

The background of the slide is a scenic landscape photograph. It shows a calm lake in the foreground, reflecting the sky. The lake is surrounded by dense evergreen forests. In the background, there are large mountains with patches of snow on their peaks. The sky is a clear, bright blue. The text is overlaid on this image.

Insects: The Agents of Succession. Dynamics of Forest Insects in Changing Ecosystems

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1. Response to change: an ecological and entomological point of view
2. Inventory and management
3. Insects on the move - defoliators and bark beetles
4. Research and management - planning, responding, risk-taking
5. Summary



1. Response to change: an ecological and entomological point of view



Ecological

In the absence of disturbances, ecosystem change in response to global warming may occur gradually over a period of decades and may not kill dominant species directly.

Although stressed, forests may superficially appear unchanged. Biotic agents (insects) will respond to this "signal" and hasten or change successional processes.

Change may not occur in an orderly progression nor indeed will there be a smooth and linear sequence of events.

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

Entomological

Small climatic changes likely will promote large responses by insects, particularly where tree species are at their distributional limits (transition zones or marginal habitats).

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

Averaging a future warmer climate may miss these insect responses.

Climate change: may alter insect population dynamics and host ranges at differential rates.
How do we model impacts?



Higher temperatures and altered precipitation regimes 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.



In the immediate future, the most notable change in insect dynamics will probably be range extension.

Sites where trees are at the outer limits of their range or on marginal sites could be ignition points for incipient outbreaks.

Higher frequency of small, localized outbreaks.



Climate, weather, host species ranges and insect outbreak dynamics, will stretch our ability to manage and maintain healthy forests



What *is* known about insects?

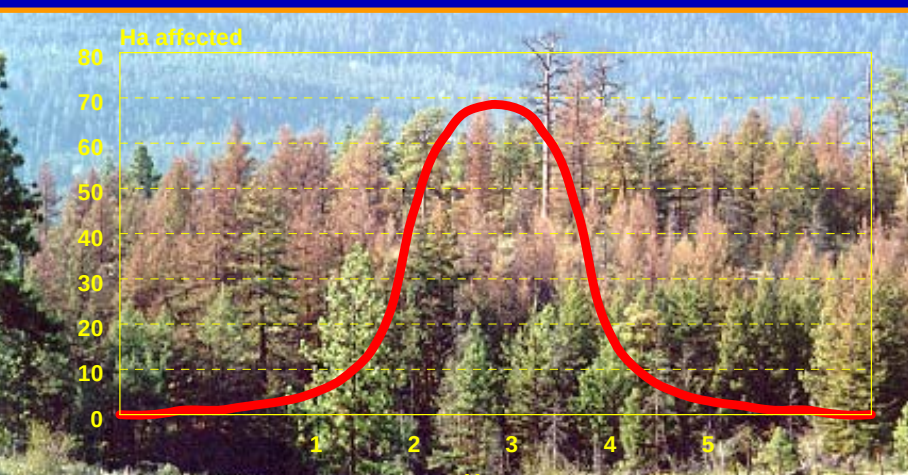
- Insects are short-lived, compared to their long-lived hosts.
- Insects are often unpredictable - certainly in the face of unpredictable climate fluctuations.
- They disregard forest management plans.
- They can be eruptive in nature.
- They can be chronic and insidious.
- Insects drive or halt succession.



In our future forests, smaller outbreaks (mortality causing insects especially) will become increasingly important as our constraints on the forest land base increase.

What *should* we know about insects?

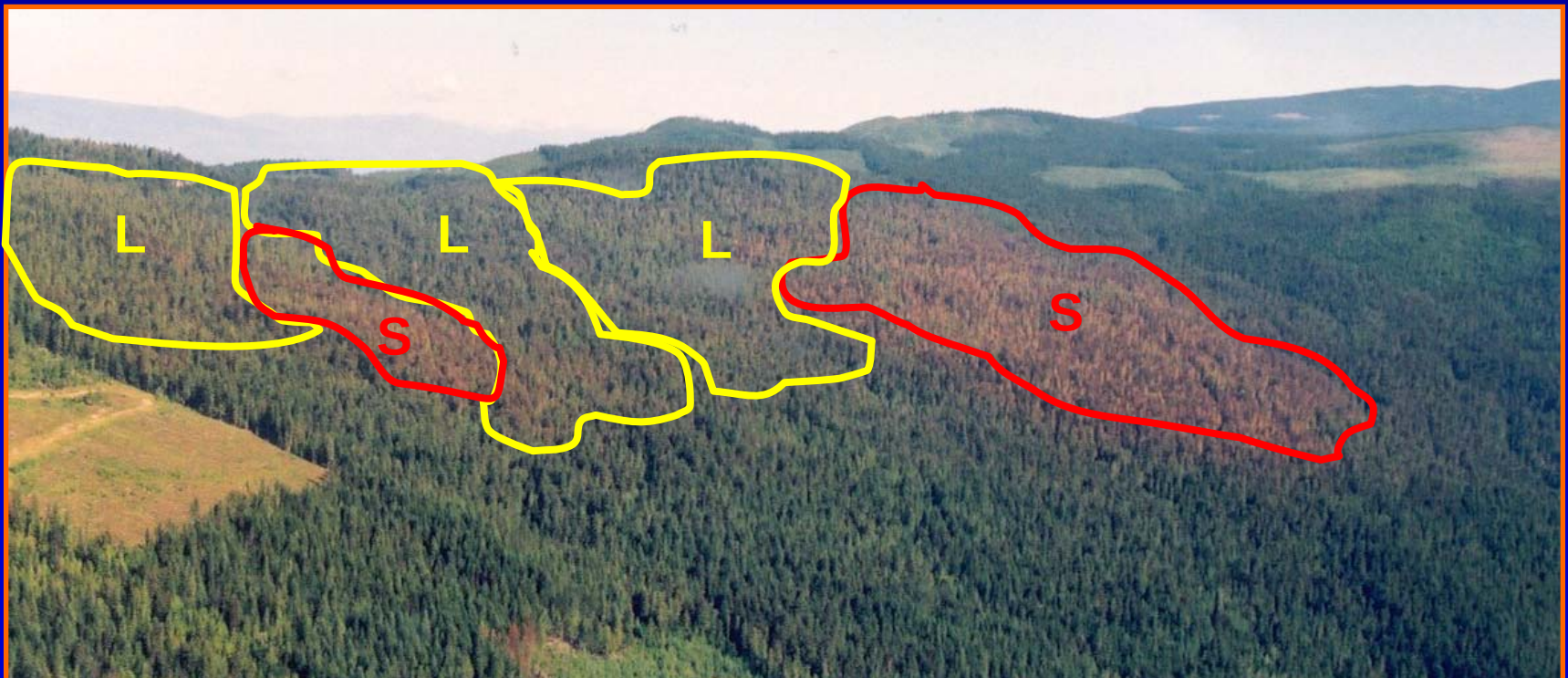
- Life history and survival functions critical to understanding the response of insects to changing environments and management regimes
- Incipient phase of insect pests and the environmental triggers
- Dispersal and outbreak dynamics in changing forest environments
- Genetic variability and plasticity of insects



