BC's Changing Landscape: An Insect's View on Forest Succession and Management

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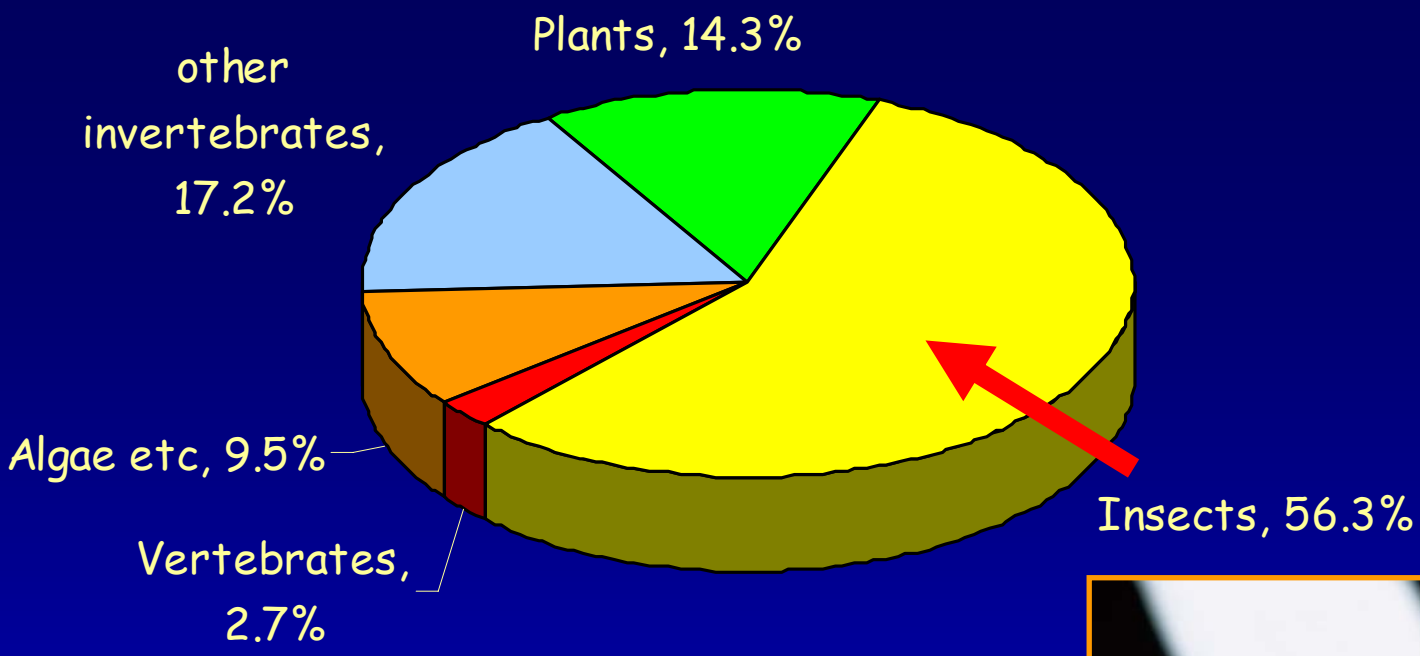
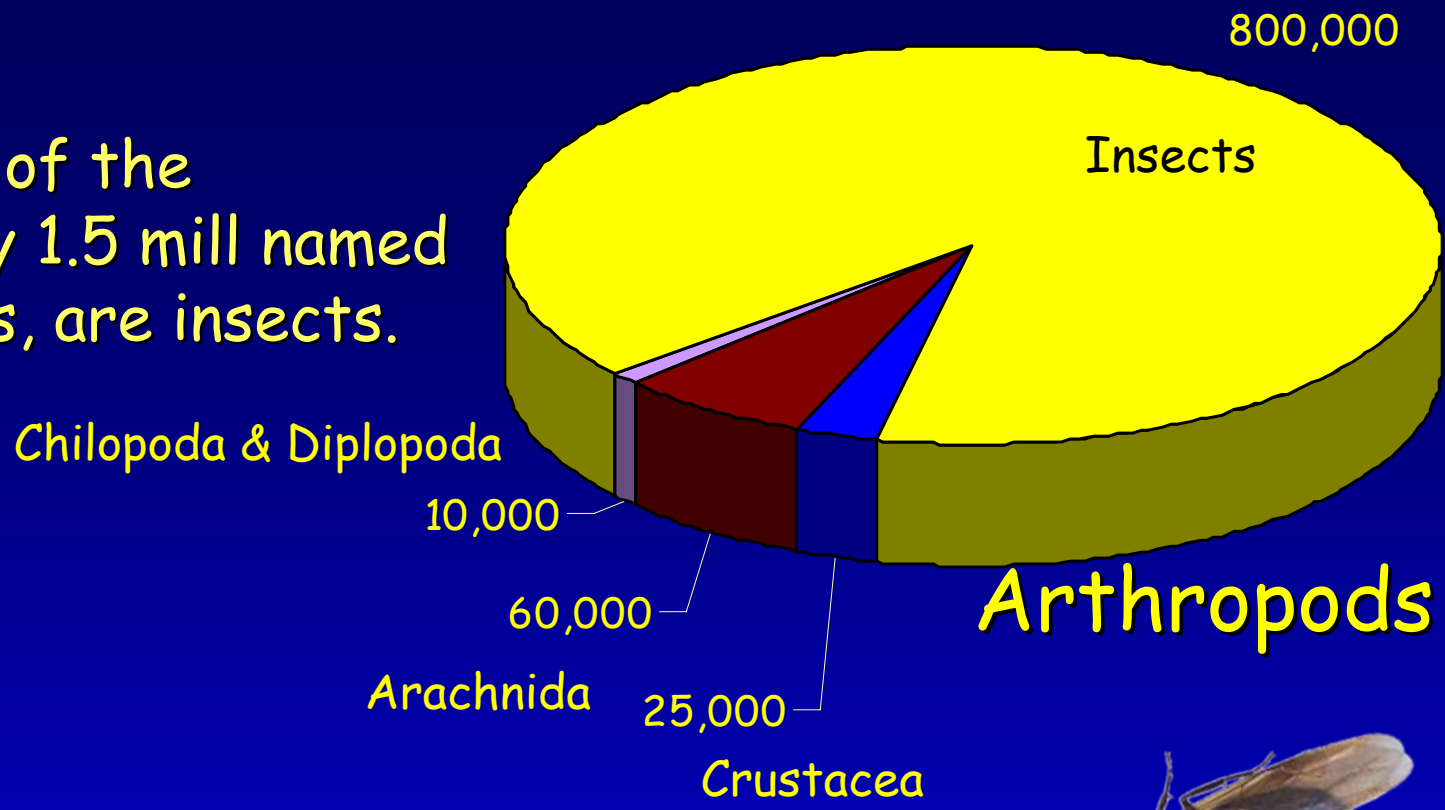
We live in a world of insects.



Insects:

- most dominant group of animals on earth
- occur in practically every environment/niche
- have existed on earth for ~350 mill years (man <2 mill), developing many unusual, and amazing features

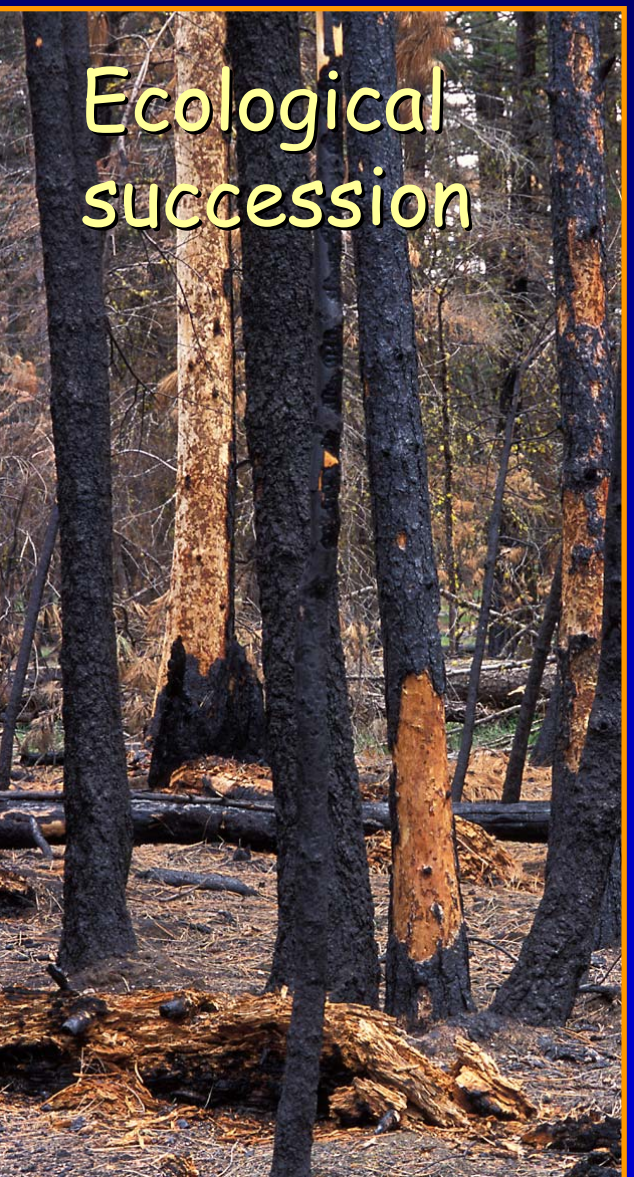
Close to 80% of the approximately 1.5 mill named animal species, are insects.



Trivia:

There are about 200,000 ants for every living human being.

An ecological response to change



Ecosystem response to change in climate *may* be gradual over decades.

Biotic agents (insects) *may* respond to these climate "signals" more rapidly and hasten, or change, successional processes.

Change may not occur in an orderly progression with a smooth and linear sequence of events.

Forests co-exist with biotic agents that respond rapidly to weather/climate events.

Entomological succession

Small climatic changes will likely promote large responses by insects, particularly where tree species are at their distributional limits.

Insect disturbances can be triggered by erratic and extreme weather events.

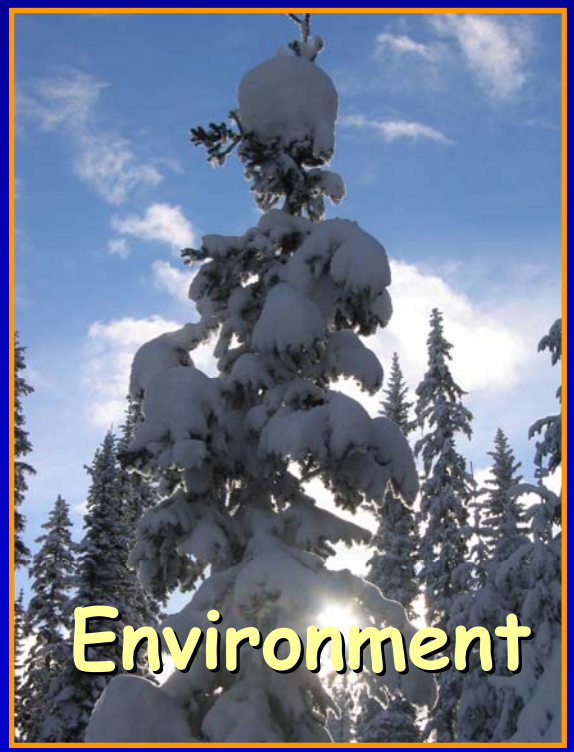
The key factor is to model the response of insects to a variety of change.

