Rapidly Emerging Trends in Southeast British Columbia

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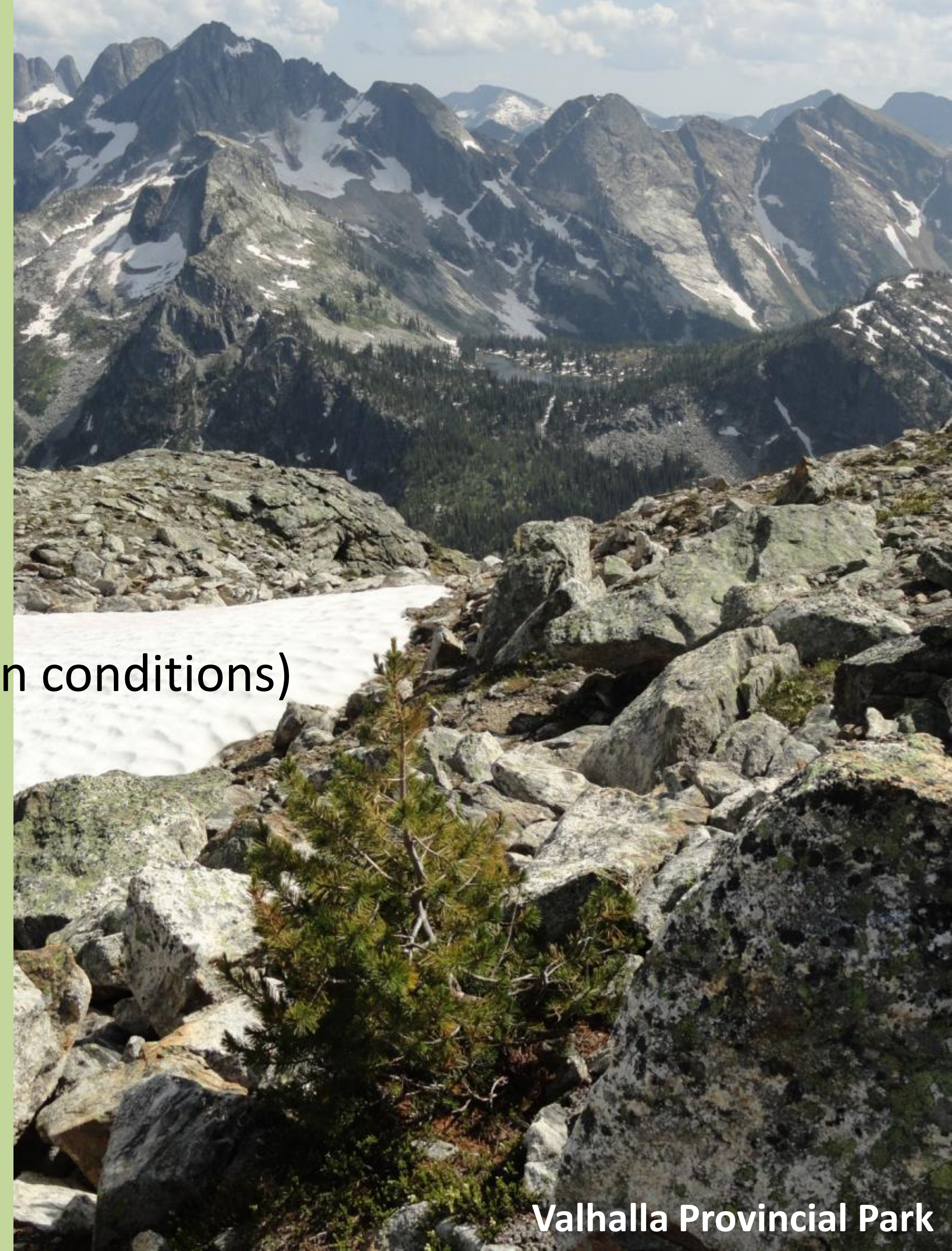
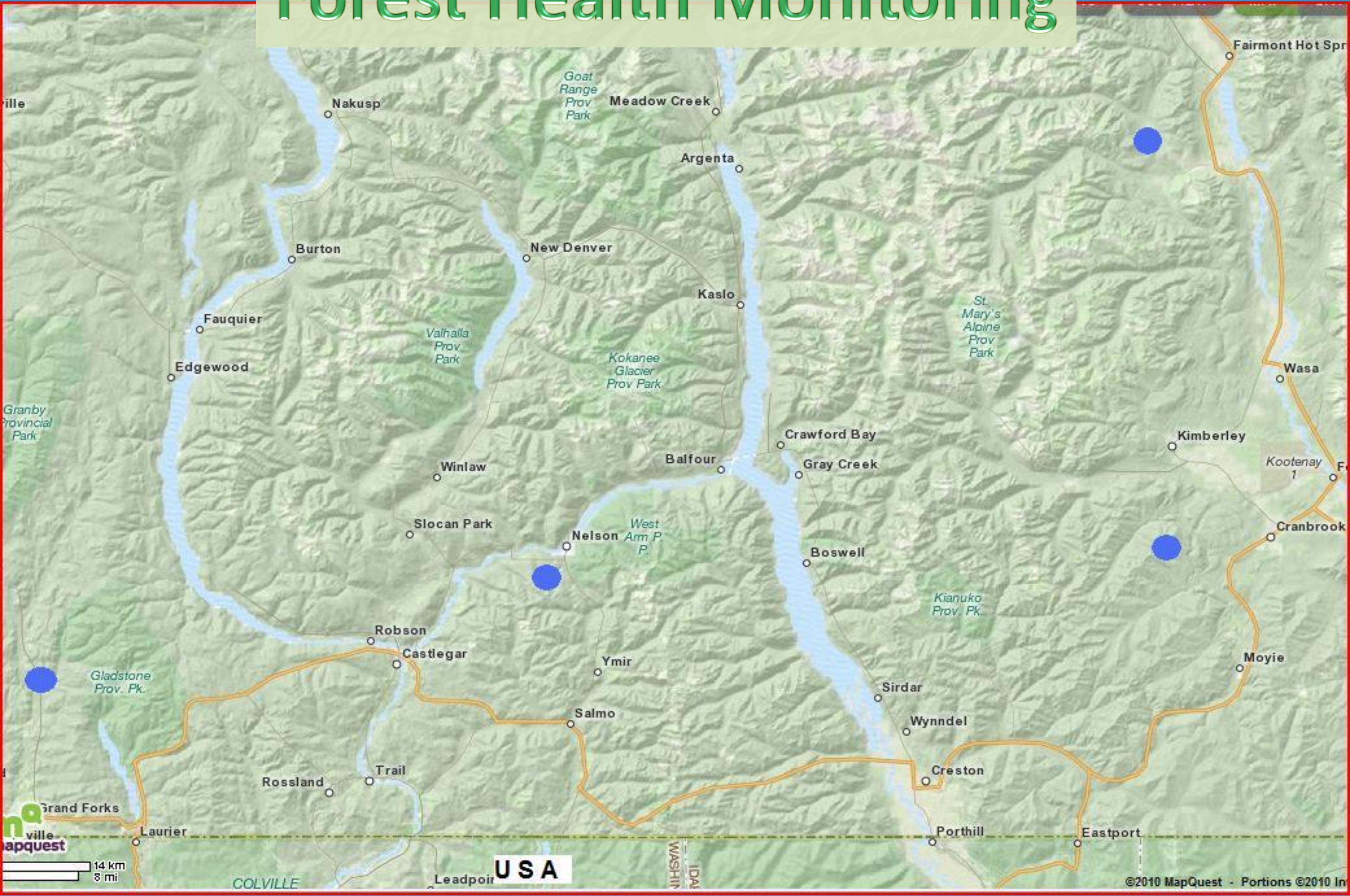
BRITISH
COLUMBIA

