Plant phenology research and monitoring pilot project at Milner Gardens & Woodland

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ABSTRACT: Global climate is changing and its impacts can be seen throughout Vancouver Island. This research studies the relationships between climate and coastal plant phenological development in order to build our understanding of how individual species and ecosystems on Vancouver Island are currently responding to climate. In 2016, a pilot project was initiated at Milner Gardens & Woodland in the Mount Arrowsmith Biosphere Region to establish field data collection and management protocols contributing to plant phenology research and monitoring on southeastern Vancouver Island. Data collection methods included both in-person and field camera observations of phenophases throughout the growing season. Data management tasks included the development of a photo observation database and contribution to an international online phenology observation network. Over time, we expect that the data collected will illustrate shifts in the timing of both the growing season and plant development phases on southeastern Vancouver Island, as well as shifts in climatic trends in the study area. Increased understanding of species and ecosystem shifts will contribute to land management and ecosystem conservation in the future.

Keywords: phenology; climate change; conservation

INTRODUCTION

Studying plant phenology, the timing of cyclic biological changes, and the relationships between climate and phenological development builds our understanding of how individual species and ecosystems respond to climate. Climate, photoperiod, and other seasonal changes trigger the initiation of species' phenophases, but they are also controlled by each species' sensitivity to environmental factors (Ide & Oguma, 2010). Numerous studies have shown that increasing global temperature is advancing the overall initiation of spring phenophases and delaying autumn

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phenophases (Cleland et al., 2007). Large spatial scale green-up and senescence patterns can be demonstrated using satellite imagery and correlated with homogenous climate averages; however, remote sensing can only represent the phenology of vegetation communities (Studer et al., 2007).

This study was initiated to evaluate the vulnerability of plant species and ecosystems on Vancouver Island to climate change. It aims to fill the site-level knowledge gap to assist site and stand level management planning. Additionally, it is understood that mid-latitude, highly seasonal, temperate regions like British Columbia have the most potential for "long-term shifts in phenology" due to climate variability (Fitchett et al., 2015). Therefore, conducting phenology research in this area is necessary to better understand the potential effects of climate change on our local ecosystems.

The project was piloted in 2016 to establish field data collection and management protocols contributing to plant phenology research and monitoring on southeastern Vancouver Island. Data collection methods included both in-person observations and field camera observations of various phenophases throughout the growing season (including bud break, leaf, flower, and fruit development, and fall senescence). Data management tasks include the development of a photo observation database and contribution to an international online phenology observation network (USA National Phenology Network, n.d.). Data collection and management protocols were developed and piloted at Milner Gardens & Woodland (Milner G&W) forested sites within the Mount Arrowsmith Biosphere Region.

Staff and volunteers at Milner G&W, staff from the Mount Arrowsmith Biosphere Region Research Institute (MABRRI), and a research ecologist from the Ministry of Forests, Lands, Natural Resource Operations and Rural Development (MFLNRORD) initiated a phenology research and monitoring project strategy combining MFLNRORD research and Milner G&W monitoring goals. Work completed to date at Milner G&W includes the selection of 44 observable native specimens (12 different species in total), which are distributed throughout three forested study sites (Figure 1).

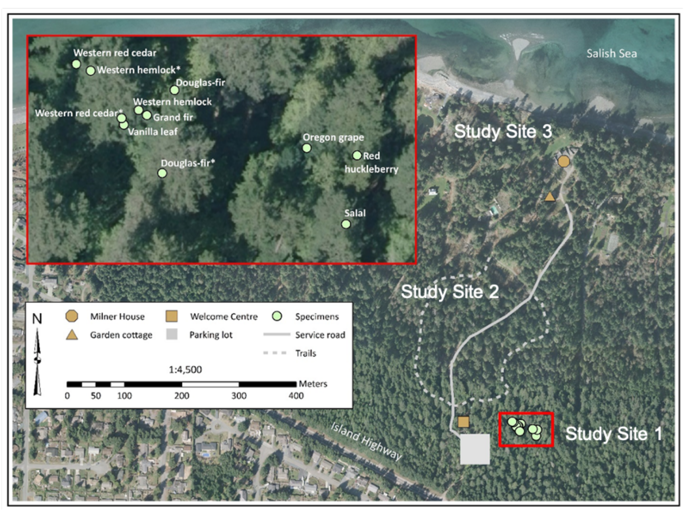

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Figure 1. Study sites at Milner G&W, highlighting specimen distribution at Study Site 1 (inset map).

Milner G&W is located within the Coastal Douglas-fir moist maritime (CDFmm) biogeoclimatic (BEC) subzone (Green & Klinka, 1994). BEC is a hierarchical system that describes sites within a subzone using relative soil moisture and soil nutrients. The three sites at Milner G&W span a range of site conditions: from the zonal site type (i.e., average soil moisture and nutrients for that BEC unit) to the we-rich soil site type. Species at the study sites were chosen to be representative of the CDFmm BEC subzone plant association, as well as of the non-timber forest product values of the site (e.g., wildlife foraging and cultural values). The research team also installed a weather station at the site to collect baseline microclimate data and to research the relationship between forest microclimate and plant phenology.