Climate change: may alter insect population dynamics and host ranges at differential rates.

Higher temperatures and altered precipitation regimes *could* enhance insect outbreaks. The inherent resistance of host trees decline thus becoming increasingly suitable for insect colonization.

Insects *may* respond by having additional reproductive cycles per year or higher brood survival as a result of more moderate weather conditions.

climate, weather, host species ranges and insect outbreak dynamics, will stretch our ability to manage and maintain healthy forests into the future



Define Healthy

Defoliators & bark beetles

- Outbreak dynamics
- Impact & management

Orgyia pseudotsugata

Choristoneura occidentalis

Dendroctonus ponderosae

The *Choristoneura* (budworms)

- great genetic variability
- lack of strong reproductive barriers among putative species
- tremendous dispersal capabilities

Choristoneura: well set-up to "outrun" its host as the host expands its range with climate change . . . and predispose hosts to other insects.

The budworms - *Choristoneura occidentalis, C. biennis, C. fumiferana*

- Periodically erupt to outbreak levels and cause widespread damage

- Largest WSB outbreak in recorded history (1985-1993) covered >830,000 ha in 1987
- The current outbreak now covers >720,000 ha
- Are outbreaks more extensive, severe and long-lived?
- 1987 outbreak temporally more synchronous across more sites than previously recorded
- The current outbreak has expanded into "new" areas

Successional forces – rates of change?

Subalpine fir, spruce, pine, budworms and numerous bark beetles are well adapted to cold, northern and mid- to high-elevation forests.

Changing susceptibility

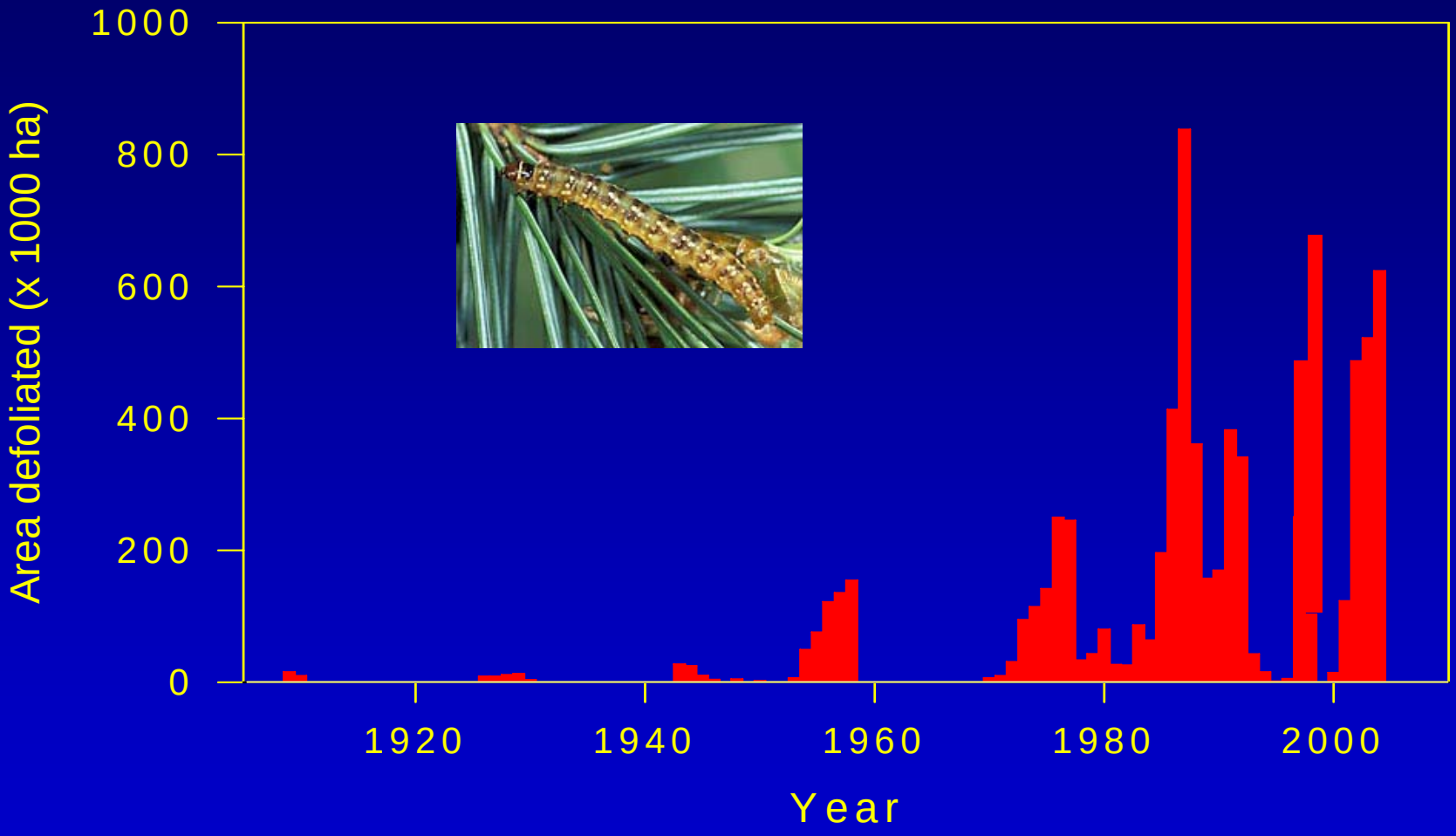
Slow succession

BI - WBBB

Rapid succession

PI - Sx

Annual area defoliated by western spruce budworm in B.C. 1909-2006

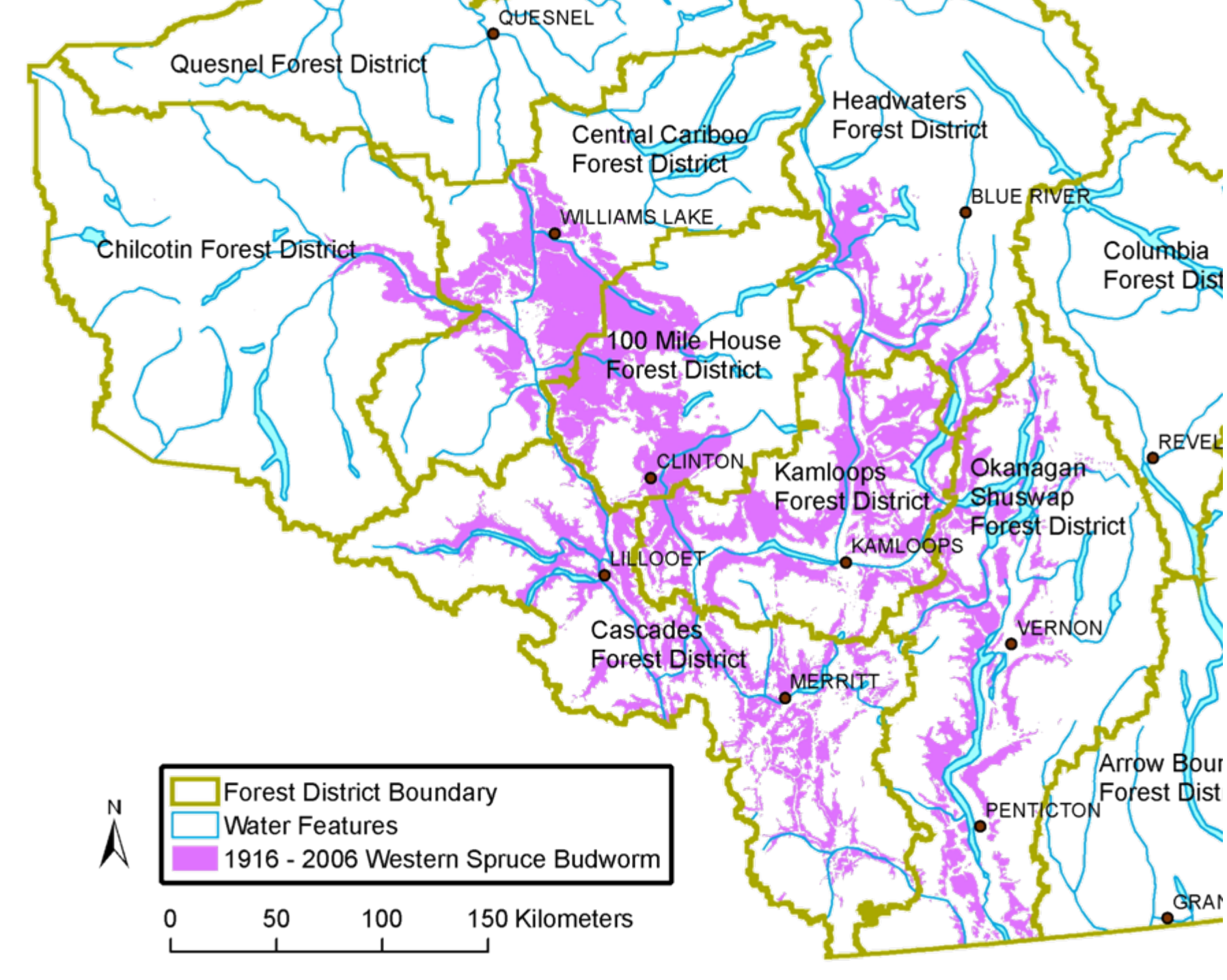


Coastal sea level

Coastal range

Coastal range & **Southern Interior**

Southern Interior & **Cariboo**


QUESNEL
Quesnel Forest District
Central Cariboo
Forest District
Headwaters
Forest District
BLUE RIVER
WILLIAMS LAKE
Chilcotin Forest District
Columbia
Forest Dist
100 Mile House
Forest District
REVEL
CLINTON
Kamloops
Forest District
Okanagan
Shuswap
Forest District
KAMLOOPS
LILLOOET
Cascades
Forest District
VERNON
MERRITT
Arrow Bour
Forest Dist
PENTICTON
GRA
Forest District Boundary
Water Features
1916 - 2006 Western Spruce Budworm
N
0
50
100
150 Kilometers