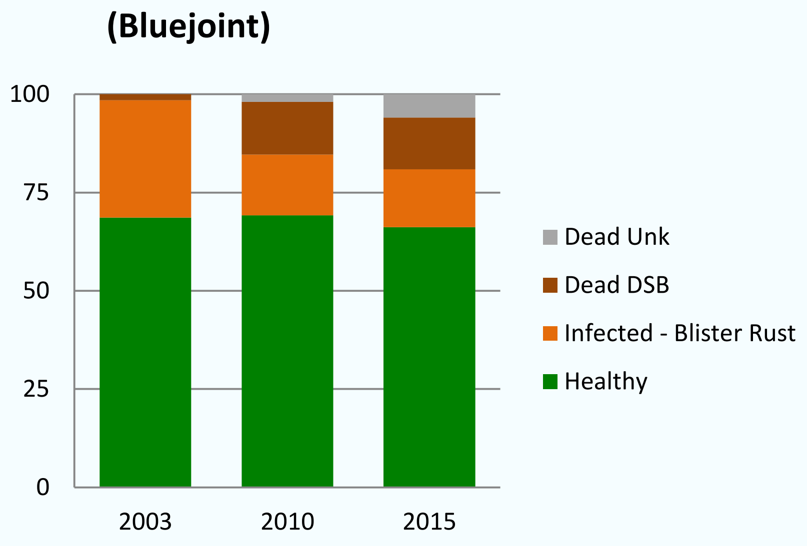
- Monitoring Results
- Cone Production
- Aerial Recon
- Climate Change (sporulation conditions)
- Blister Rust Resistance

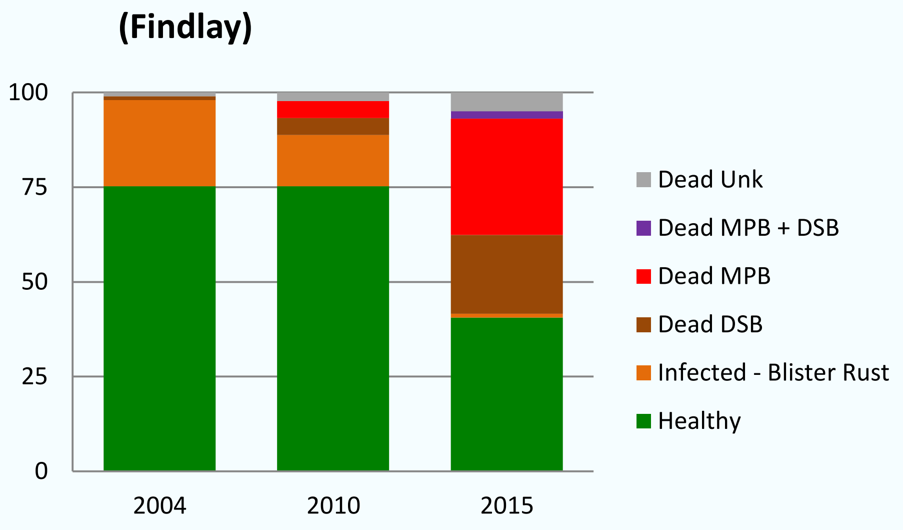

Valhalla Provincial Park

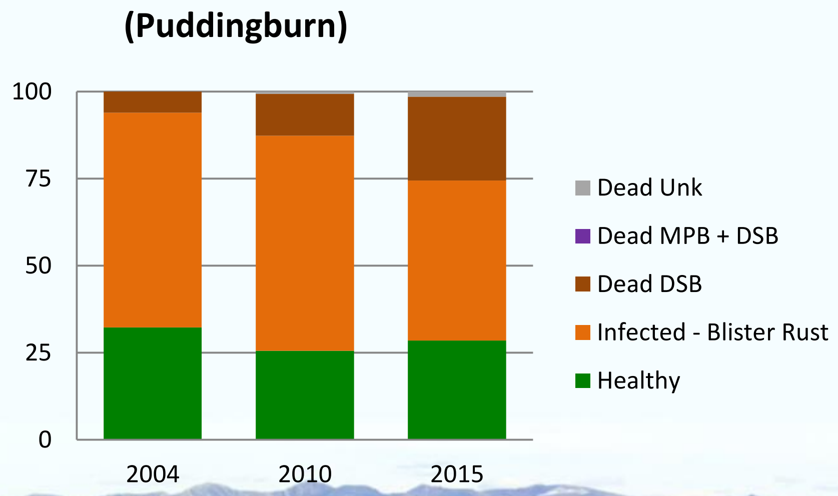
Forest Health Monitoring



Forest Health Monitoring


(Bluejoint)


(Findlay)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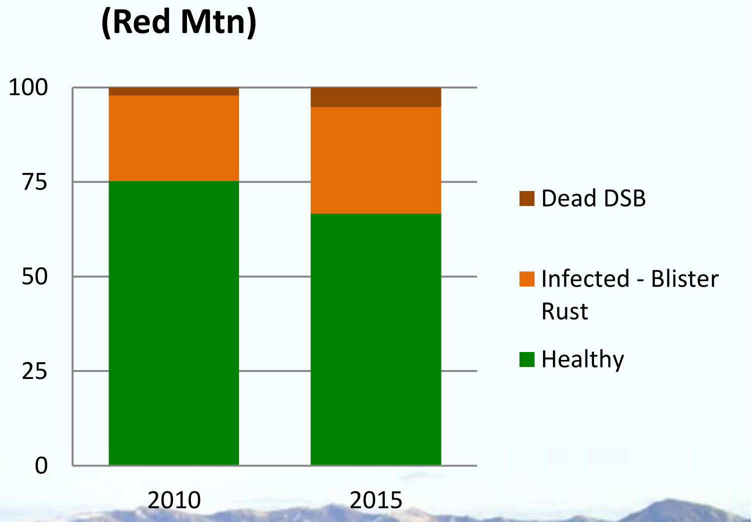
(Red Mtn)