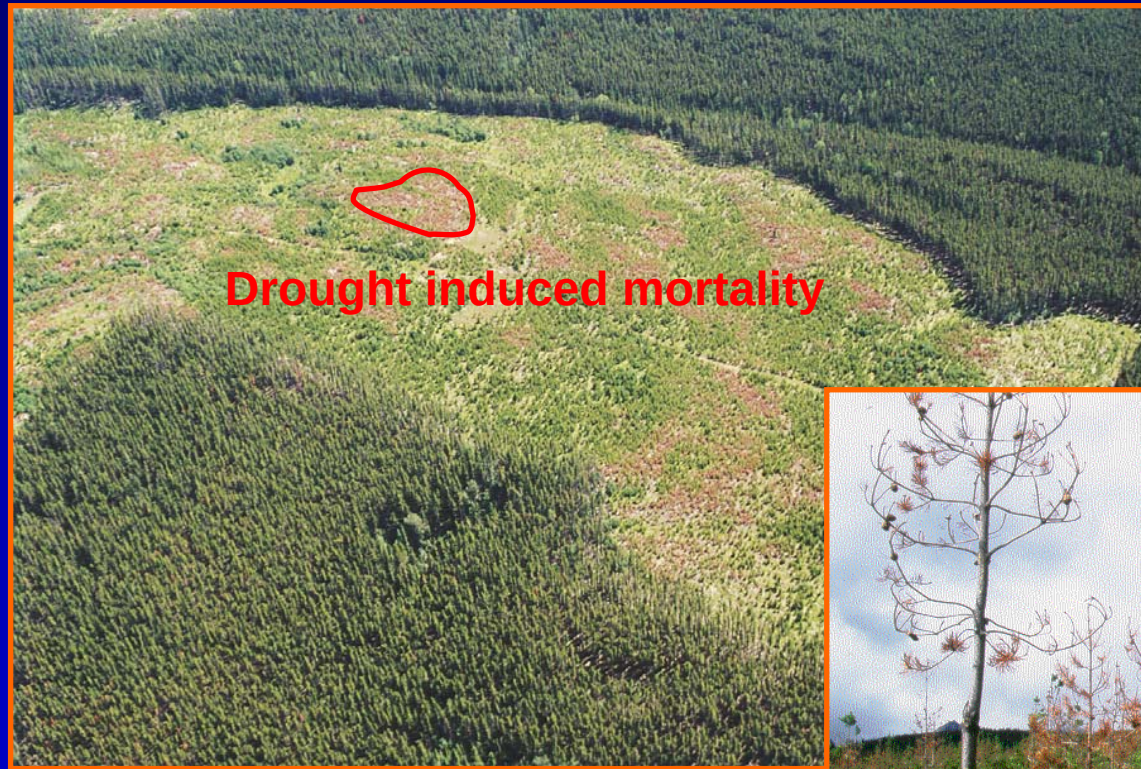
2. Inventory and management

BC's tracking/inventory systems for pest/forest damage is among the best.

Insect damage and disturbance is mapped annually and is well tailored to capturing "change" on the landscape.

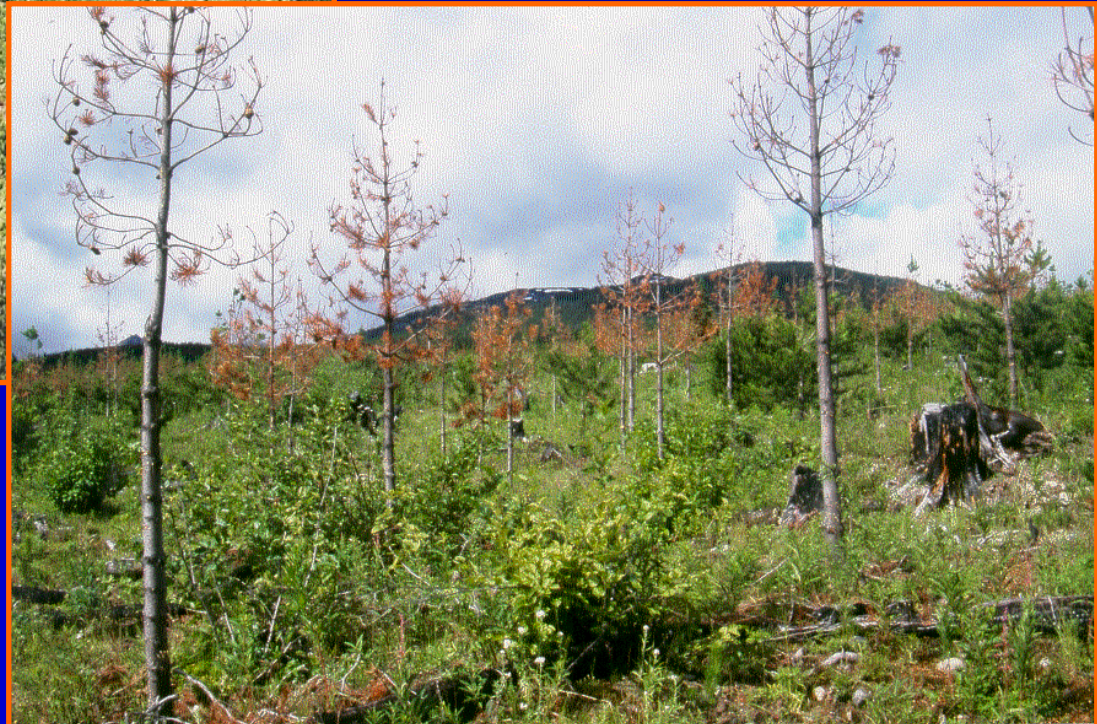


The challenge is to compare the changing patterns of damage (scale, intensity, geographic distribution) with the changes of ecosystems or trees/vegetation.



Drought induced mortality

Erratic, unpredictable changes will stretch our ability to manage and maintain healthy forests.



Planning for future change is the acceptance of associated risks.

Questions



Assessing management intent - what are we trying to do when we apply "pest management" on the landscape? Is this even possible?

The management imperative - The best available management tools are useless without the political will to use them in a uniform effort over time and space. How do we achieve that?

Loss of expertise and experience - Given current demographics, institutional and public memory is going to fade. How do we avoid an erosion of political will?

In mature, unmanaged forests our options for intervention will remain largely confined to being reactive.

However, there are pre-emptive approaches that can be applied to better set-up both our existing mature inventory and future forests to maximize their resiliency and productivity.



