111 Extension Note

March 2014

Enhancing Provincial Climate Monitoring: the Forest Ecosystem Research Network and the Climate Related Monitoring Program

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Introduction

The Research Program within the Ministry of Forests, Lands and Natural Resource Operations (FLNRO) recognizes that environmental monitoring and research is vital to sound natural resource science and management. Many of the research scientists within FLNRO have installed weather stations to support their research, some of which have climate records spanning multiple decades. Recognizing that these climate data are useful to the larger scientific and operational community, FLNRO research joined the Climate Related Monitoring Program (CRMP) in 2009. The CRMP, initiated and led by the Ministry of Environment, was formed to build a strong foundation of climate knowledge to address British Columbia's Climate Action Plan (www.env.gov.bc.ca/cas/programs.html). The CRMP has a mandate to make long-term meteorological data available for climate change analysis and adaptation through an agreement with the Pacific Climate Impacts Consortium. The CRMP provincial climate network consists of weather monitoring conducted by the Ministry of Environment, Ministry of Forests, Lands and Natural Resource Operations, Ministry of Transportation and Infrastructure, Ministry of Agriculture, BC Hydro, and Rio Tinto Alcan. FLNRO researchers are participating by contributing climate data to a Forest Ecosystem Research Network (FERN). This work addresses the goals of the Ministry's Climate Change Strategy (www.for.gov.bc.ca/het/climate/index.htm) through the provision of climate science to aid adapting forest management to a changing climate.

This extension note highlights the role that the Forest Ecosystem Research Network plays in monitoring remote and otherwise unmonitored sites in the province. It describes the network, introduces and explains how FERN interacts with the overarching network organization in the province, and details a few important case studies where FERN data have proven valuable for understanding specific extreme events or detailed features of British Columbia's climate. Finally, the role that FERN plays in understanding climate in the province as a whole is described.

British Columbia

The Forest Ecosystem Research Network

The Forest Ecosystem Research Network (FERN) consists of 83 weather stations operated by FLNRO researchers (Figure 1). Equipment was installed to answer a variety of forest research questions asked by four research subgroups. The hydro-geomorphology group runs an extensive network of weather and climate stations associated primarily with long-term research installations, including Mayson Lake Hydrologic Processes Study (Winkler 2010a), Upper Penticton Creek Research Watershed (Winkler 2010b), West Arm Demonstration Forest (Jordan 2010), Russell Creek Watershed (Floyd 2010, 2011), and climate change and permafrost/slope stability monitoring (Geertsema and Foord 2014). The Biogeoclimatic Ecosystem Classification program (BEC) runs weather stations to classify environments with little to no information, such as alpine ecosystems, and to aid in adapting BEC to climate change (British Columbia Ministry of Forests and Range 2009). Silviculture projects have also used weather stations in the southern interior to help interpret lichen responses in caribou habitat (Stathers et al. 2001; Sagar et al. 2005), microclimate impacts of the mountain pine beetle, and frost monitoring for Douglas-fir regeneration (Sagar and Waterhouse 2010). Weather monitoring is also part of forest health projects looking at microclimate changes and severity of pine foliar diseases. The Research Program is also actively increasing its network of weather stations on Vancouver Island, the Central Coast, and Haida Gwaii to support research for Ecosystem Based Management and worker safety related to wet-weather safety shutdown guidelines and avalanche forecasting. Many of the research weather stations are found in areas under-represented by the operational networks in the province, and consequently provide data to improve understanding of the spatial and temporal variability of weather and climate in British Columbia's complex terrain.

Standard meteorological measurements being made include air temperature, relative humidity, rainfall, wind speed, and wind direction (Figure 2). Many stations also include additional climate parameters such as solar radiation, barometric pressure, snow depth, seasonal precipitation, snow water equivalent, snow temperature, snow free period, snow melt, soil temperature, rock temperature, and leaf wetness (Figures 3 and 4). Intensive monitoring at some study sites allows for the collection of multiple climate variables within short distances providing information on temperature profiles above ground,