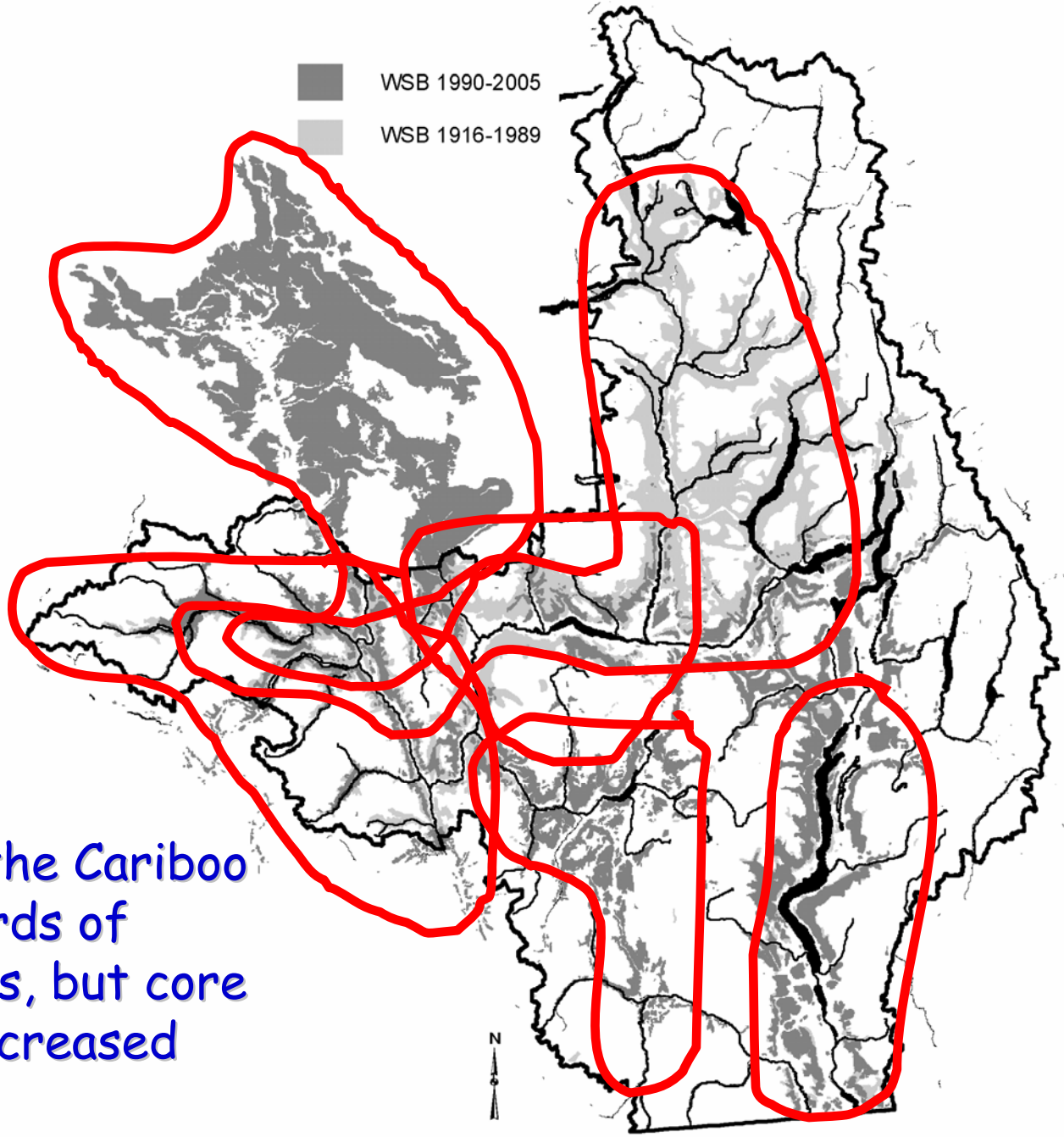
1916-1959

1960-1979

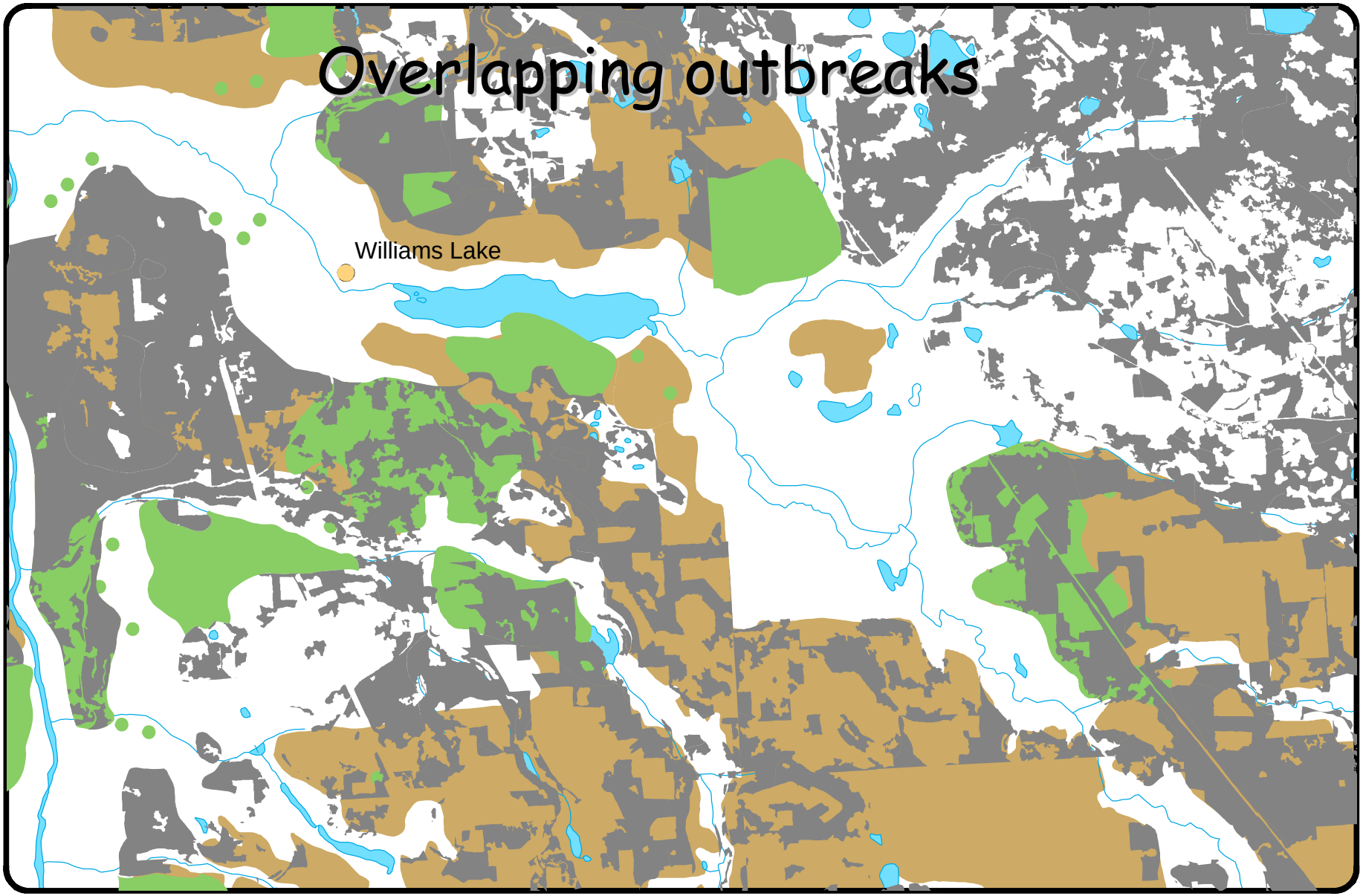
1980-1989

1990-1999

2000-2006

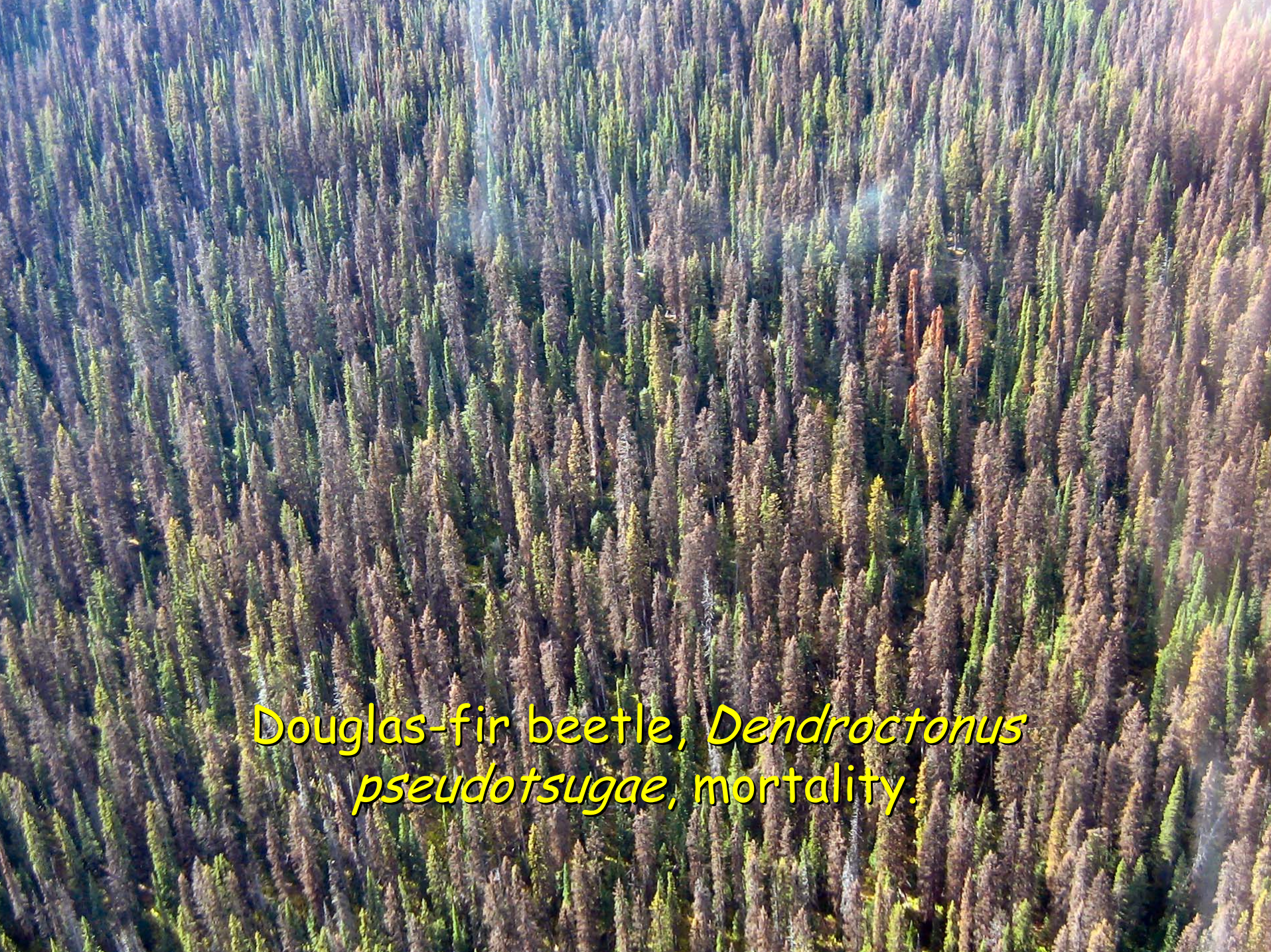


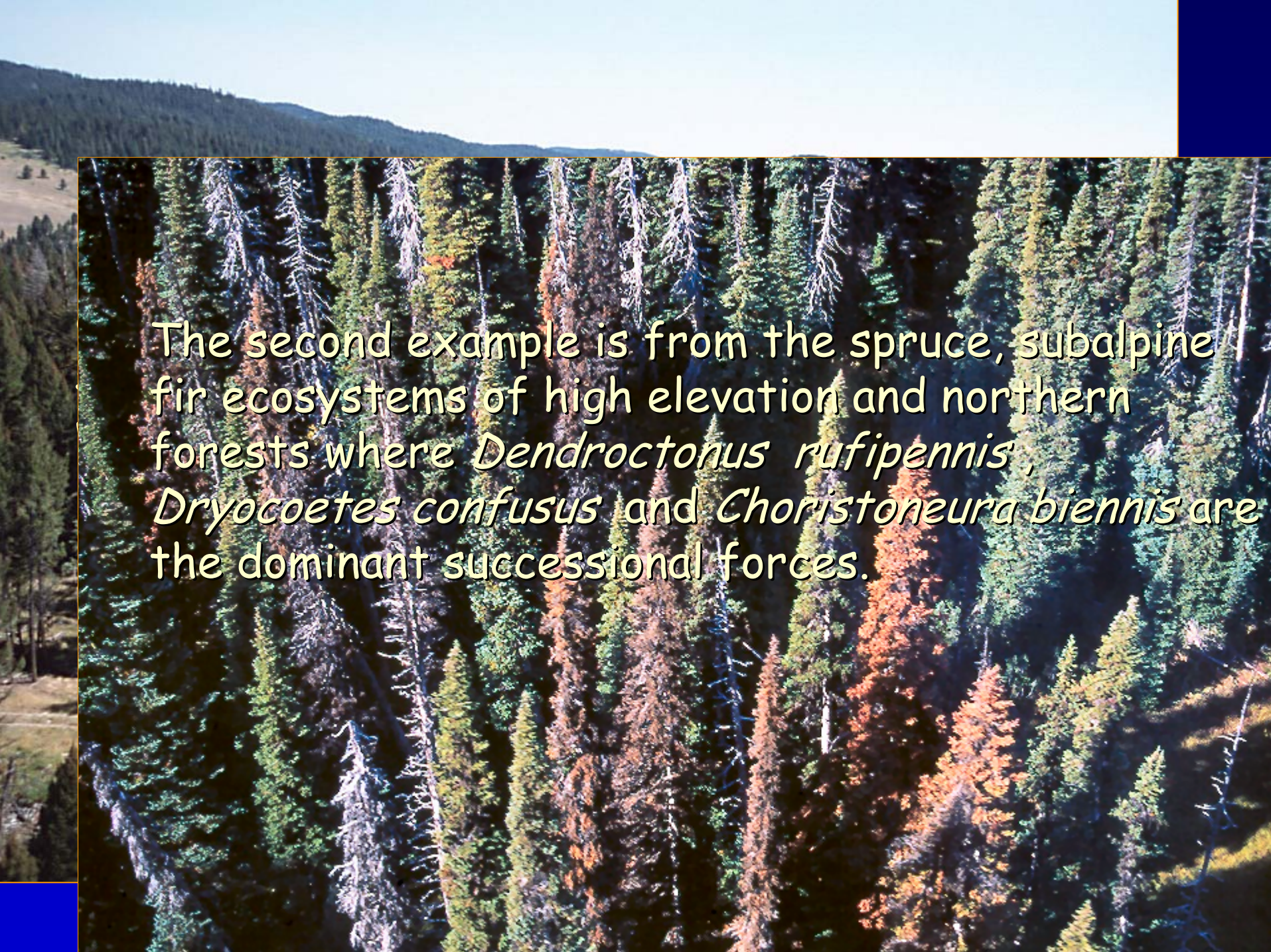
Discrete areas in the Cariboo have historic records of budworm outbreaks, but core analysis show an increased range.


Overlapping outbreaks
Williams Lake
western spruce budworm
mountain pine beetle
Douglas-fir beetle
N
0
5
10 Kilometers


Here today gone tomorrow?


Western spruce budworm
defoliation near Alexis Lake.


Douglas-fir beetle, *Dendroctonus pseudotsugae*, mortality.


The second example is from the spruce, subalpine fir ecosystems of high elevation and northern forests where *Dendroctonus rufipennis*, *Dryocoetes confusus* and *Choristoneura biennis* are the dominant successional forces.

Develop Models to Guide Monitoring

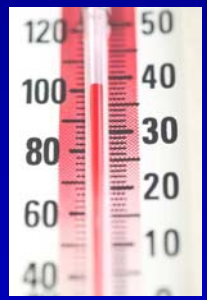
- Use historic patterns, but discern population processes driving patterns
- Study insect / host interactions and key triggers
- Perception is biased so use analytical approach to forecasting

WSB is predominantly found in lower elevation, dry, warm ecosystems predominated by Douglas-fir in southern B.C.

The 2-year cycle budworm is found at higher elevations in the south, and throughout the north, where Abies/*Picea* dominate.