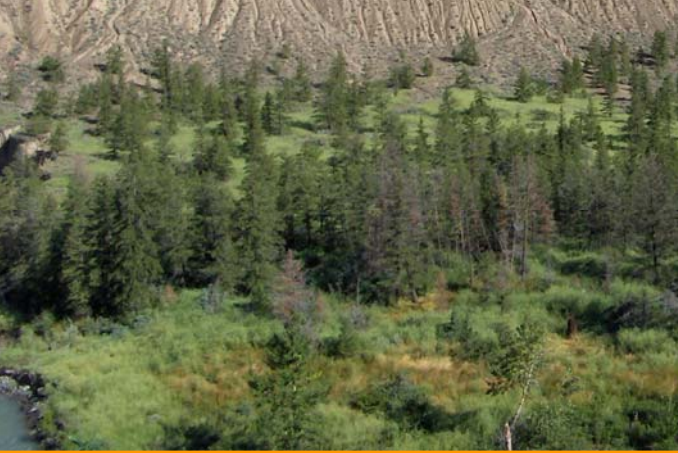
Establishment of new forests should be done "thoughtfully" and with pests and change in mind.

3. Insects on the move - defoliators and bark beetles



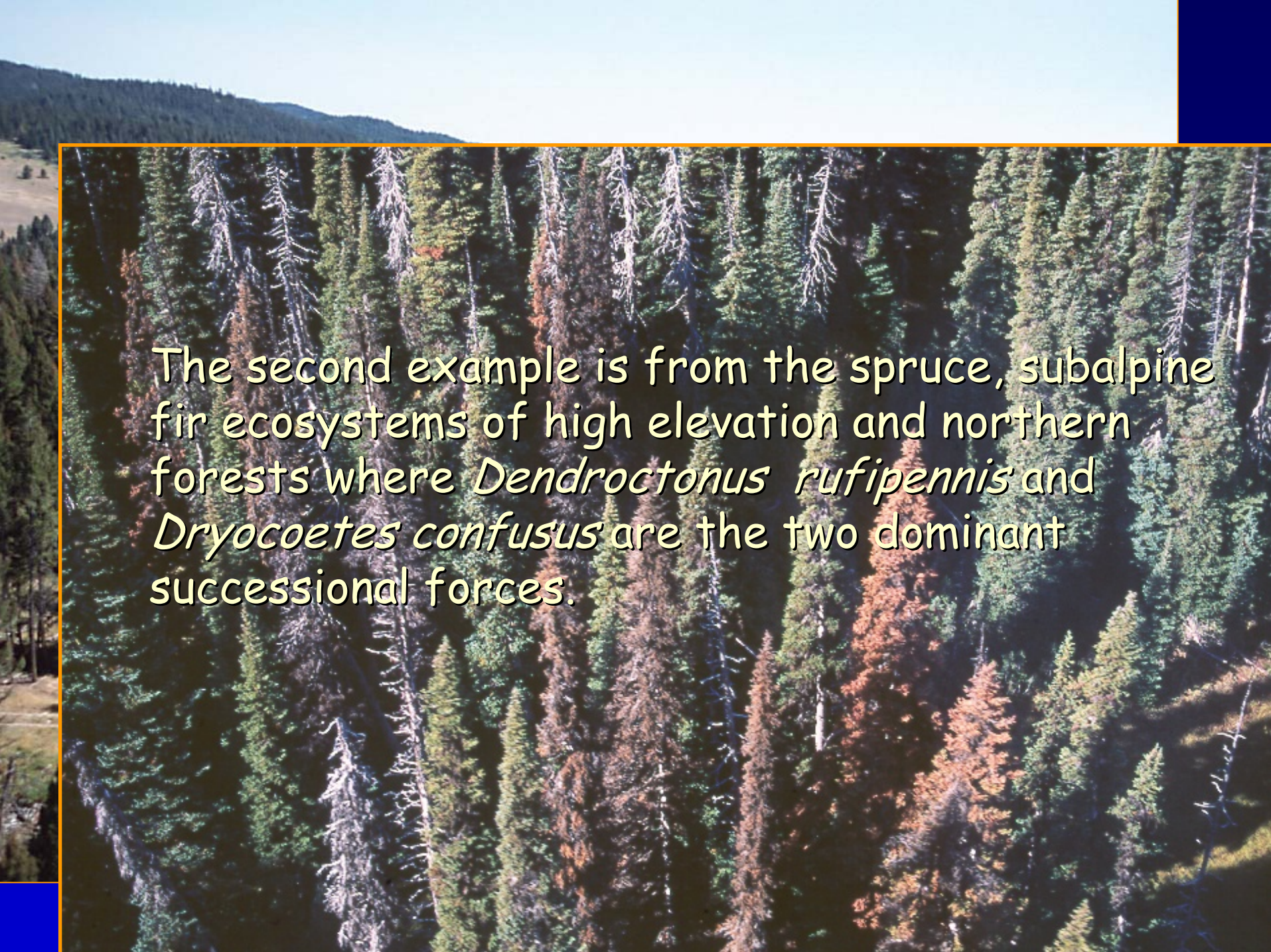


Two ecological
extremes



Observed and
predicted insect
outbreak
dynamics





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

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
- Outbreaks more extensive, severe and long-lived
- 1987 outbreak temporally more synchronous across more sites than previously recorded
- Expanded into "new" areas

Outbreak populations respond to climatic influences therefore, with altered climatic conditions historical outbreak patterns could also change.