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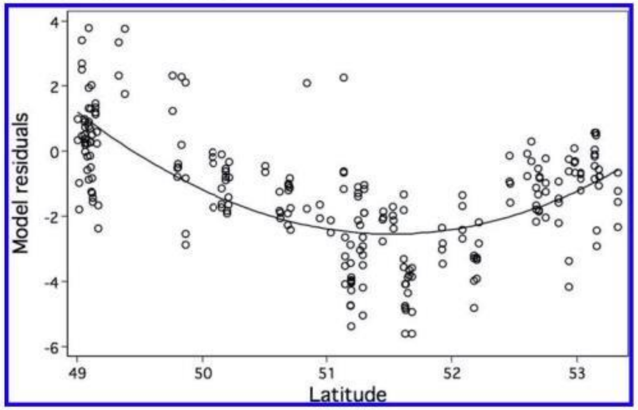
Fig. 3. The number of live whitebark pine (*Pinus albicaulis*) trees that are infected by white pine blister rust (*Cronartium ribicola*) varies by latitude: highest in the southern part of the study area, then dropping significantly in the central Canadian Rockies, and then rising again at the northern part of the study area. The model residuals are the residuals after accounting for all other variables in the model. The line is the fitted line using the model coefficients and the means of the other covariates.



WPBR infection spread is heavily influenced by environmental conditions such as moisture, air temperature, and air circulation (Sturrock et al. 2011), with high hazard conditions of about 48 h of <20 °C and 100% humidity producing ideal conditions to form basidiospores, disperse, germinate, and infect white pines (Ostry et al. 2010). These moisture-saturated environments are more typical of our western sites (Smith et al. 2008).

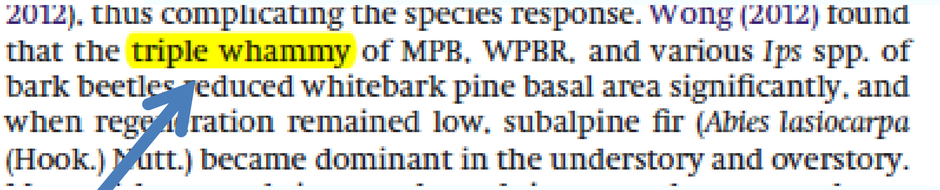
While the percentage of canopy kill declined between measurement periods, it continues to reduce cone production because nearly all cones are produced in the upper third of the crown (Arno and Hoff 1989). The observed decline may reflect (*i*) the death of the trees from 2003–2004 that had high canopy kill, such that the remaining healthier trees comprise a larger percentage of live trees, (*ii*) that there were fewer infection events in the intervening years, and (or) (*iii*) that there was observer variance in classifying the percentage of canopy kill.

Similar to Rochefort (2008), we found that mortality levels decreased with elevation, although our infection levels showed no response to elevation. We hypothesize that the lower mortality levels were due to slower disease development and spread at higher elevations, due to the shorter growing season. However, predicted warmer temperatures at higher elevations may provide favourable conditions for WPBR to spread more rapidly in the future (Larson 2010). Climate warming is also driving recent increases in MPB infestation at higher elevations by lengthening the developmental period and shortening the periods of cold temperatures that kill beetles (Logan and Powell 2001). Also, with climate warming, beetles of different generations are now surviving and killing whitebark pine in a single summer (Bentz et al. 2011). In addition, in some areas, MPB have preferentially selected trees that were infected by WPBR, which may occur more frequently with drought stress (Six and Adams 2007; Bockino and Tinker 2012). High levels of WPBR infection prior to MPB infestation may amplify both disturbances, accelerating the loss of whitebark pine (Gibson et al. 2008; Larson 2010, Sharik et al. 2010). Although our results showed a decrease in mortality from MPB, populations in lodgepole pine (*Pinus contorta* Douglas ex Loudon) have been increasing in the central and northern zones of our study area and are predicted to continue to increase given conservative climate change scenarios (Carroll et al. 2006), while in the southern part of our study area, previous pine beetle activity already limits the potential for MPB population growth (Dalman 2004).