METHODOLOGY

In-Person Observations

At Milner G&W, in-person observations have been collected since the project was initiated in 2016 by a group of citizen scientists, Vancouver Island University students, and staff of both MABRRI and MFLNRORD. Capturing the exact date of phenophase initiation requires daily observations, but studies have found that fortnightly observation sessions will generate reasonably accurate results (Crimmins & Crimmins, 2008; Morellato et al., 2009). In-person observations are scheduled based on the seasonal magnitude of activity observed; sessions are conducted weekly in spring and summer, fortnightly in autumn, and monthly in winter. Observations are made collaboratively in order to reduce bias and inconsistencies (Benton, 2009). Data collection guides and detailed definitions derived from the National Phenology Network's Nature's Notebook (USA National Phenology Network, n.d.) were created for each phenophase and species, and corresponding photographs were taken as examples of each phenophase identified to guarantee correct identification. Nature's Notebook's in-situ monitoring protocols are standardized across taxonomic groups to facilitate collaborative research by using consistent definitions for phenophase status (Denny et al., 2013). Site specific data collection forms were developed based on Nature's Notebook tablet app and are used to monitor not only the date of initiation of each phenophase, but also the intensity and abundance. Phenophase statuses are tracked individually to allow simultaneous measurement of several stages. Every observation is recorded using either a data collection form or the Nature's Notebook tablet app (USA National Phenology Network, n.d.). All field observations are submitted to Nature's Notebook's open online database.

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Field Camera Observations

Since 2017, the research team has trialed field camera observation techniques at Milner G&W. Field cameras are deployed and directed at each specimen to capture daily phenophase development. The time-lapse field cameras are set to face each specimen at the optimal focal distance (approximately one metre) (Figure 2). They are programmed to capture multiple photos every day during optimal light times, to ensure a backup photo would be available if one was impacted by poor lighting or other quality issues. As opposed to the coarse in-person data collected, the field cameras provide continuous daily phenophase development data throughout the growing season.

Each camera hosts an SD card that stores the series of photos and their accompanying metadata. All data captured during the growing season are entered into a photo data capture database. Student researchers from Vancouver Island University are hired to manually assess each photo and identify all visible phenophases using the same definitions and abundance or intensity measures as are used for the in-person observations. During this process some gaps in the image database might occur due to missing or poor-quality photos on those days. Missing photos can occur if camera batteries die, and poor-quality photos can occur during poor weather (e.g., cloud cover, heavy rain).

To date, we have tested three different camera models. A published study by Xie, Civo, and Silander (2018), recommends using Moultrie Wingscape trail cameras (Moultrie, moultriefeeders.com) and had positive results utilizing these cameras for phenology analysis. Wingscape cameras are designed to take gallery quality photos using time lapse technology for bird enthusiasts, whereas other cameras we have tested, such as Reconyx Hyperfire™ (Reconyx, reconyx.com) and Bushnell Trophy Cam (Bushnell, bushnell.com), designed for wildlife research, primarily to locate game for hunting. Due to their focus on time lapse and high-resolution imagery, we found that Wingscape cameras are better suited for this project.

Figure 2. Wingscape timelapse field camera capturing data on a red huckleberry specimen.

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Microclimate Station

A microclimate station was installed to establish baseline microclimate data at the study site (Figure 3). The Onset HOBO (Onset, onsetcomp.com) station measures ground surface and air temperature, relative humidity, solar radiation, wind speed and direction, and precipitation, in addition to both soil moisture and temperature at 30cm below surface. This will allow us to examine relationships between microclimate and plant phenological development at our study site. Temperature influences the timing of phenophase development (Allstadt et al., 2015; Cleland et al., 2007) while soil moisture functions as a proxy variable for understanding the interaction between land surface and atmospheric conditions and evaluating patterns of climate change (Entin et al., 2000). The dynamics of soil moisture play a dominant role in vegetation stress and suitability of vegetation to climate and soil conditions (Guswa, 2002), though this is not as well linked with phenophase development in current literature. We are exploring air and soil temperature, as well as soil moisture as potential triggers to developmental and reproductive plant phenophases, such as bud break and berry production.

The microclimate data will later be coupled with modelled climate change projections, allowing us to examine potential future impacts to species productivity and ecosystem composition over time.

Figure 3. Microclimate station at the Milner G&W study site.

NEXT STEPS

As a result of the pilot project, the team was able to determine the feasibility and scope of this long-term research project, including evaluation of the utility of field cameras to capture plant phenophase on remote research sites. Staff of MABRRI and MFLNRORD developed a research program to expand the study of microclimate and plant phenology across elevational and latitudinal transects on southeastern Vancouver Island, from the Bowser to Victoria area. After testing both in-person and field camera techniques, we decided to move forward with the field camera observation technique for all subsequent sites. In 2017, we established two more study sites distributed within two BEC subzones: Thetis Lake Regional Park (CDFmm) and Mount

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Arrowsmith Massif Regional Park (Mountain Hemlock moist maritime (MHmm)). In 2020, we were awarded funding from the BC Parks Living Lab for Climate Change and Conservation Program to establish additional zonal sites within the Coastal Western Hemlock very dry maritime (CWHxm) subzone at Bowser Ecological Reserve and Koksilah River Provincial Park. Sites within CWHxm provide us with data between the low elevation (CDFmm) and high elevation (MHmm) study areas, which will allow an analysis of shifts in plant survival and productivity across latitudinal and regional climatic gradients on the east coast of Vancouver Island. Findings from all sites will be integrated to contribute to both site- and landscape- level understandings of baseline plant phenology and microclimate relationships and understanding of potential impacts of climate change to the growth and productivity of species and plant communities.

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