the Atmosphere and Oceans, University of Washington. Available at: http://www.atmos.washington.edu/~mantua/REPORTS/PDO/PDO_egec.htm (accessed 2 November 2011).

Marra, P. P., C. Francis, R. Mulvihill, and F. Moore. 2005. The influence of climate on the timing and rate of spring bird migration. Oecologia 142(2):307-15.

Nakawatase, J. M, and D. L. Peterson. 2006. Spatial variability in forest growth – climate relationships in the Olympic Mountains, Washington. Canadian Journal of Forest Resources 36:77–91.

National Weather Service Glossary. National Oceanic and Atmospheric Administration. Website http://weather.gov/glossary/ (accessed 30 March 2011).

Redmond, K. 1998. El Niño, La Nina, and the Western U.S., Alaska and Hawaii: Frequently Asked Questions. Western Regional Climate Center, Desert Research Institute. Available at: http://www.wrcc.dri.edu/enso/ensofaq.html (accessed 30 March 2011).

Tomanek, L., and B. Helmuth. 2002. Physiological ecology of rocky intertidal organisms: A synergy of concepts. Integrative and Comparative Biology 42(4):771-775.