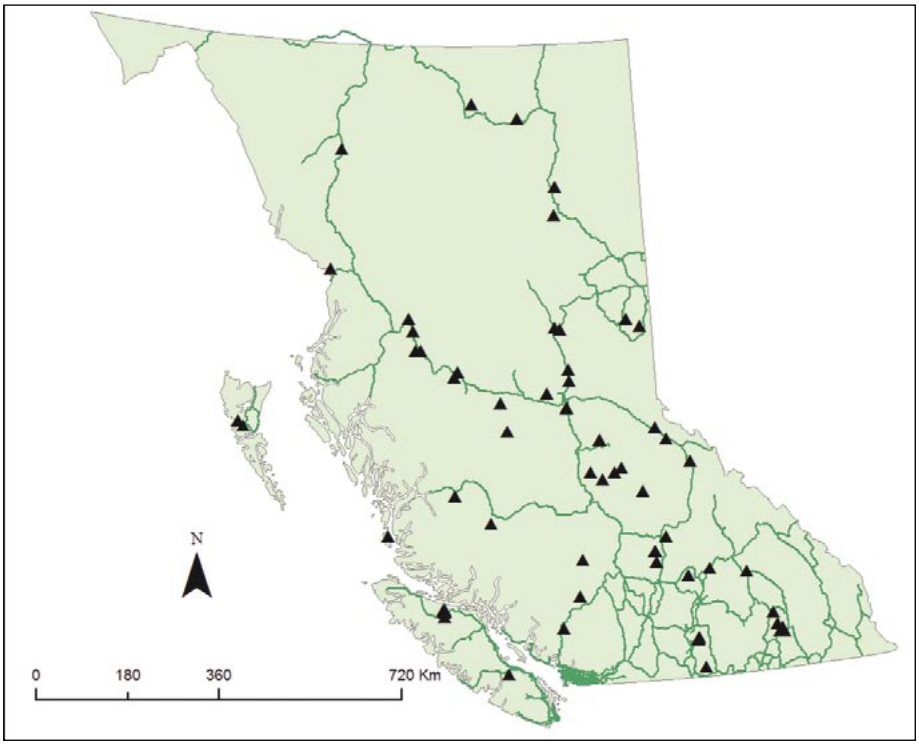

FIGURE 1 *Weather stations of the Forest Ecosystem Research Network (FERN).*

FIGURE 2 *FERN station on Canoe Mountain.*

FIGURE 3 *Snow survey and FERN station at Russell Creek.*

FIGURE 4 *Connecting to a below-ground permafrost monitoring probe.*

frost, cold air drainage, rain/snow boundaries, rainfall interception, and lapse rates for precipitation and temperature. Some research sites include manual snow surveys or the collection of understorey light data from hemispherical photography. These rich data sets are critical to increasing scientific understanding and aid the development of tools for practitioners and decision makers.

Enhancement of Provincial Climate Knowledge

The FERN research stations provide valuable information about provincial climate that is not typically covered by the operational networks in the province. Among their mandates, the operational networks tend to focus on infrastructure (e.g., Ministry of Transportation and Infrastructure), public safety (River Forecast Centre), or power generation (BC Hydro). Middle- and high-elevation climates are under-represented within the operational provincial weather station network. For example, the CRMP network including Environment Canada's British Columbia weather stations represents an average elevation of approximately 660 m. In contrast, the FERN stations' average elevation is 1275 m, and FERN operates 36 stations above 1500 m. There is a lack of climate information in the northern part of the province (>53° N) compared to the south. The CRMP network with Environment Canada's network has 27% of its stations in the north, compared to the FERN stations with 40% of its network in the north. Although the FERN stations are limited in their real-time reporting (five exist currently, with more planned) and length of record for newly installed stations, FLRNO researchers are identifying areas with poor representation to ensure that we have suitable data re-

cords for future users of weather and climate information. These data will become increasingly useful for climate scientists for process model validation, understanding regional climatology, and quantifying extreme events in remote areas, particularly at high elevations.

Extreme weather events are sometimes spatially isolated and difficult to capture. Long-term weather stations and research installations located across the province increases the likelihood of capturing these events. For example, a record precipitation event occurred at Russell Creek watershed in 2011, where up to 160 mm of water (partially from snowmelt) was delivered into the watershed in 24 hours. Nine FERN weather stations, located between 300 and 1500 m, captured the rain-on-snow event, which resulted in three landslides, a nearby highway closure, and extensive channel change within Russell Creek. The high density of weather stations, combined with the 20-year climate record, provided a unique opportunity to fully describe the driving processes behind the event. Data captured from events like this can be used to aid in the design of infrastructure, provide guidance for mitigation measures to ensure that future landslides do not close the highway, and contribute to the scientific understanding of extreme weather.

Some FERN stations are expanding our knowledge of extreme climates in British Columbia. For example, extreme wind gusts of 168 km/h were recorded at a FERN station on Nonda Mountain in the northern Rockies. High wind speeds observed on similar northern alpine sites have changed the perception of what we assumed the climate to be: from estimates of moderate snowpack to predominantly windswept and low snow environments. At Middlefork Creek, a cold air drainage site in northeast British Columbia, the mean annual temperature is below -3° C, and the average number of frost-free days is only 40. Although the instrumental data from the FERN station represent a short period of record, using interpolated data from Climate WNA (v4.72) gives a mean annual temperature of 0.1° C and frost-free days of 138 (Wang et al. 2012).