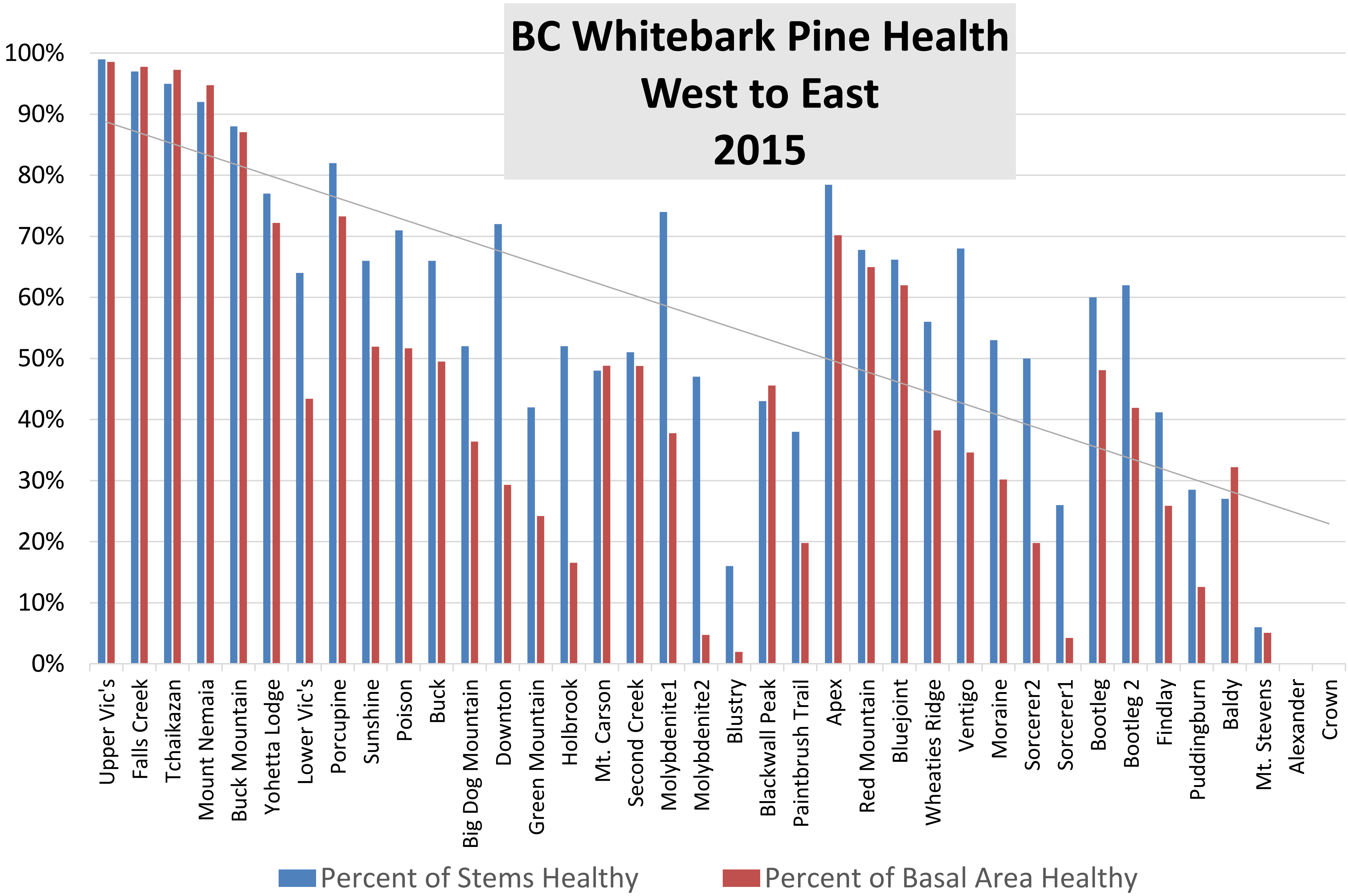
These two agents (climate warming and MPB) are further fragmenting existing small populations of whitebark pine, increasing the risk of loss of these remnants to wildfires, which are expected to be more intense under a warming climate (Tomback and Achuff 2010). Isolated stands may also be less frequently visited by Clark's nutcrackers, which are the sole disperser of WBP seed (Tomback 1982), thus reducing regeneration. Millar et al. (2012) observed improved growth in whitebark pine trees that survived drought and hypothesized that fitness may be improved with some levels of forest dieback. However, cone production in these stands may be below the predicted threshold for visitation by Clark's nutcrackers (McKinney and Tomback 2007; McKinney et al. 2009; Barringer et al. 2012), reducing dispersal and thus regeneration potential.

Disturbance agents operate on different time scales and frequently affect different demographic stages of populations (Wong 2012), thus complicating the species response. Wong (2012) found that the triple whammy of MPB, WPBR, and various *Ips* spp. of bark beetles reduced whitebark pine basal area significantly, and when regeneration remained low, subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.) became dominant in the understory and overstory. Many of the severely impacted stands in our study area may be on a trajectory towards extirpation without active management of competing species and assistance in regeneration.

Infection (44%, range 0%–100%) and mortality (30%, range 0%–90%) levels in plots observed in this study are higher than in surveys a decade earlier in British Columbia (31% infection and 19% mortality: Zeglen 2002; 27% infection and 21% mortality: Campbell and Antos 2000; also see review in Smith et al. 2008). They are also higher than in surveys between 2005 and 2009 in Alberta protected areas (0%–33% infection and 0%–13% mortality: K. Ainsley and A. Benner, unpublished data), but are similar in that the highest levels are in the south. Levels in the Canadian Rockies are higher than in the Greater Yellowstone Ecosystem (mean 20% infection: GYWPMWG 2010) and Washington (mean 22% infection and 31% mortality: Rochefort 2008). The estimated 3%/year in-

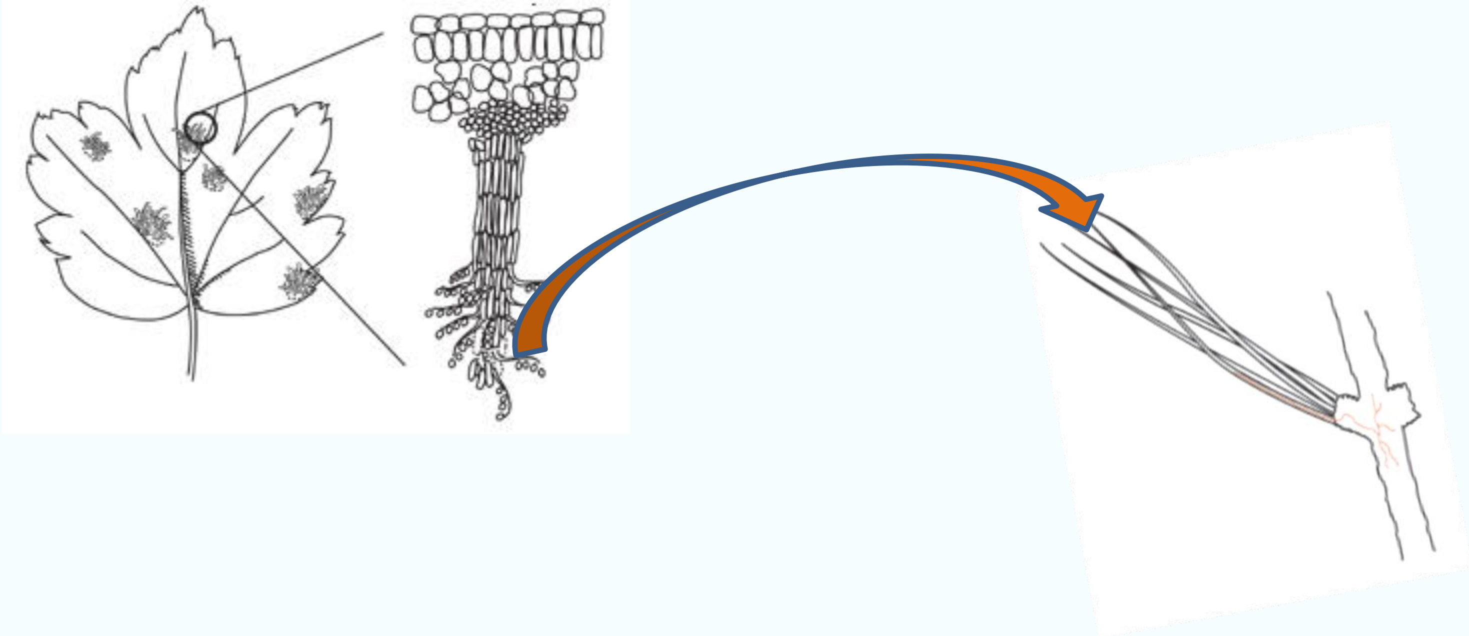

2012), thus complicating the species response. Wong (2012) found that the triple whammy of MPB, WPBR, and various *Ips* spp. of bark beetles reduced whitebark pine basal area significantly, and when regeneration remained low, subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.) became dominant in the understory and overstory.