Weather determines processes such as;

- Rates of development (*e.g.* degree-days)
- Threshold effects (*e.g.* cold tolerance)
- Behavioral events (*e.g.* migration)



Which in turn determine:

- Geographic and host range
- Population levels and rates of change

Courtesy of V. Nealis, Pacific Forestry Centre

BUDWORM: Synchronizing spring emergence with bud flush of the host tree

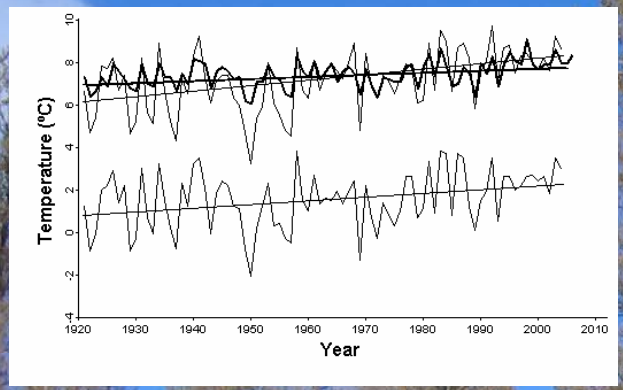
Spring emergence is a temperature-dependent event determined by physiological and behavioral processes specific to the budworm

Bud flush is a temperature-dependent event subject to a photoperiodic threshold specific to Douglas fir

Courtesy of V. Nealis, Pacific Forestry Centre

Western spruce budworm
same old outbreaks, different places

Winter temperatures 1921-2004



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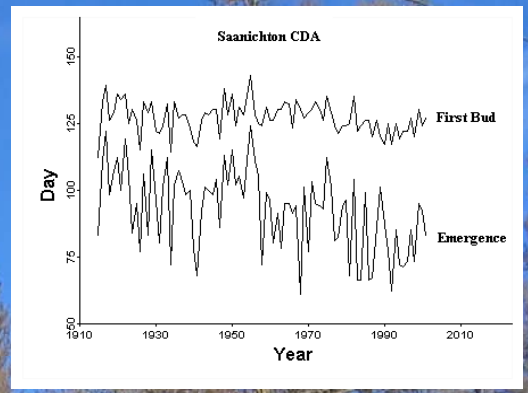
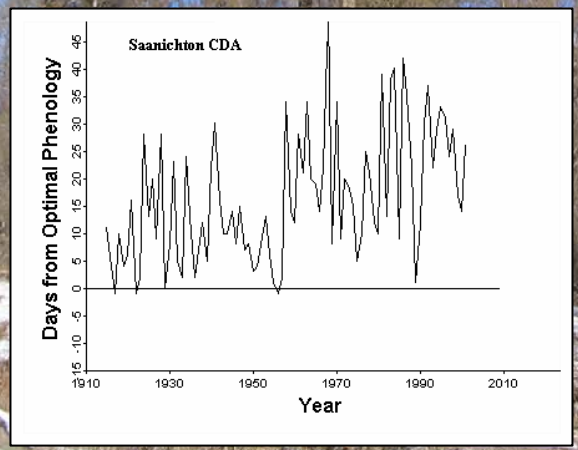
Differential biological response



Bud flush

Budworm emergence

=



Diverging phenologies affecting trophic relationships and outbreak behavior

***Courtesy of A. Thomson and R. Benton*, Pacific Forestry Centre**

Western balsam bark beetle, *Dryocoetes confusus*

When does chronic become epidemic?

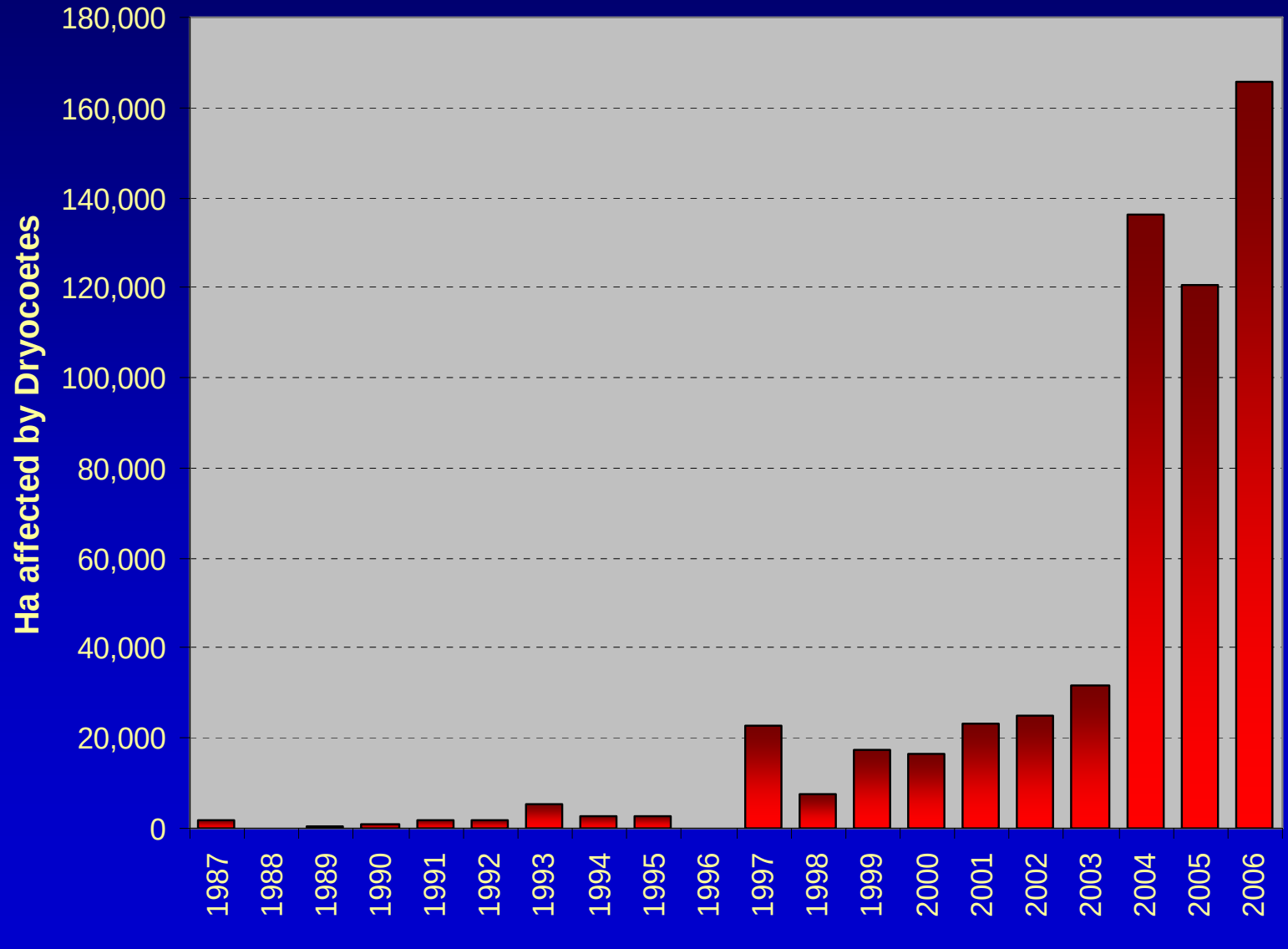
- Increasing mortality.
- Longer periods of high in-stand mortality.