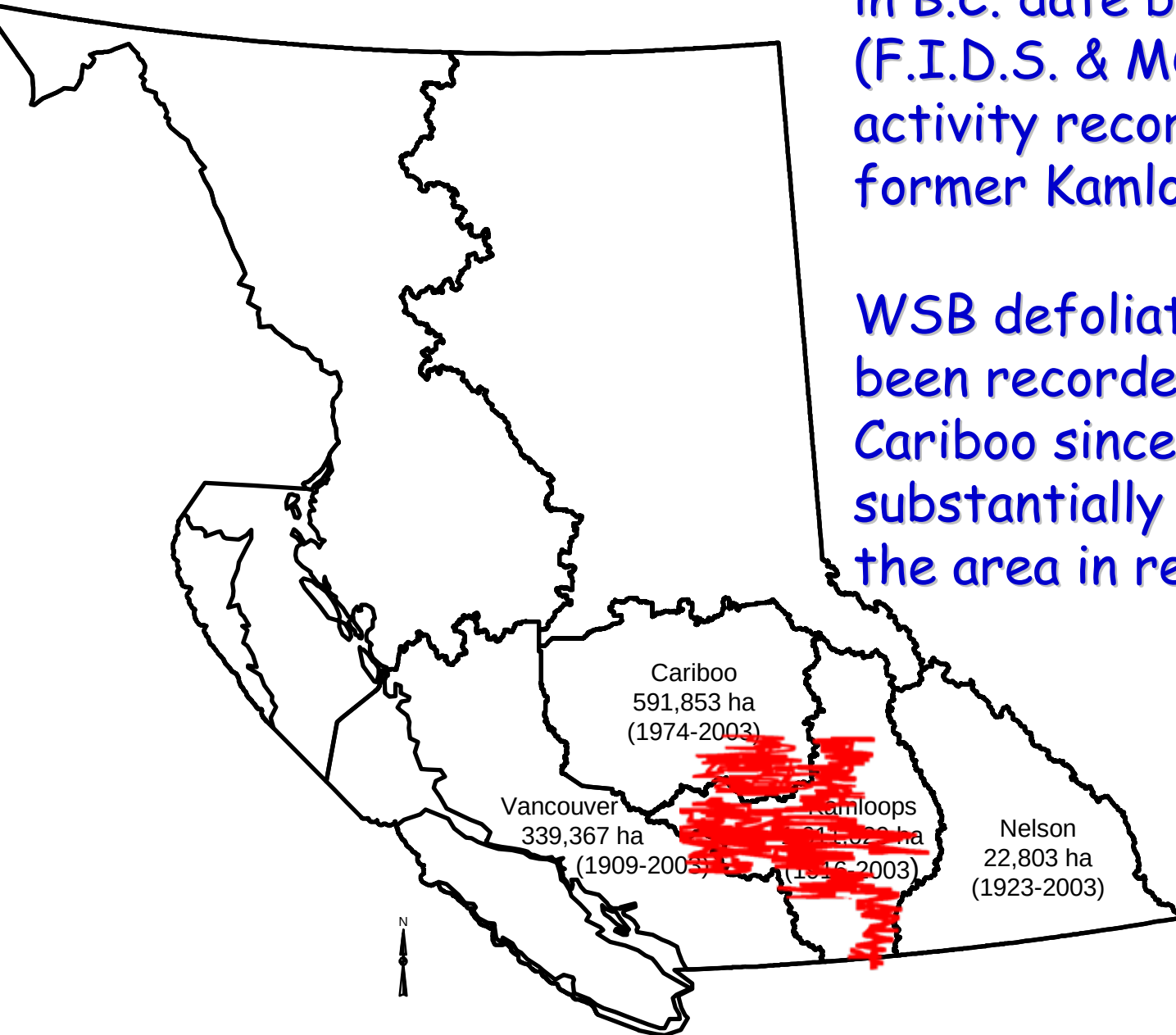
Struggling forests:

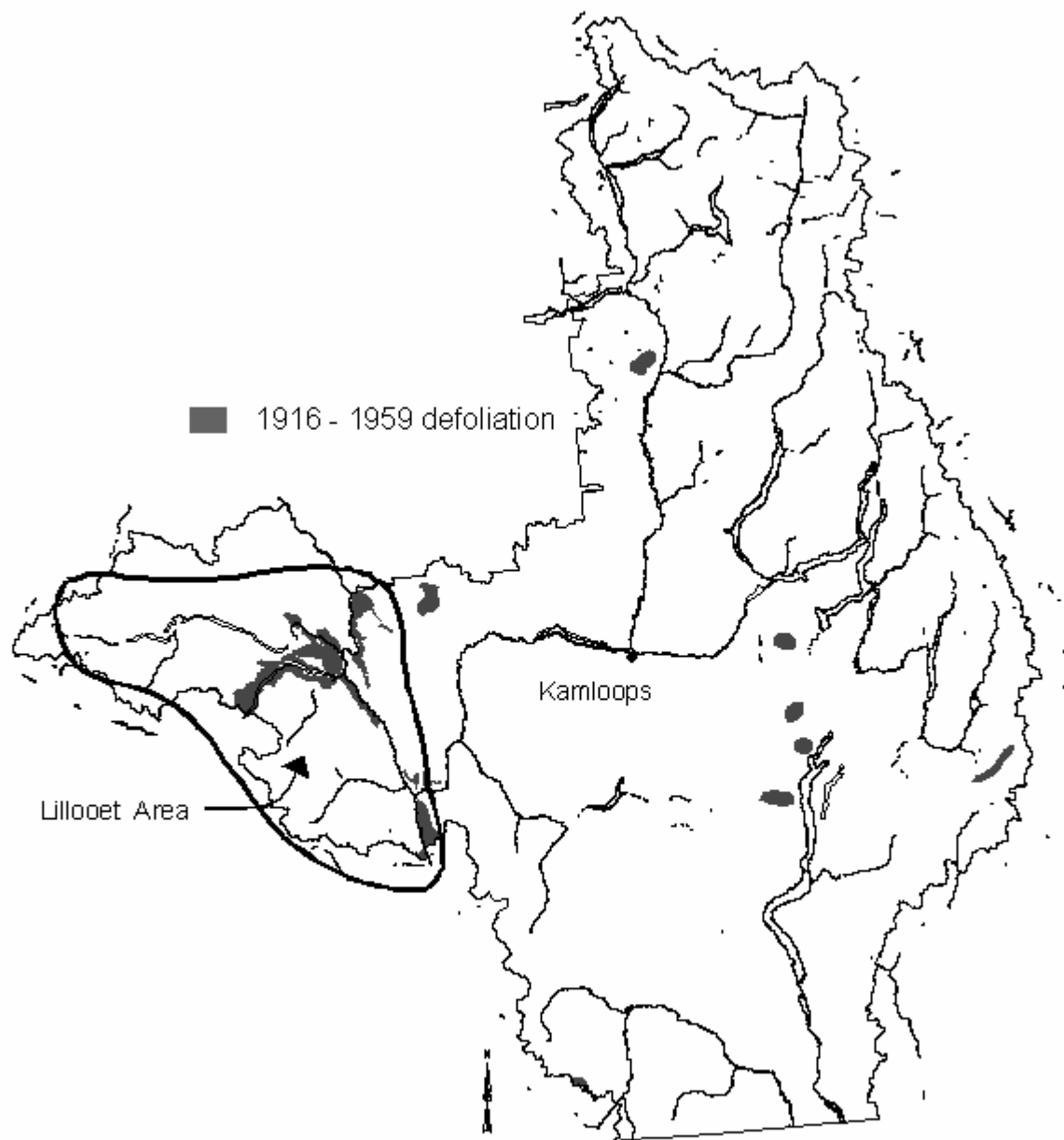
- Suppression of fires
- encroachment and expansion of host species
- harvest/silviculture practices
- climate change, and
- other management influences