BC Whitebark Pine Health
West to East
2015



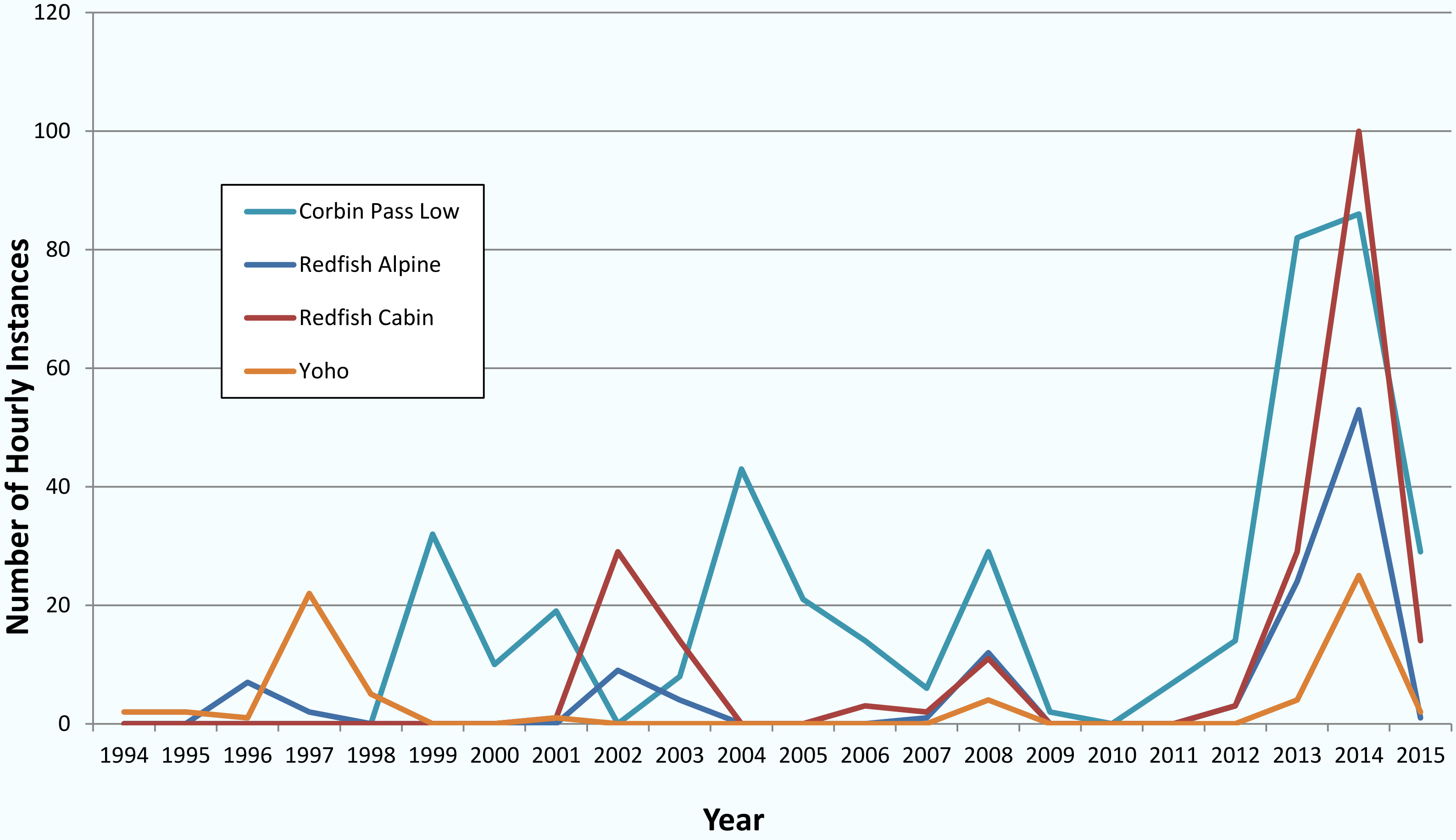
Moody and Murray (2016)

Climate Change



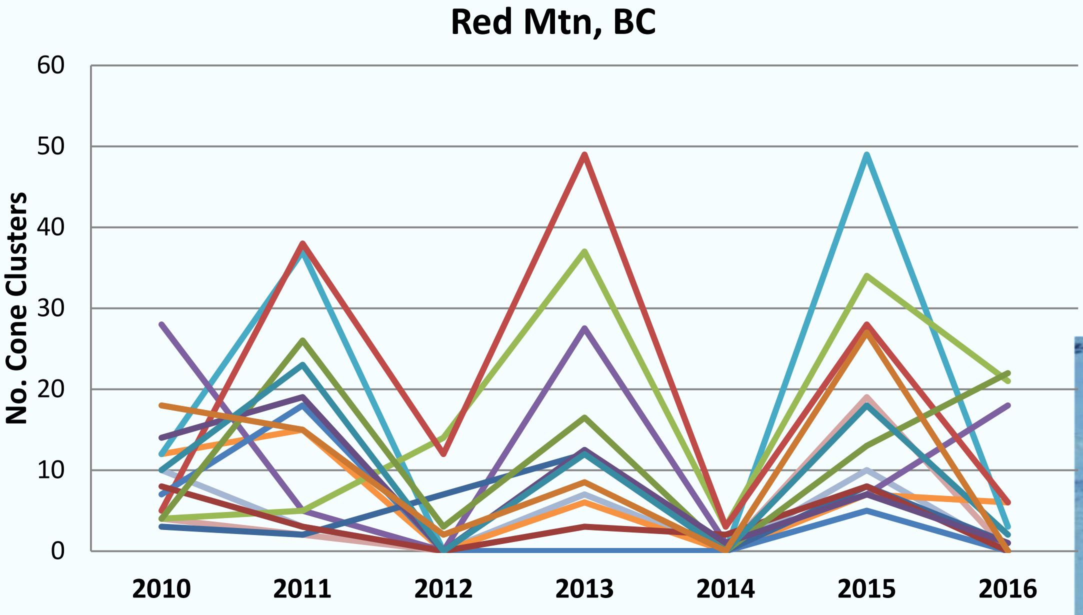
(Illustration by Vickie Brewster)