Many of the research trials associated with FERN stations have multiple temperature measurements within a constrained geographic area. These high-resolution measurements could potentially improve spatially interpolated climate products with detailed information on temperature lapse rates and cold air drainage. Some FERN weather stations have shown that temperature differences can be very dramatic at small spatial scales. For example, at the Middlefork Creek weather station, an extreme cold temperature of -53.6° C was recorded on January 28, 2008. Nearby measurements, upslope 36 m and 1 km to the west, had temperatures 5.3 degrees warmer, and further upslope, 72 m and 0.7 km to the east, temperatures were 14.5 degrees warmer. The FERN sites are also identifying areas with winter inversions; for example, at Nonda Mountain in the northern Rockies where winter temperatures in the alpine are 5–9 degrees warmer than in the forested valley 800 m below.

Some of the FERN stations and associated research installations are describing climate-related processes where currently little information is known for the province; for example, rain on snow in coastal British Columbia and permafrost monitoring in northeastern British Columbia. This latter work consists of four FERN weather stations, and 15 associated air, soil, and snow temperature monitoring stations to determine microclimate effects on areas of isolated permafrost. These measurements also aid assessing impacts of a changing climate on permafrost melt and the risk to slope stability. The monitoring information can also be used for verification of British Columbia's permafrost mapping (www.env.gov.bc.ca/esd/distdata/ecosystems/Permafrost/PermaFrostModel/).

The CRMP and the Provincial Climate Data Set

The Climate Related Monitoring Program has brought together information from a variety of provincial operational weather networks into one agreement and one provincial database. This includes Ministry of Environment Air Quality network and Automated Snow Pillow network, FLNRO Fire Weather network and FERN, Ministry of Transportation and Infrastructure Avalanche and Weather Program, two privately maintained networks supporting the Ministry of Agriculture's Farmwest (www.farmwest.com/) and Waterbucket (http://waterbucket.ca) programs, BC Hydro Hydromet network, and Rio Tinto Alcan's Nechako Reservoir stations. Station information such as name, location, elevation, start date, contact person, and parameters measured are provided in a Google Earth© kml file available on the CRMP website (www.env.gov.bc.ca/epd/wamr/crmp.htm). Through the Agreement on Management of Meteorological Networks in the Province of British Columbia, historical meteorological data from each of these networks, as well as Environment Canada's British Columbia weather stations, are available publicly on the Pacific Climate Impacts Consortium (PCIC) Provincial Climate Data Set portal (www.pacificclimate.org/tools-and-data/pcds-portal). The PCIC data

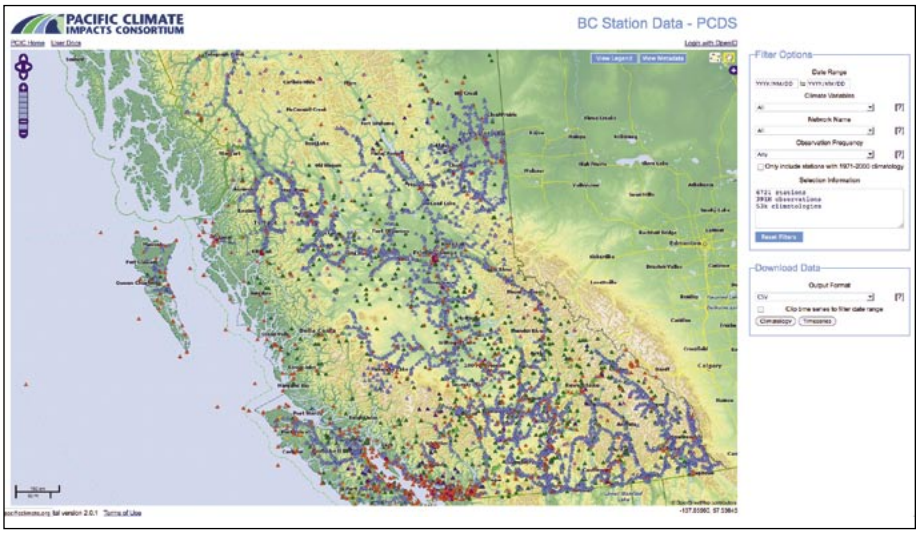

FIGURE 5 *The Provincial Climate Data Set, as provided by PCIC.*

portal allows users to select a specific geographic area to show available weather stations and filter those data based on date range, weather variable, and network type (Figure 5). Climate normals (30-year averages) are also available for download for stations with a long enough period of record, as are basic metadata.