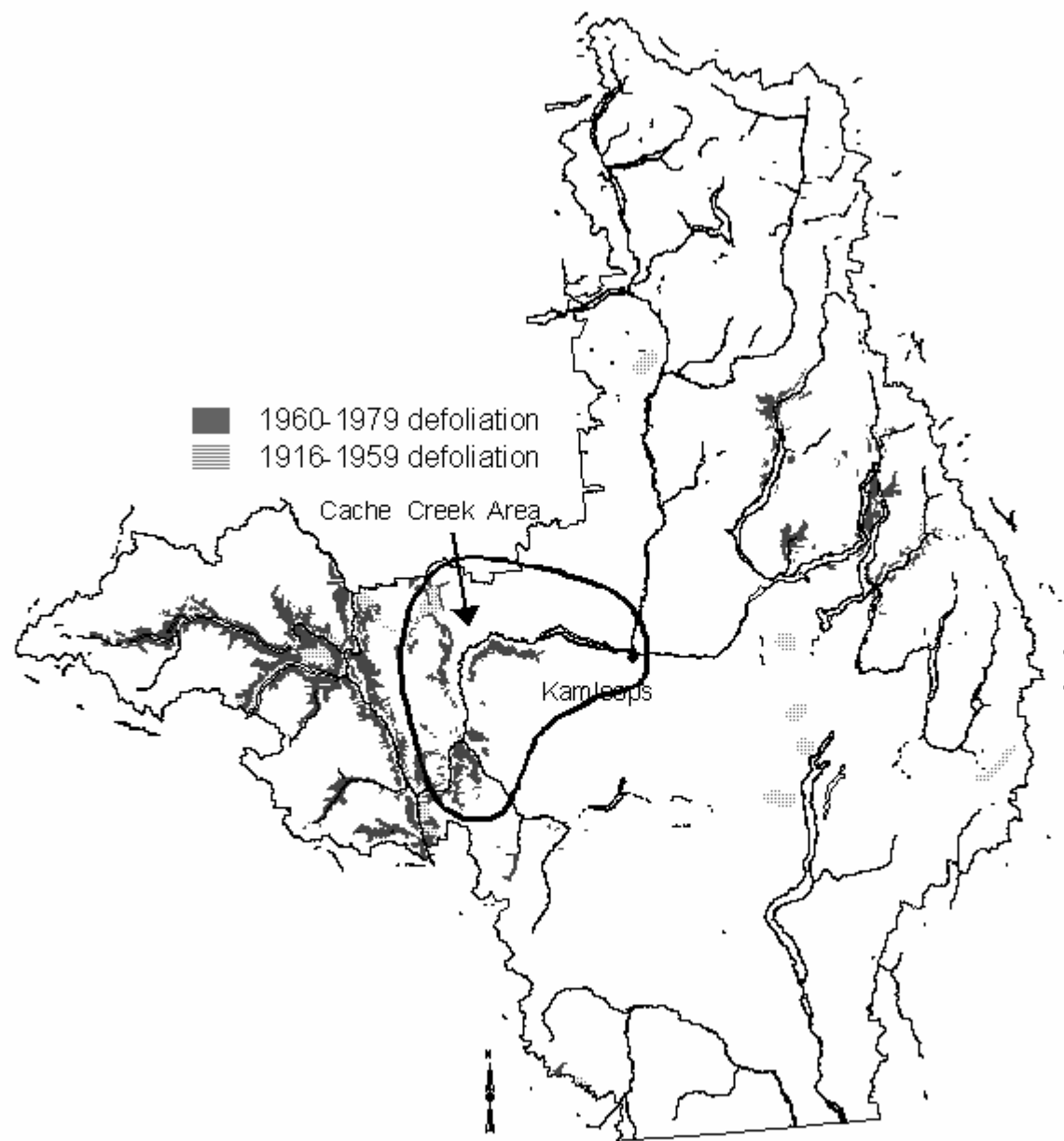
Records of WSB defoliation in B.C. date back to 1909 (F.I.D.S. & MOF) with most activity recorded in the former Kamloops Region.

WSB defoliation has only been recorded in the Cariboo since 1974 and has substantially expanded in the area in recent years.