What happens when these typically harsh environments becomes warmer; trees are drought stressed; and, summers are longer for insect attack and development?

Population dynamics and outbreak cycles could change and successional patterns altered. GOOD or BAD?

Defoliation could predispose subalpine fir to attack by western balsam bark beetle.

Ha affected by western balsam bark beetle in southern B.C. (1987-2006)



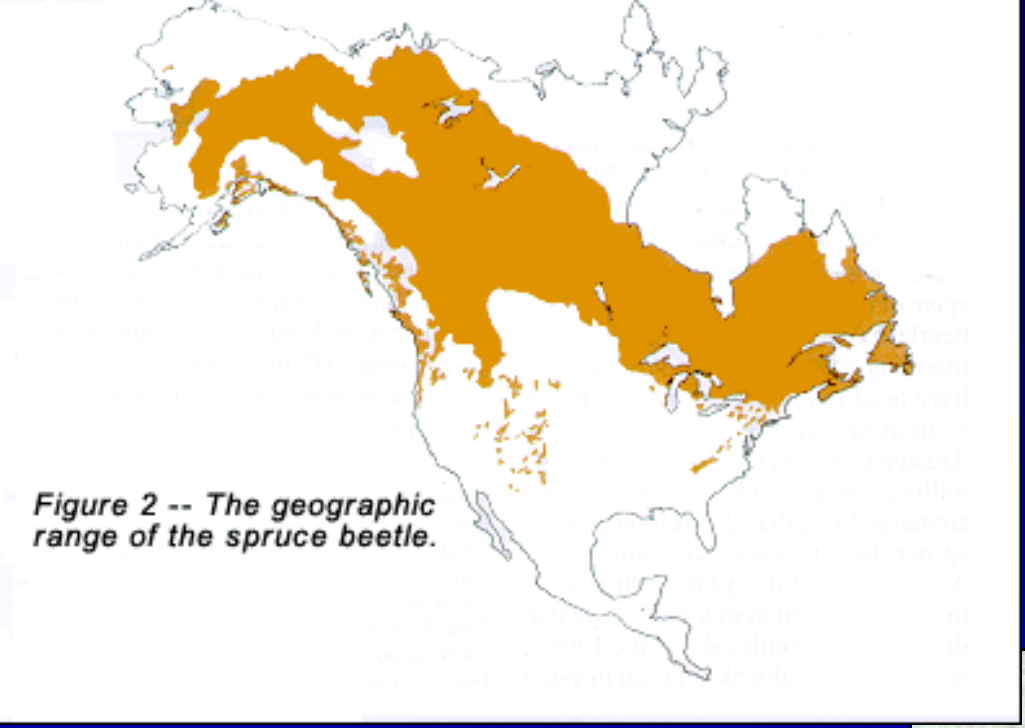


Figure 2 -- The geographic range of the spruce beetle.

The spruce beetle, *Dendroctonus rufipennis*, infests all species of spruce within its geographical range.

From: Holsten, Munson, and Gibson. 2000. USDA Pest Leaflet 127.

The inventory of spruce on BC's landscape is aging and highly susceptible - another large outbreak is imminent.

Alaska and the Yukon have just experienced huge areas of damage from spruce beetle.

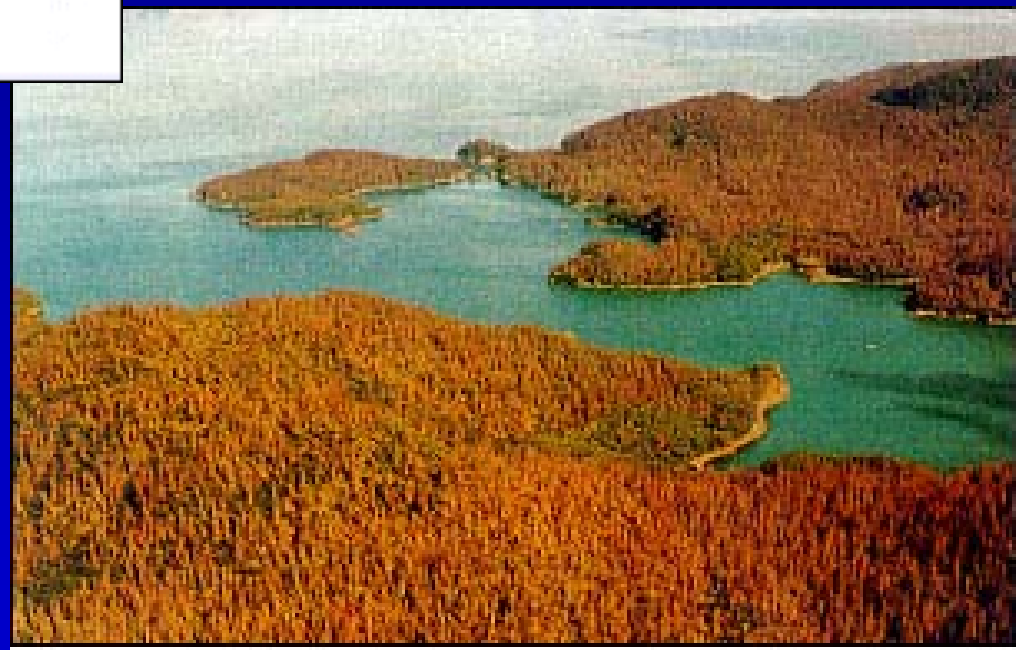
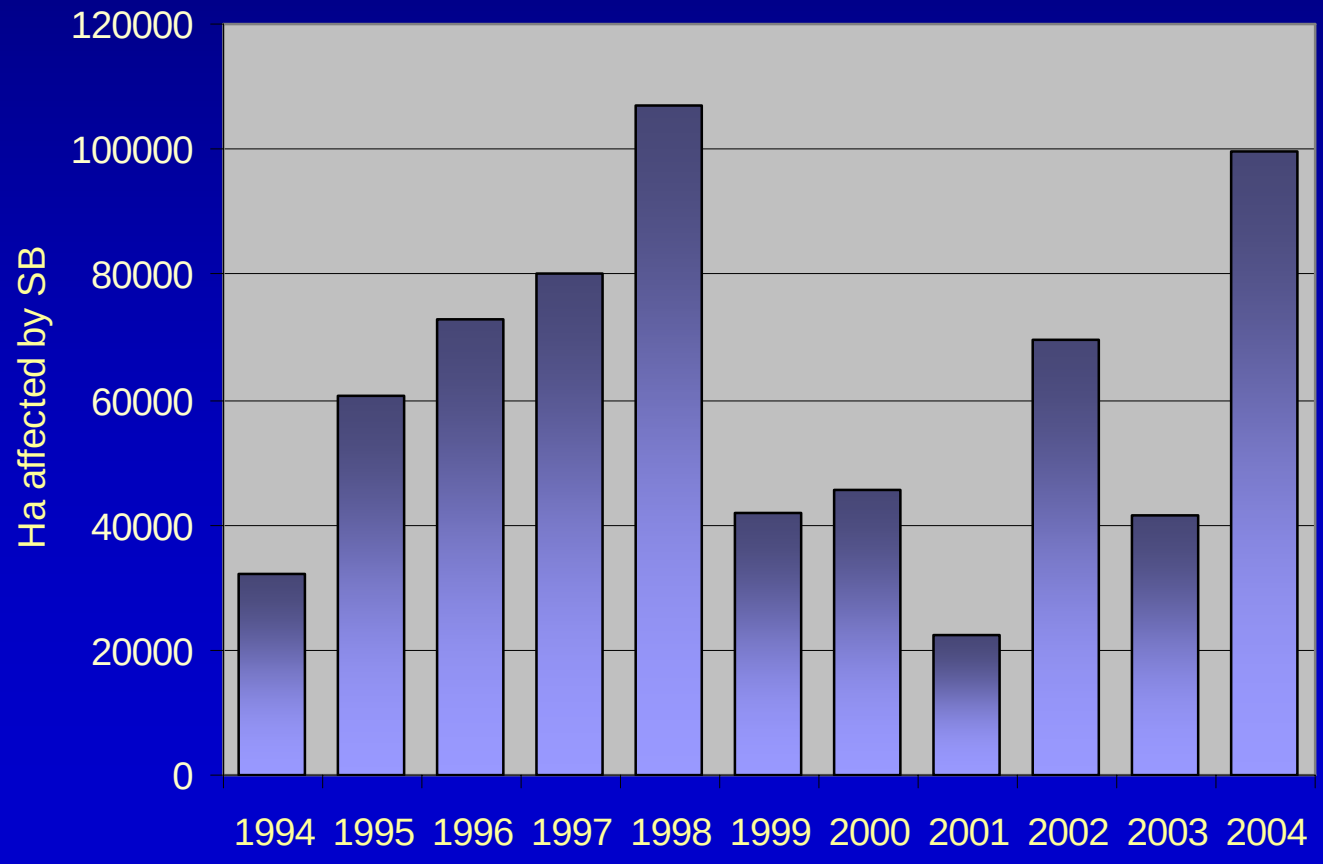


Figure 1 -- Yellowish orange and reddish colors of faded spruce are evidence of an intense spruce beetle infestation in Alaska.

Over 400,000 ha in the Yukon have been affected by spruce beetle – the largest ever to affect Canadian forests.