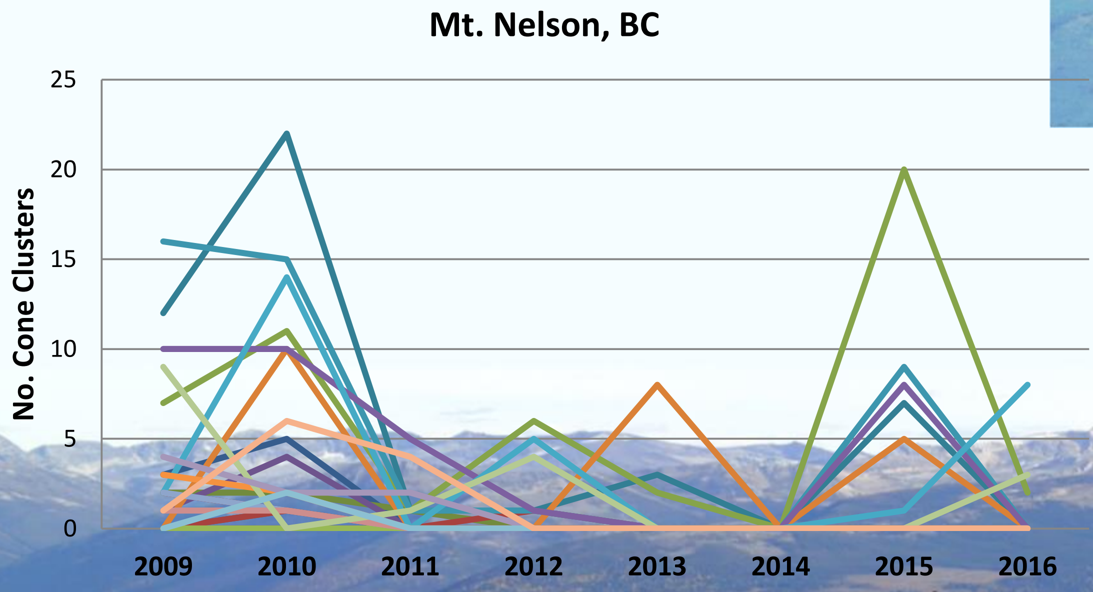
Climate Conditions: Conducive for Whitebark Pine Infection



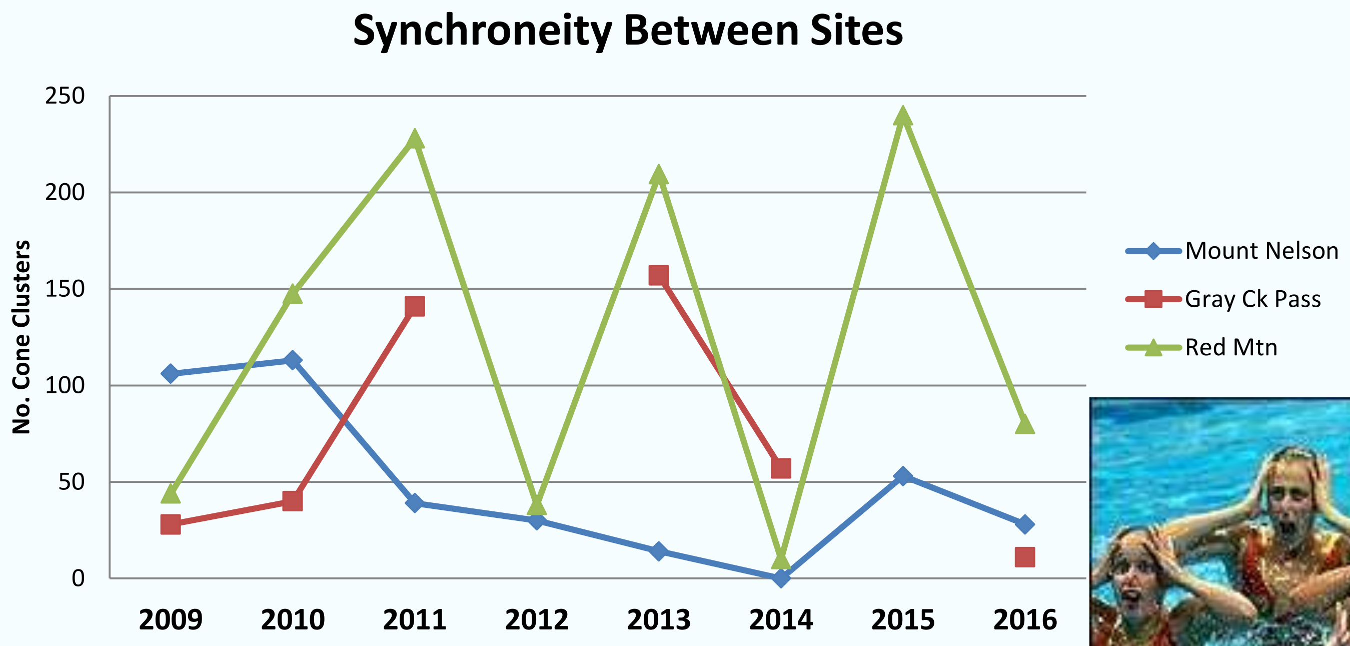
Number of Hourly Instances of Temperature between 10 and 18°C and Relative Humidity above 97% for Stations above 1600 m in the Kootenay and Boundary Regions