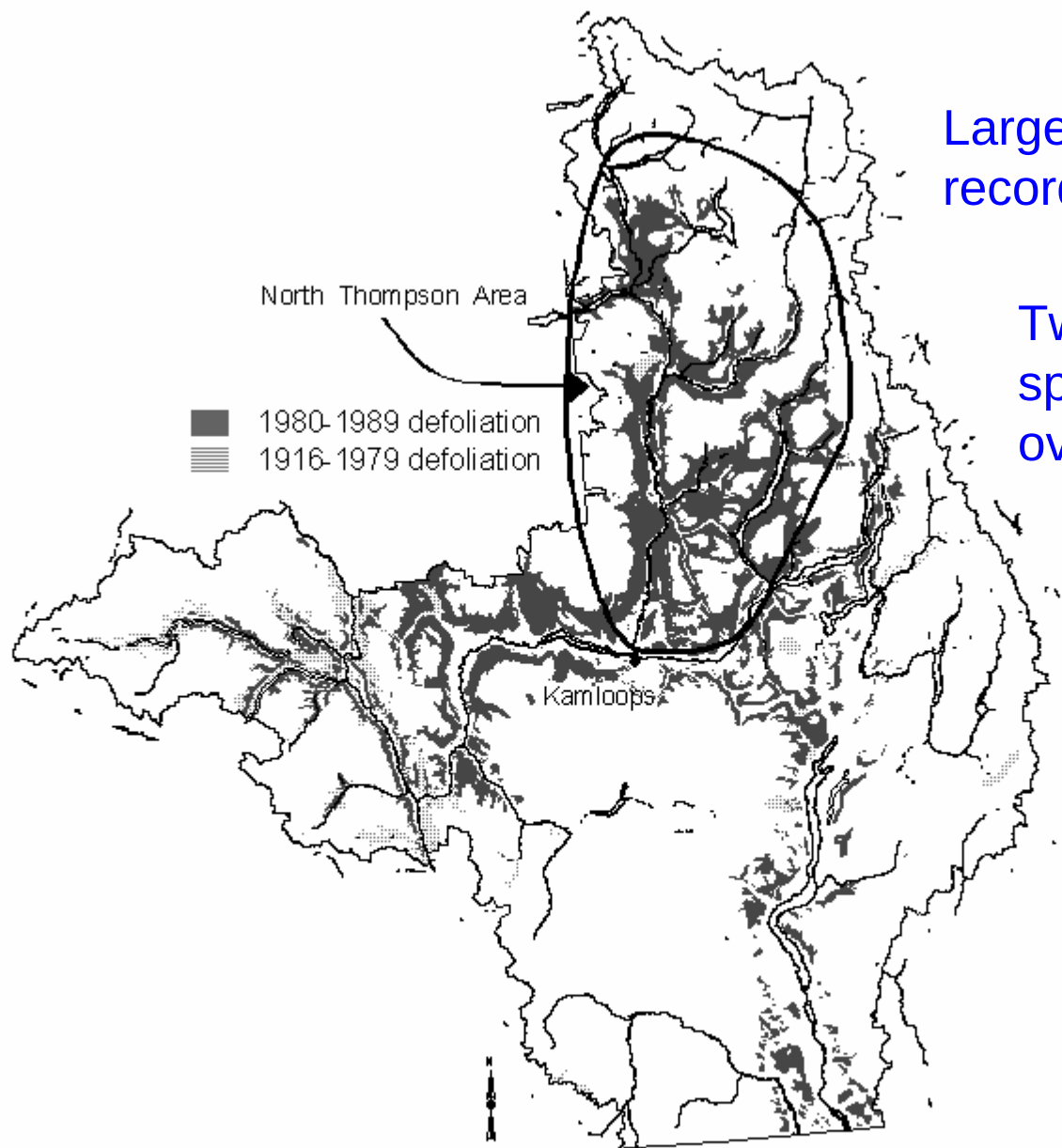




a) 1916-1959 defoliation



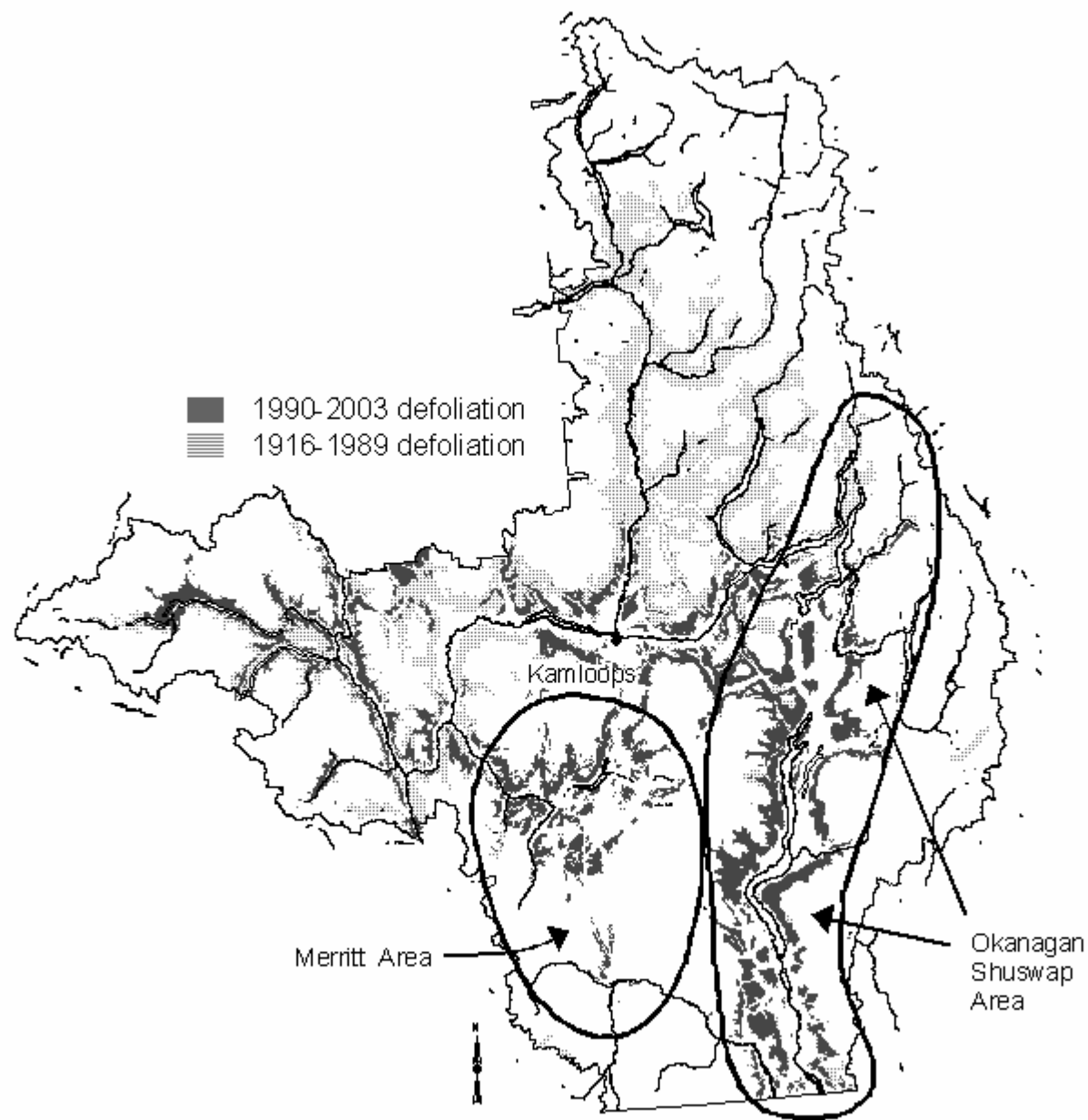
b) 1960-1979 defoliation



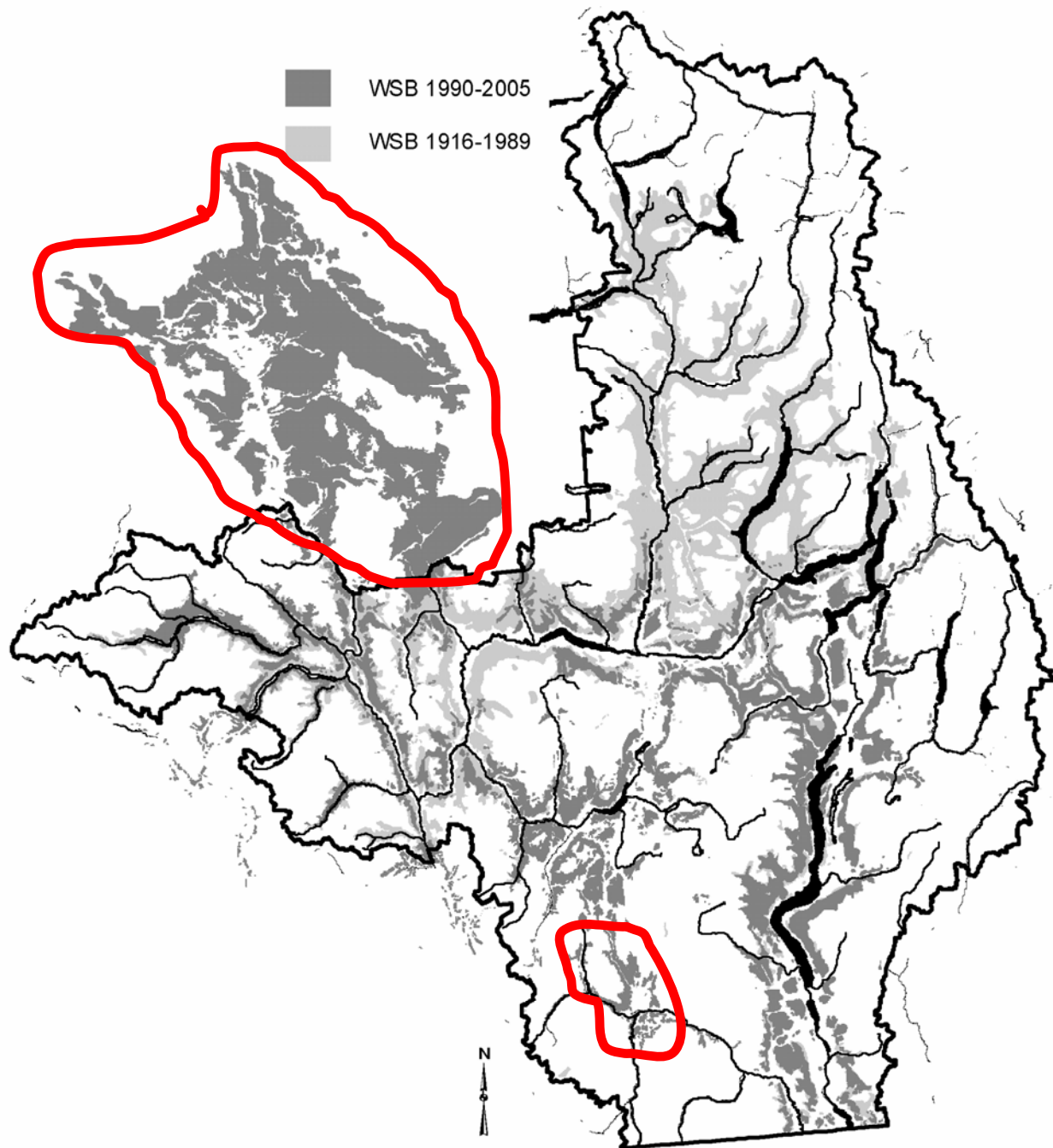
Largest outbreak ever recorded in 1987.