In the past, data from provincial networks, most notably the FLRNO Fire Weather Network, supplemented with information supplied by Environment Canada, were used to produce station and gridded climate normals for the province. The gridded climate normals were developed using PRISM technology (Parameter-elevation Relationships on Independent Slopes Model described in Daly et al. 2008) to create the base data for the high spatial resolution climate prediction tools ClimateBC and Climate WNA (Wang et al. 2012). These tools are extensively used in research studies and operational applications. Bringing data and network information together from different agencies is not a new concept in British Columbia; however, the CRMP formalizes the process and seeks to create a standard for how the data are collected. Data from the participating agencies have been used to produce a variety of climate change summaries for the province.

Through the efforts of government scientists, the CRMP, and PCIC, historical meteorological and climatological data for British Columbia have become readily accessible. This information is contributing to a wide range of research including adaptation and development of predictive tools for management. FLNRO researchers are doing their part to enhance the state of provincial climate knowledge through monitoring efforts and innovative research.

Literature Cited

British Columbia Ministry of Forests and Range. 2009. Biogeoclimatic ecosystem classification and climate change. Forest Science Program, Victoria, B.C. Online at: www.for.gov.bc.ca/hfd/pubs/Docs/Bro/Bro89.htm

Daly, C., M. Halbleib, J.I. Smith, W.P. Gibson, M.K. Doggett, G.H. Taylor, J. Curtis, and P.P. Pasteris. 2008. Physiographically sensitive mapping of climatological temperature and precipitation across the conterminous United States. International Journal of Climatology. DOI: 10.1002/joc.1688.

Floyd, B. 2010. Russell Creek Watershed. Streamline Watershed Management Bulletin, Vol. 14(1). www.forrex.org/sites/default/files/publications/articles/Streamline_Vol14_No1_Art10.pdf

————. 2011. The sensitivity of coastal watersheds to climate change. www.abcfp.ca/publications_forms/BCFORmagazine/documents/BCFORPRO-2011-2_AllArticles/BCFORPRO-2011-2_Floyd.pdf

Geertsema, M. and V.N. Foord. 2014. Landslides in the isolated patches permafrost zone, northeastern British Columbia (NTS mapsheet 94G east half). Third World Landslide Forum, Beijing, China.

Jordan, P. 2010. West Arm Demonstration Forest. Streamline Watershed Management Bulletin, Vol. 14(1). www.forrex.org/sites/default/files/publications/articles/Streamline_Vol14_No1_Art13.pdf

Sagar, R.M. and M.J. Waterhouse. 2010. Microclimate studies in uniform shelterwood systems in the Sub-Boreal Spruce zone of central British Columbia. B.C. Min. For., Res. Br., Victoria, B.C. Technical Report 57. www.for.gov.bc.ca/hfd/pubs/Docs/Tr/Tr057.htm

Sagar, R.M., M.J. Waterhouse, and B. Chapman, B. 2005. Microclimate studies in silviculture Ssystems on the Chilcotin Plateau of British Columbia: the Itcha-Ilgachuz Project (1997–2003). BC Ministry of Forests Research Branch, Victoria, B.C. Technical Report 22.

www.for.gov.bc.ca/hfd/pubs/Docs/Tr/Tr022.pdf

Stathers, R.J., T. Newson, M.J. Waterhouse, and C. Sutherland. 2001. Microclimate studies on a group selection silviculture system in a high-elevation ESSFwc3 forest in the Cariboo Forest Region. Forest Science Program, B.C. Ministry of Forests, Victoria, B.C. Work. Pap. 58. www.for.gov.bc.ca/hfd/pubs/Docs/Wp/Wp58.htm

Wang, T., A. Hamann. D. Spittlehouse, and T.N. Murdock. 2012. Climate WNA – high resolution spatial data for western North America. J. Applied Meteorology and Climatology. 51: 16–29.

Winkler, R. 2010a. Mayson Lake Hydrological Processes Study. Streamline Watershed Management Bulletin, Vol. 14(1). www.forrex.org/sites/default/files/publications/articles/Streamline_Vol14_No1_Art7.pdf

———. 2010b. Upper Penticton Creek. Streamline Watershed Management Bulletin, Vol. 14(1). www.forrex.org/sites/default/files/publications/articles/Streamline_Vol14_No1_Art11.pdf

Citation

Foord, V., B. Floyd, and T. Weick. 2014. Enhancing provincial climate monitoring: the Forest Ecosystem Research Network and the Climate Related Monitoring Program. Prov. B.C., Victoria, B.C. Exten. Note 111. www.for.gov.bc.ca/hfd/pubs/Docs/En/En111.htm