Cone Production

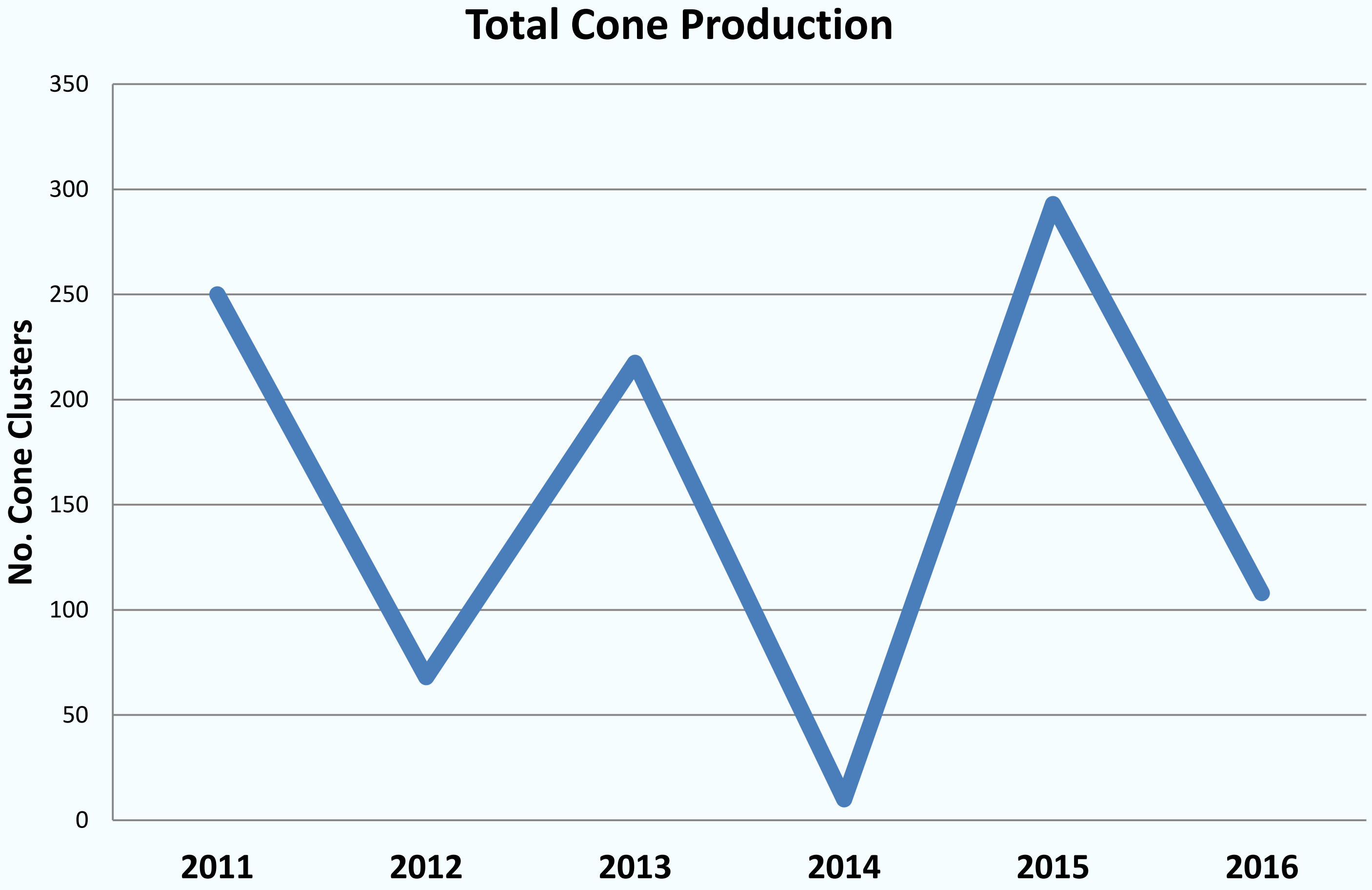

Red Mtn, BC


Mt. Nelson, BC

Cone Production



Cone Production

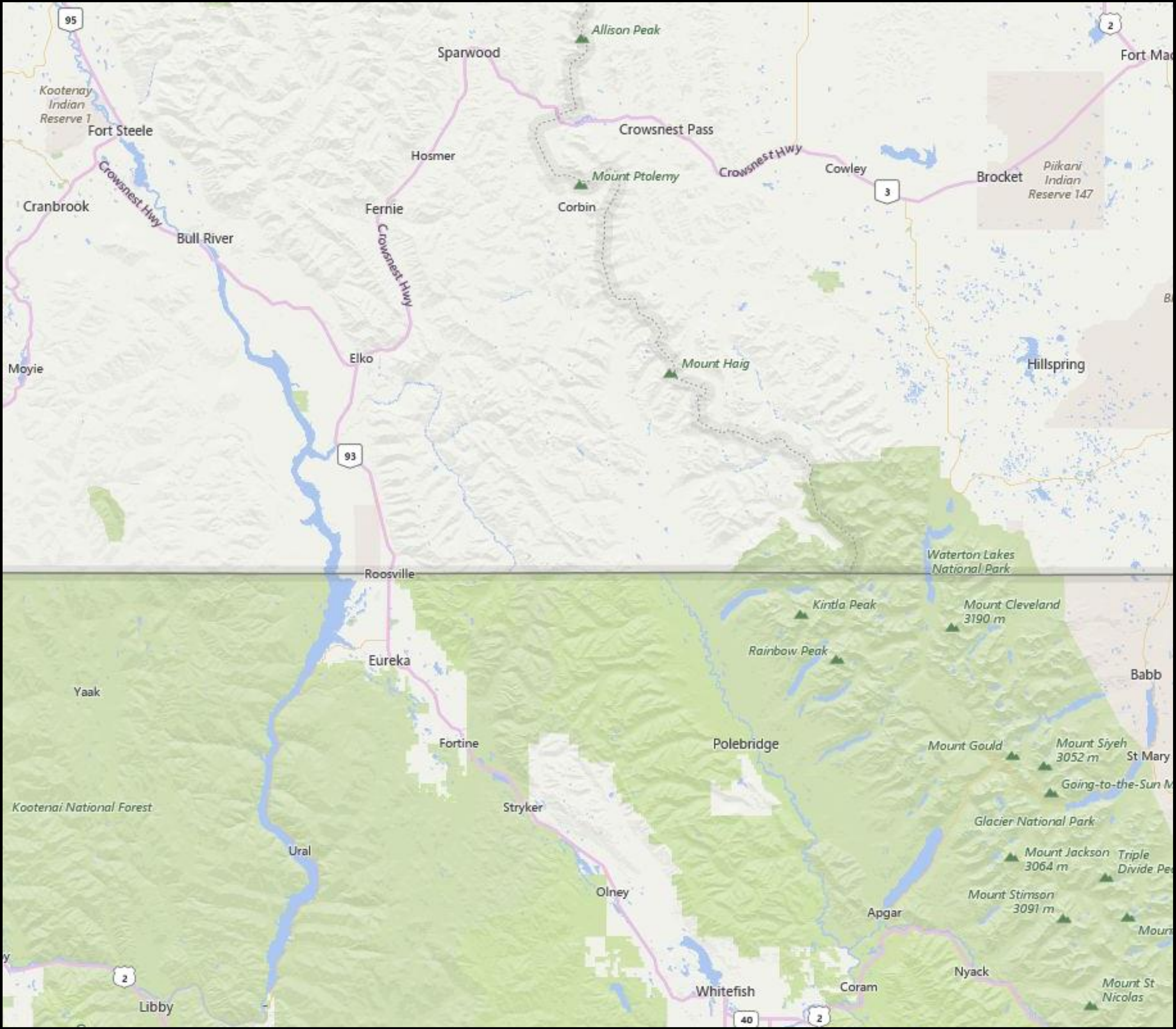


Blister Rust Resistance Screening

Blister Rust Screening

Inoculation Year	No. Families (Parents) Screened
2013	10
2014	30
2015	10
2016	35

Preliminary Findings: About half of parents have high survivorship and low incidence of disease symptoms.