Two budworm species ranges overlap.

c) 1980-1989 defoliation



d) 1990-2003 defoliation



Host and insect ranges have changed over the past century but what are the underlying causes of this change?

Evaluations of stand structure, vigour, mortality and outbreak histories through various means, including dendrochronology, have led to significant findings.

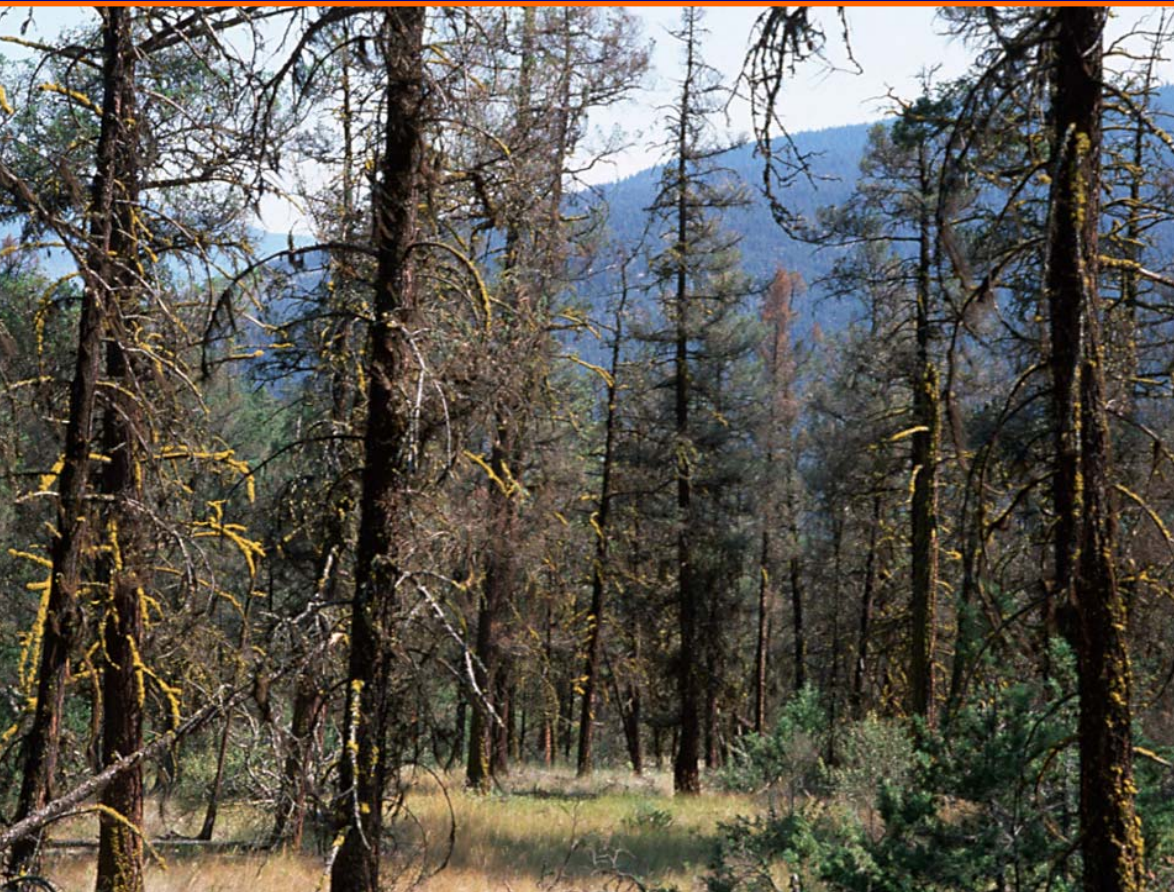


An aerial photograph showing a vast, dense forest of coniferous trees covering a hillside. The forest is thick and green, with some lighter patches visible where the canopy is thinner or where there are fallen trees. The terrain appears to be a gentle slope. The sky is clear and blue at the top of the frame.

This natural stand type is most resilient to WSB, although very scarce over the landscape.

Caution

Most stands assessed in the Cariboo possess **Type 3** structure characteristics which foster higher, and more chronic populations of budworm and suffer the greatest impact.



- result of selective harvesting
- continuous entries to extract MPB-killed lodgepole pine
- warming trends have allowed **extension** of the budworms range

Recommendations:

- harvesting plans should accommodate WSB concerns
- promote less complex stand structures (patch cuts in drier ecosystems)
- space and thin existing stands
- promote mixed species where ecologically viable
- think about expanding the range of Ponderosa pine and growing lower densities of Douglas-fir





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.



The *Choristoneura*:

- 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.



Successional forces - rates of change?

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



Changing
susceptibility



Slow
succession

BI - WBBB



Rapid
succession

Sx - SB





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.