Ha affected by spruce beetle in the Yukon

1994-2004

Clearing the fog on the future of B.C.'s pine forests

- The "other" outbreak – status of Ponderosa pine in the southern interior
- The current status of young pine & mountain pine beetle
- Learning from the past and applying in the present & future

Interior forests are most often regenerated through catastrophic events.

Setting the stage and paying the price – what have we learned?

Okanagan Mtn. Park fire 2003

The other outbreak . . .

Western pine beetle, *Dendroctonus brevicomis*, in southern B.C.

45,537 ha of Ponderosa pine mortality mapped in 2006.

Most of the 2006 attack

Entrance into Kamloops


Exponential increase of MPB & WPB attack into
Ponderosa pine dominated areas in 2006.

Why is the MPB attacking young pine?

- Supply of large, mature host is diminishing
- Extreme beetle numbers dispersing during summer flight period – population "mixing"

- Young stands are now more vulnerable:
  - proximity to high populations of MPB
  - trees have larger diameters at younger age
  - Successive years of drought stress

MPB attack in small diameter or young pine is **NOT** a new phenomena.

As an outbreak declines in an area, MPB is pushed into less desirable host material.

This phenomena typically indicates a population "crash".

Brood production is low; with negative population growth in these stands.

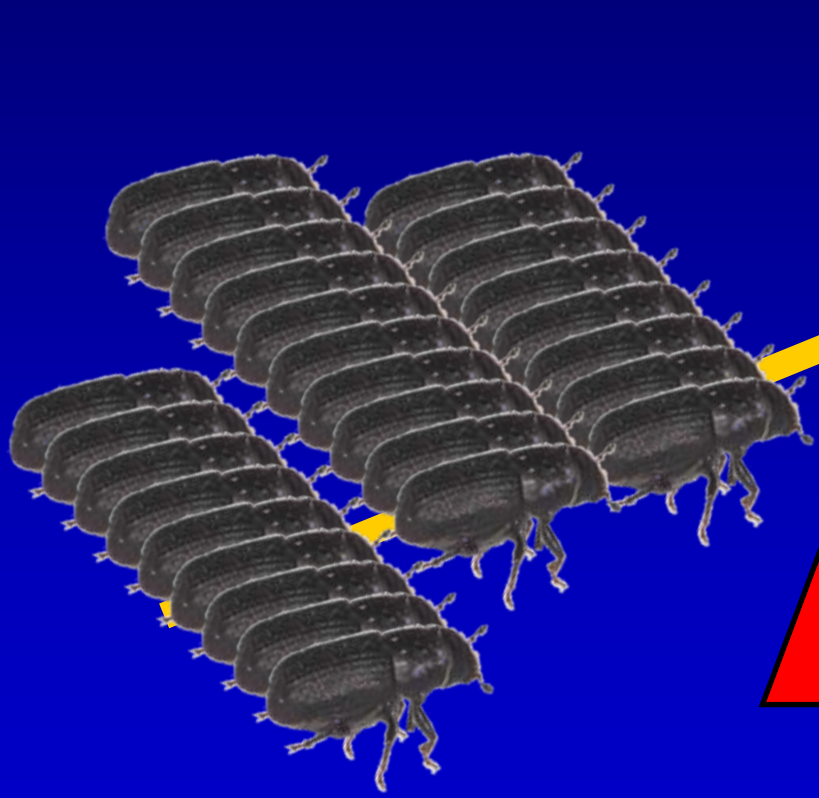
MPB

Biological/physical control agents

My version of "Desperate Housewives"

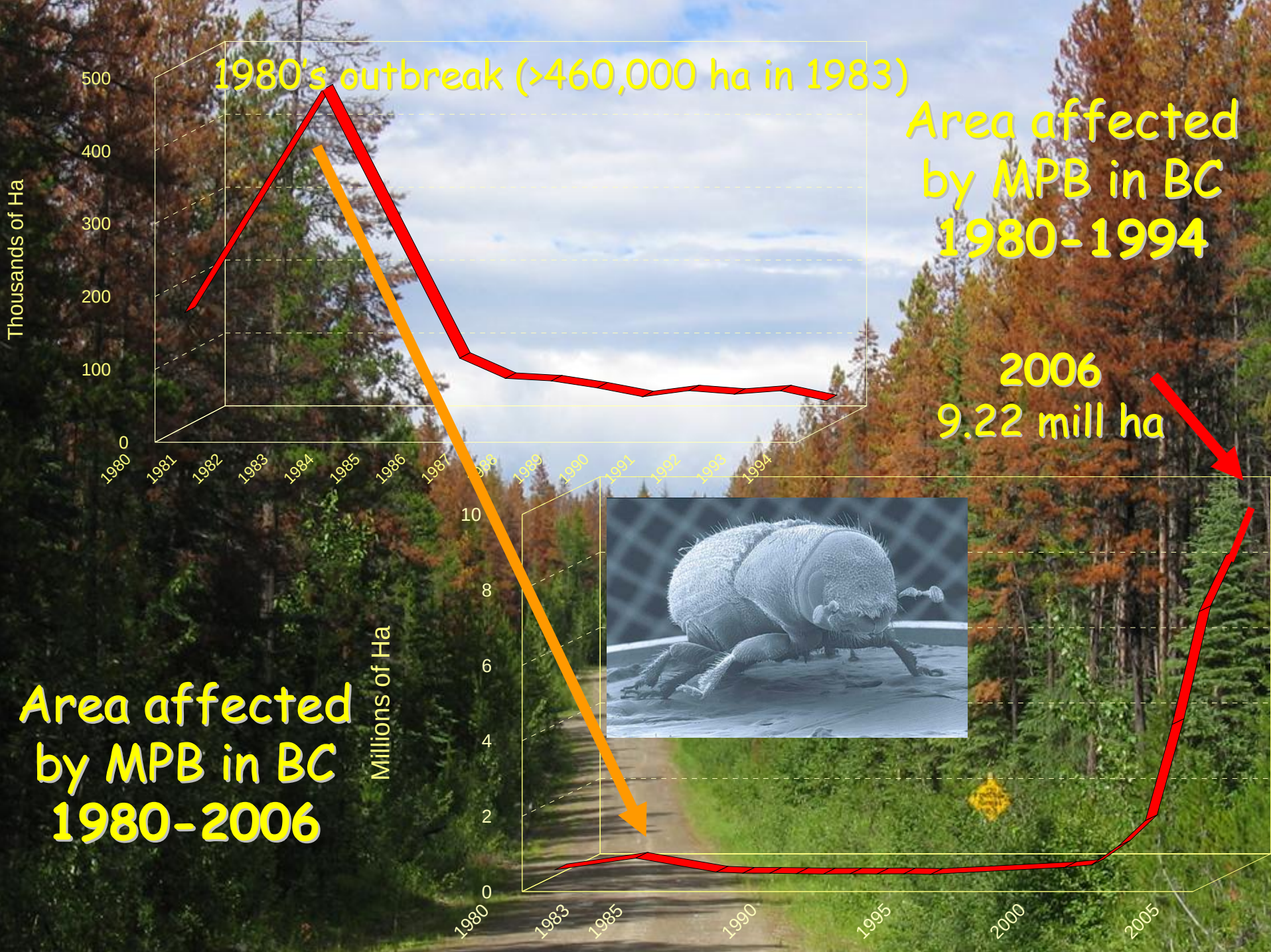
"Desperate Bark Beetles"

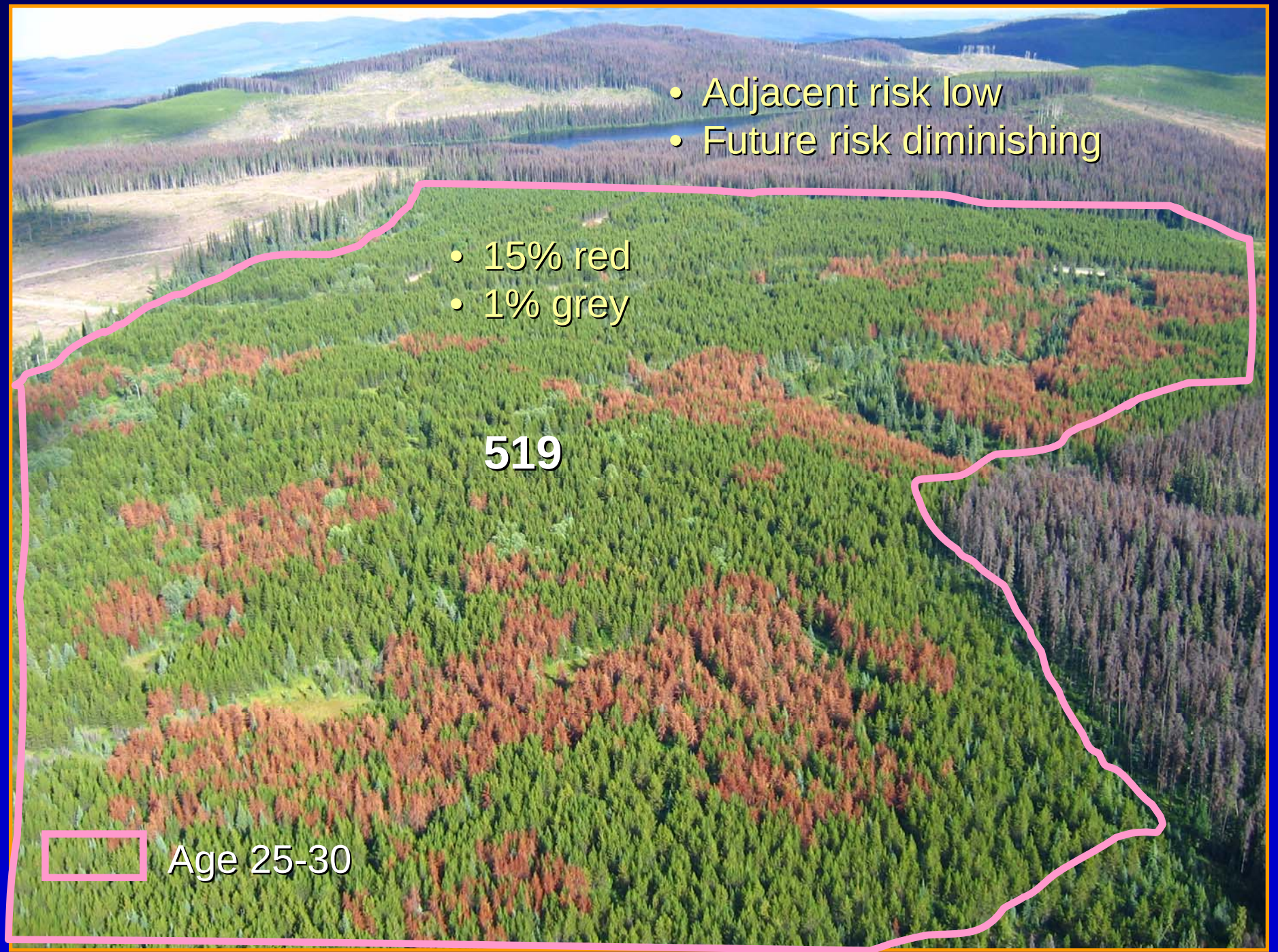
Overwhelmed!!