95
Allison Peak
Sparwood
2
Fort Mac
Kootenay Indian Reserve 1
Fort Steele
Crowsnest Pass
Hosmer
Crowsnest Hwy
Cowley
Mount Ptolemy
Brocket
Piikani Indian Reserve 147
3
Crowsnest Hwy
Cranbrook
Fernie
Corbin
Bull River
Crowsnest Hwy
Elko
Moyie
Mount Haig
Hillspring
93
Waterton Lakes National Park
Roosville
Kintla Peak
Mount Cleveland 3190 m
Rainbow Peak
Eureka
Babb
Yaak
Fortine
Polebridge
Mount Gould
Mount Siyeh 3052 m
St Mary
Going-to-the-Sun M
Kootenai National Forest
Stryker
Glacier National Park
Ural
Mount Jackson 3064 m
Triple Divide Pe
Olney
Mount Stimson 3091 m
Apgar
Moun
Nyack
2
Libby
Whitefish
Coram
Mount St Nicolas
40
2

st Health Monitoring

Summary

Rapidly Emerging Trends in Southeast British Columbia

- Cone Production:
  - Within Site: Trees generally in sync
  - Between Sites: Variability
- Aerial Recon: Conspicuous Mining & Harvest
- Climate Change: Favorable conditions for spread of blister rust may be increasing.
- Blister Rust Resistance: Half of candidate trees are showing high survivorship and low incidence of disease symptoms.
- Whitebark Pine Decline: 3 of 4 Monitoring Plots (blister rust and some beetle).

The End

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NOTE

A one & one-half whammy associated with whitebark pine (*Pinus albicaulis*) decline.

Michael P. Murray

Abstract: Whitebark pine (*Pinus albicaulis* Engelm.), a keystone species in subalpine ecosystems of western North America, is under threat across its range from white pine blister rust, mountain pine beetle, fire exclusion, and climate change. Loss of whitebark pine is predicted to have cascading effects on many ecosystem services. We remeasured 115 whitebark pine plots in the Canadian Rocky Mountains to determine whether infection and mortality rates from blister rust were changing over time and (or) latitude. Average rust infection of trees among plots increased from 42% in 2003–2004 to 52% in 2009, while mortality increased from 18% to 28%. In eight plots that have been measured three times, infection increased from 43% of live trees in 1996 to 70% in 2003 and 78% in 2009. Mortality increased from 26% to 65% in the same time period. Overall, infection and mortality have increased 3%/year over the 13 years of the study. Incidence of infection and mortality was highest among plots in the southern part of the study area, particularly on the western side of the Continental Divide. The slowing rates of infection and mortality that we found suggest that some level of natural selection may already be occurring in areas with high levels of both.

Résumé : Le pin à écorce blanche (*Pinus albicaulis* Engelm.), une espèce clé dans les écosystèmes subalpins de l'Ouest de l'Amérique du Nord, est menacé partout dans son aire de répartition par la rouille vésiculeuse du pin blanc, le dendroctone du pin ponderosa, l'exclusion du feu et les changements climatiques. On prévoit que la perte du pin à écorce blanche aurait des répercussions en cascade sur plusieurs services de l'écosystème. Nous avons remesuré 115 places échantillons contenant du pin à écorce blanche dans les montagnes Rocheuses canadiennes pour déterminer si les taux d'infection et de mortalité par la rouille vésiculeuse changeaient avec le temps et la latitude. Le taux moyen d'infection des arbres par la rouille vésiculeuse dans les places échantillons a augmenté de 42% en 2003–2004 à 52% en 2009 tandis que la mortalité a augmenté de 18% à 28%. Dans huit places échantillons qui ont été mesurées trois fois, le taux d'infection est passé de 43% des arbres vivants en 1966 à 70% en 2003 et 78% en 2009. La mortalité a augmenté de 26% à 65% durant la même période. Dans l'ensemble, les taux d'infection et de mortalité ont augmenté de 3% par année durant le cours de l'étude qui a duré 13 ans. L'incidence de l'infection et de la mortalité était la plus forte parmi les places échantillons situées dans la partie sud de la zone d'étude. Le ralentissement que nous avons observé dans l'augmentation des taux d'infection et de mortalité indique qu'un certain degré de sélection naturelle est peut-être déjà à l'œuvre dans les régions où l'infection et la mortalité atteignent des niveaux élevés. [Traduit par la Rédaction]

Introduction

Whitebark pine (*Pinus albicaulis* Engelm.), a keystone species in subalpine ecosystems of western North America, is under threat across the species' range. It is being impacted by white pine blister rust (WPBR), caused by the introduced invasive fungus *Cronartium ribicola* A. Dietr., mountain pine beetle (*Dendroctonus ponderosae* Hopkins, 1902) (MPB), fire exclusion, and climate change (Tomback et al. 2001). Loss of whitebark pine is predicted to have cascading effects on the many ecological processes and species, including provision of high-energy food for wildlife, particularly Clark's nutcracker (*Nucifraga columbiana* (Wilson, 1811)) and grizzly bear (*Ursus arctos* Linnaeus, 1758) (Tomback and Kendall 2001), nurse trees for other species in open terrain (Callaway 1998; Resler and Tomback 2008), and retention of snowpack (Farnes 1990; Tomback et al. 2001).

WPBR impacts whitebark pine by reducing seed availability (canopy kill and direct mortality), seed dispersal, and seedling survival. The rust usually kills the upper, cone-bearing branches before the tree itself (McDonald and Hoff 2001). Nearly all cones are produced in the upper third of the crown, so loss of canopy means loss of seed production (Keane et al. 1994). Seedlings of all sizes may also be infected by WPBR, and once seedlings develop cankers, the majority die within 3 years (Hoff and Hagle 1990), reducing regeneration. Although MPB prefer the thicker phloem layer of larger diameter trees (>10–12 cm), which create better reproductive conditions (Cole and Amman 1980), even small-diameter whitebark pine trees may be very susceptible to MPB attack because of their proximity to larger diameter stems in multistem clusters (Perkins and Roberts 2003).

WPBR, in particular, has devastated many northern whitebark pine populations and is quickly invading others, making it almost rangewide in its distribution across a diversity of habitat types and plant associations as well as edaphic conditions (Schwandt et al. 2010; Tomback and Achuff 2010, and references therein). MPB outbreaks are widespread in several whitebark pine regions (Gibson et al. 2008). While these, and other, studies have reported on the incidence of WPBR on whitebark pine and subsequent mortality, only a few have reported on rates of change in these variables (Keane and Arno 1993; Smith et al. 2008; GYWPMWG 2010).

Long-term observations are an opportunity to examine how stands and landscapes respond to agents such as WPBR and MPB over time (Geils et al. 2011); for example, rust incidence and tree mortality may vary at different stages of an epidemic, or depending on stand age or other factors. A more complete understanding

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