B.C.

Critical Mass Theory


1980's outbreak (>460,000 ha in 1983)
Thousands of Ha
500
400
300
200
100
0
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
Area affected by MPB in BC 1980-1994
2006
9.22 mill ha
Millions of Ha
10
8
6
4
2
0
1980
1983
1985
1990
1995
2000
2005
Area affected by MPB in BC 1980-2006


• Adjacent risk low
• Future risk diminishing
• 15% red
• 1% grey
519
Age 25-30

Mortality in young pine is due to massive movement of beetles from surrounding depleted mature pine, rather than build-up within these younger age-classes.

Other insects are also killing these trees:

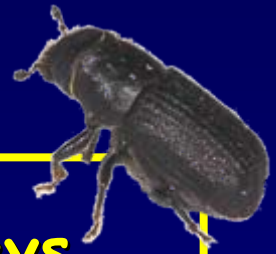
Pityokteines

Pityogenes

Ips

and others

Young Pine Project - Quick Facts



2005 - Aerial surveys

143 mapsheets

1,206 stands

49% w MPB

4.3% w >50% red attack

Range: 0-90% red attack

2006 - Aerial surveys

226 mapsheets

2,528 stands

74% w MPB

~9% w >50% total attack

Range: 0-95% red attack

Ground surveys

164 stands in 6 Districts

48% w MPB

Ave. 20% green attack

Ave. 4% red attack

Ground surveys

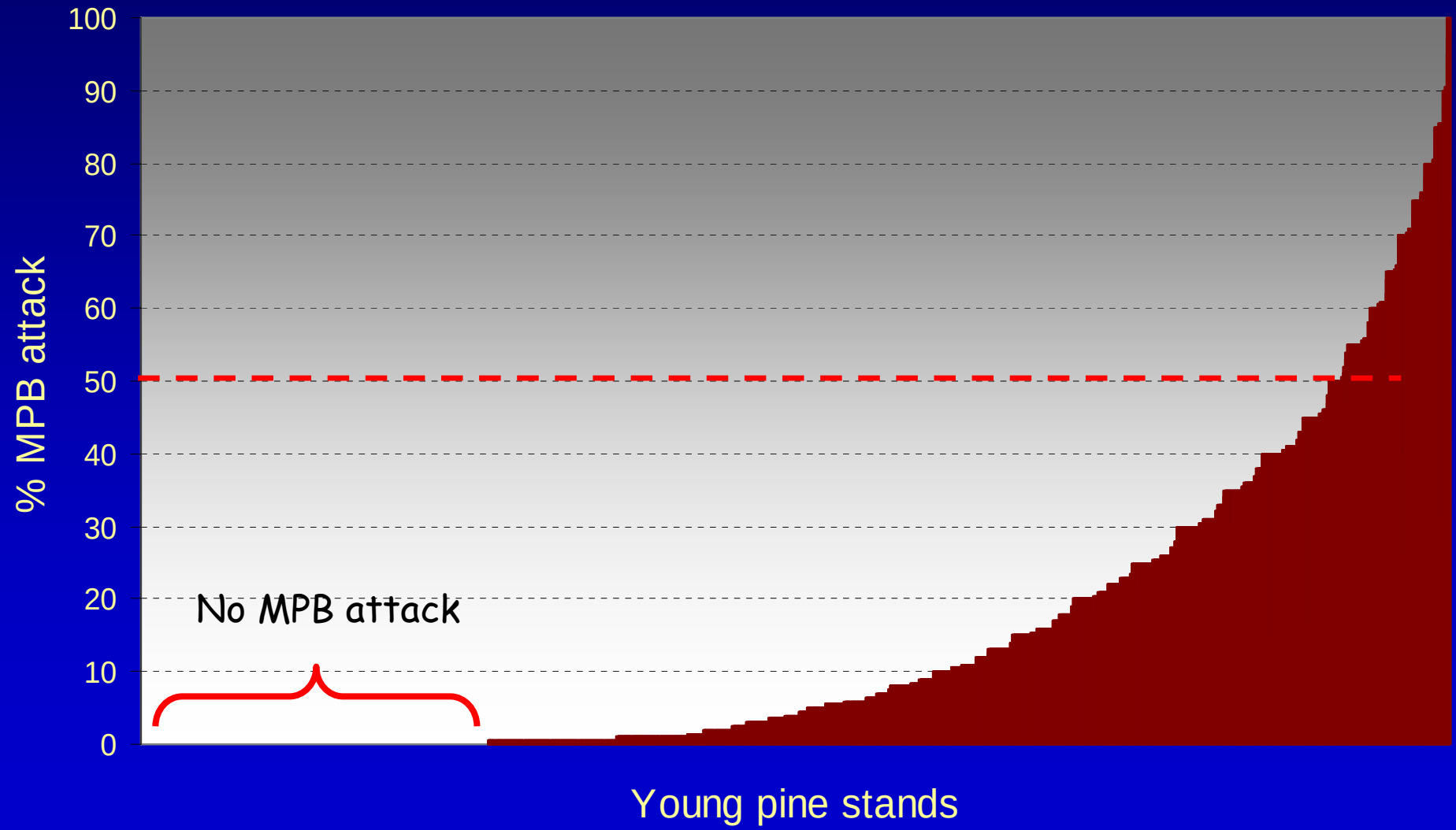
285 stands in 9 Districts

73% w MPB

Ave. 30% green attack

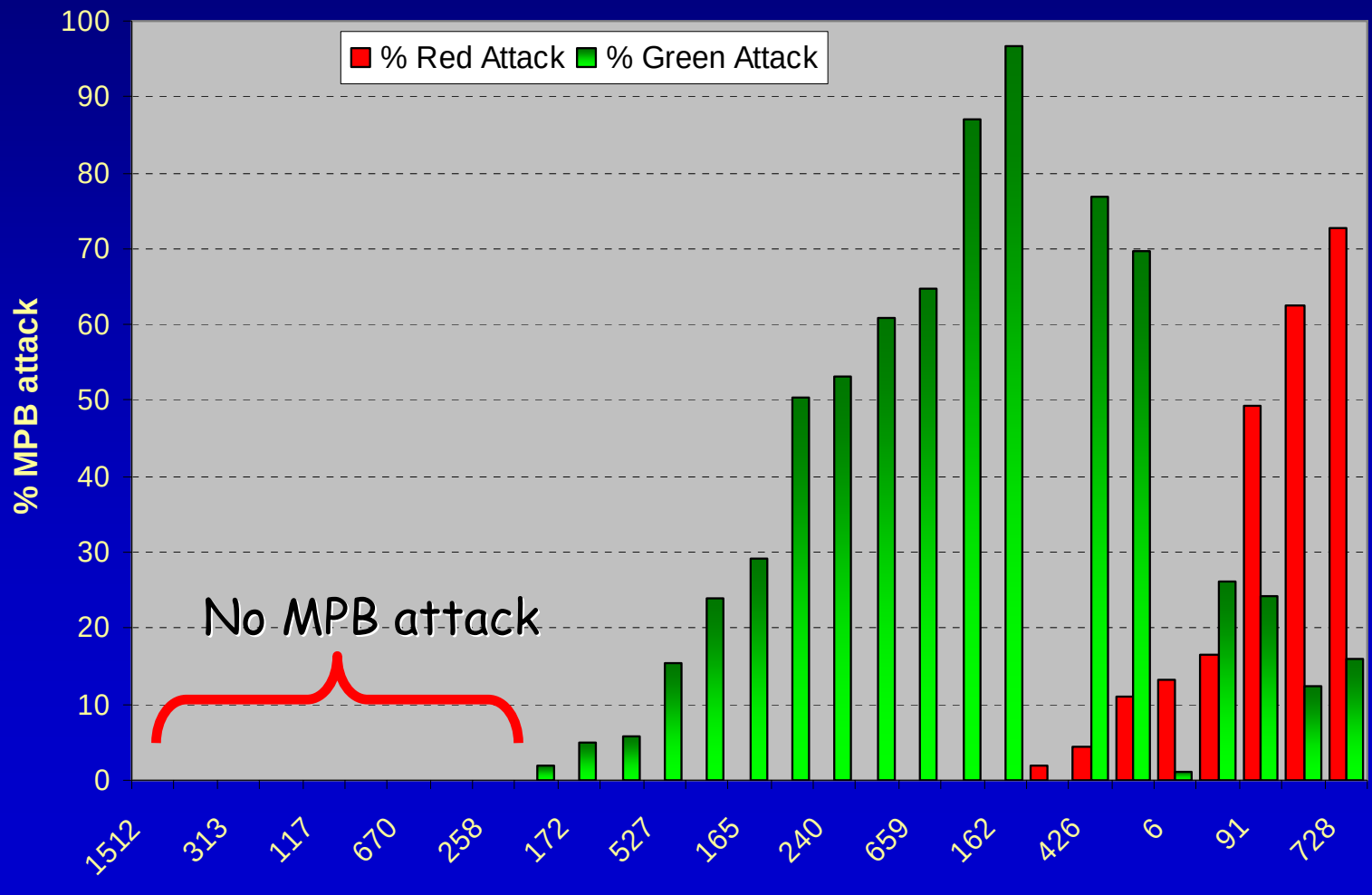
Ave. 11% red attack

Percent mortality as assessed in aerial surveys in 2007 – all stands (red + grey)



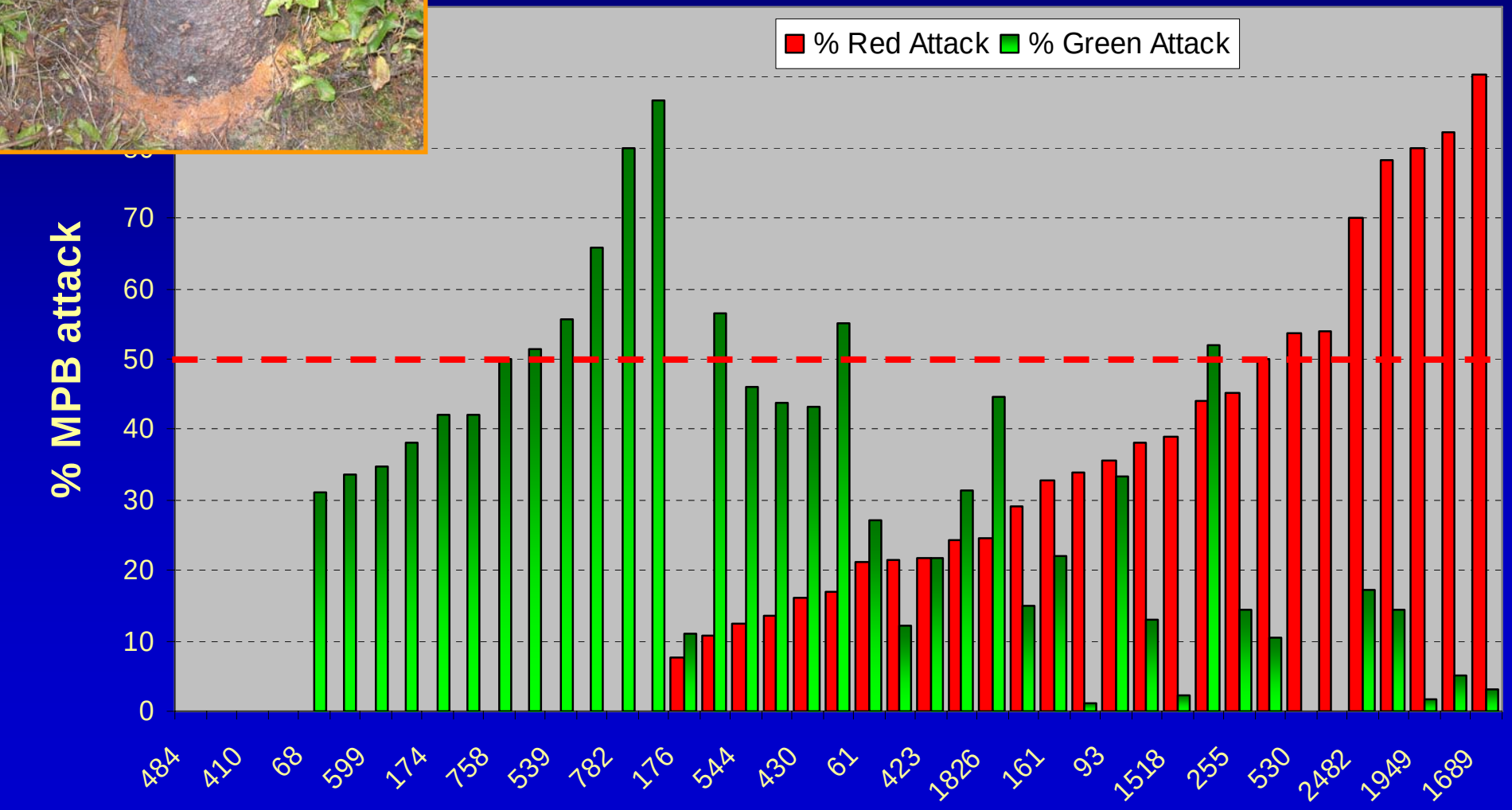
2006 Ground Surveys

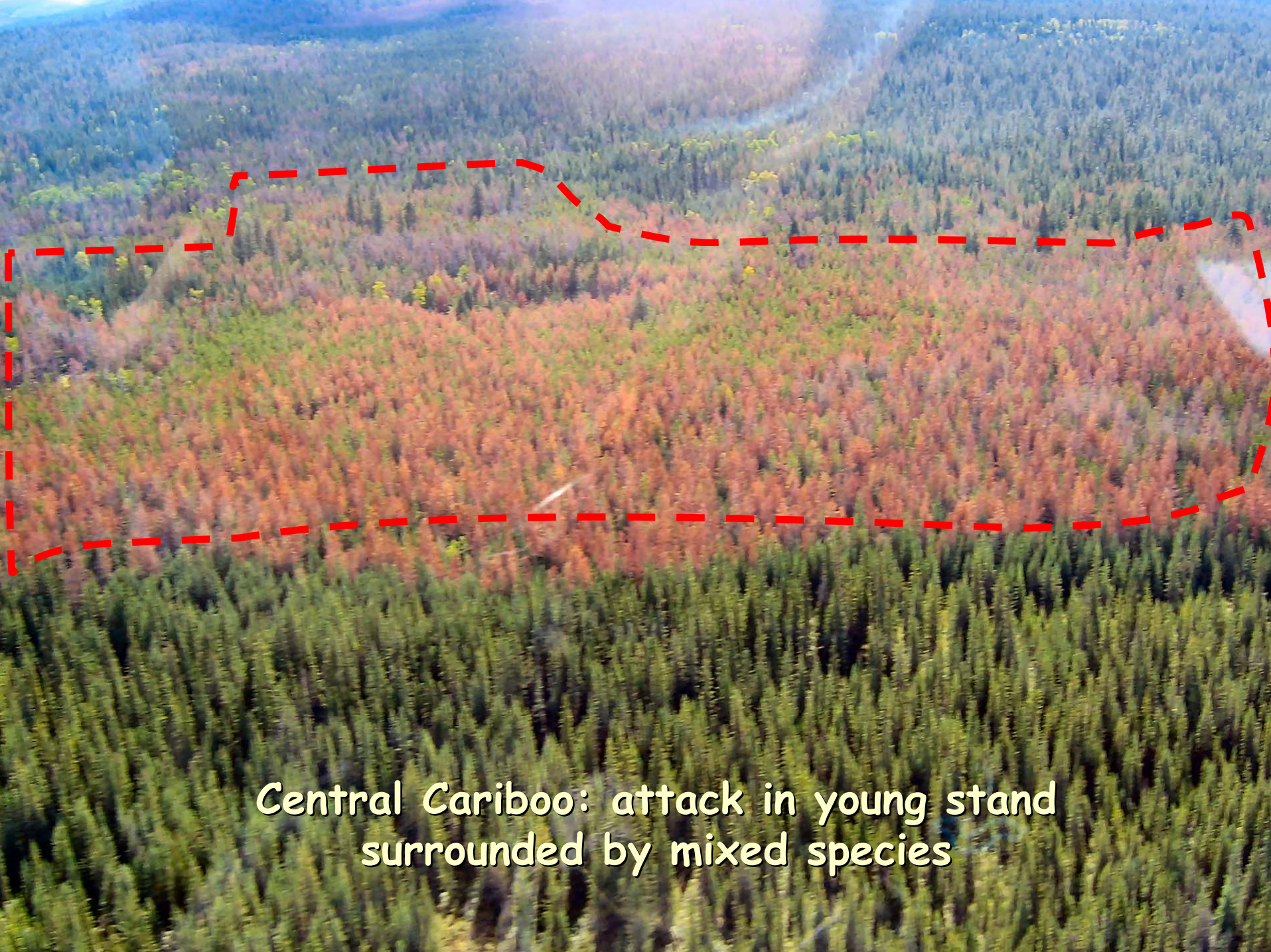
Average percent MPB attack - Vanderhoof



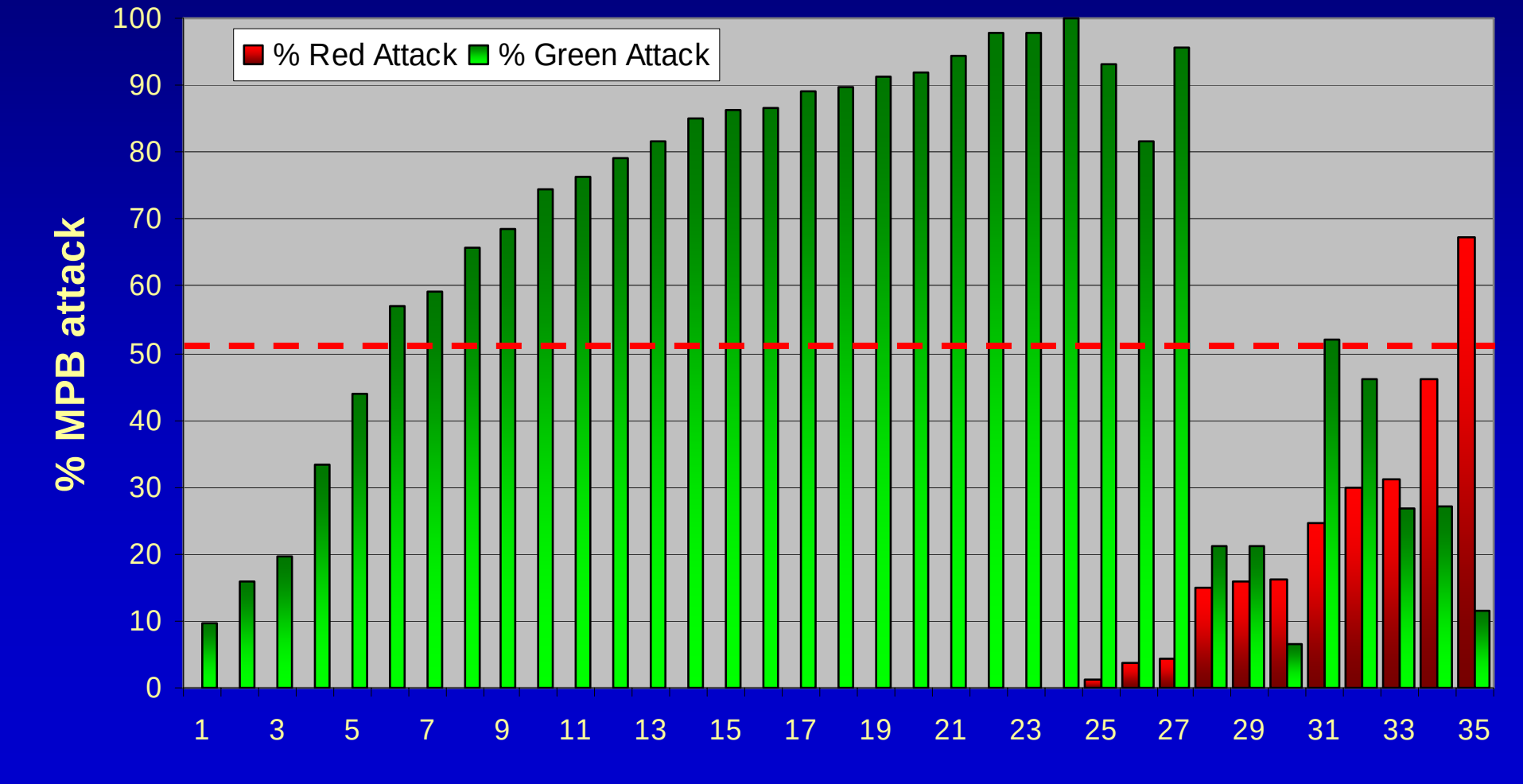

Vanderhoof, August 2006

Average percent MPB attack – Central Cariboo




Central Cariboo: attack in young stand
surrounded by mixed species

Percent MPB attack (old *vs.* new) – 100 Mile House




Central Okanagan 2006
Too late – overrun

Beetle sink or beetle factory?

R-values (brood production) ranging from 2-9 in young trees compared to 18-21 in mature stands in same locations.

R-value of 4 = increasing population.

Observations

Raffa and Berryman 1983

- Reproductive success decreases at attack densities >80 galleries/m^2

Galleries per m^2 in young pine range from 100/m^2 to >300/m^2.

Spaced and fertilized trees yielding more brood.

R-values after Dec cold-snap:

Immature = 5.3

Mature = 6.5


Quesnel 2005
93B077_378


Quesnel 2006
93B077_378


Quesnel 2005
93B086_131


Quesnel 2006
93B086_131


Quesnel 2006
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Quesnel 2006


Thank you.