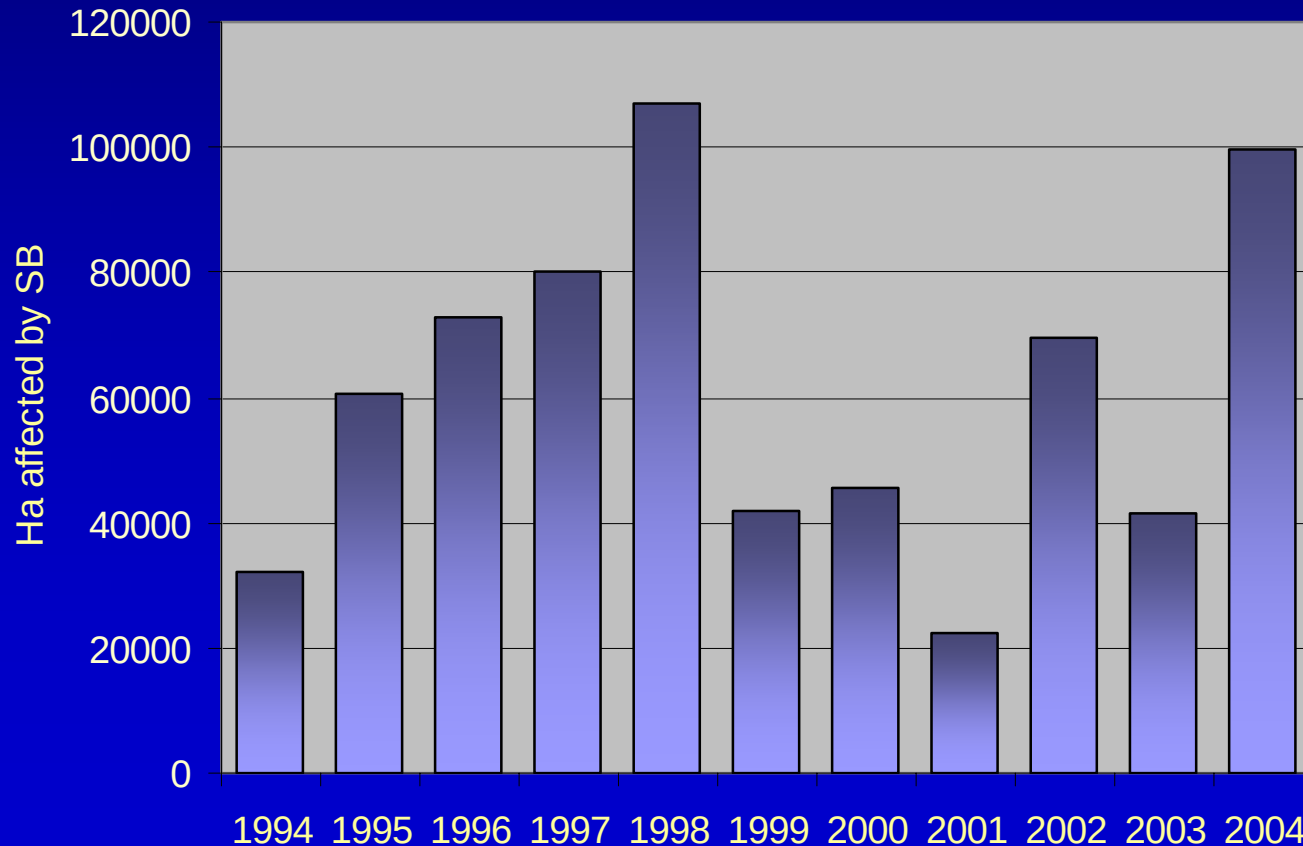
The inventory of spruce on BC's landscape is aging and highly susceptible - another large outbreak is imminent.

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



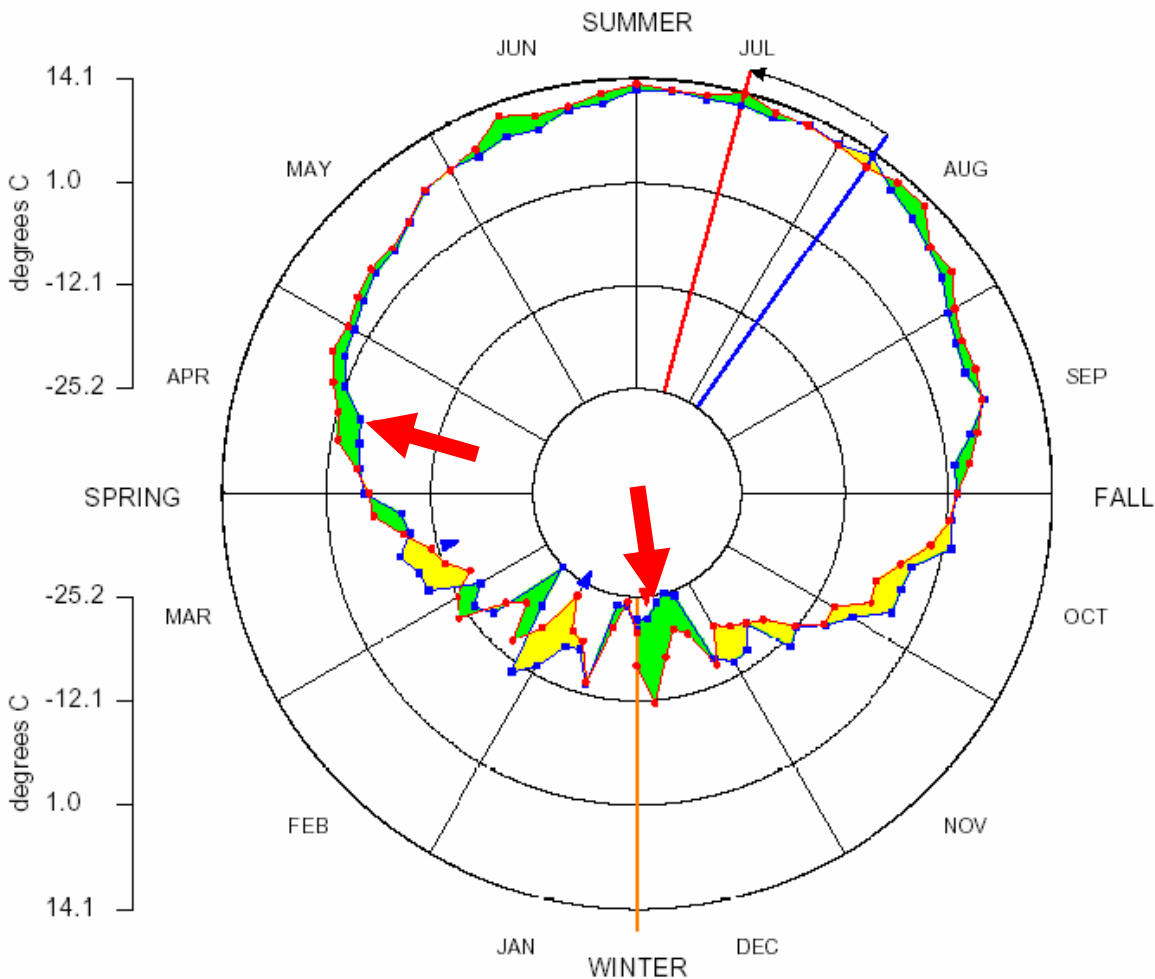
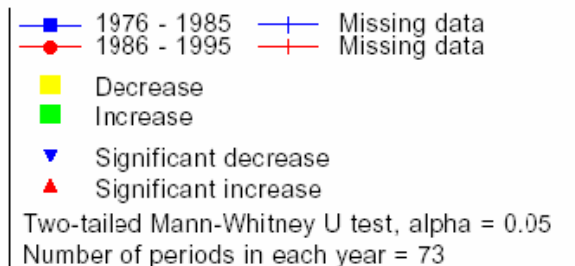
Figure 1 -- Yellowish orange and reddish colors of faded spruce are evidence of an intense spruce beetle infestation in Alaska.

Over 400,000 ha in the Kluane region of 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

Decadal temperature data: 5 day averages
2100182, Burwash A, YT



Significant increases in decadal temperature norms most likely influenced spruce beetle outbreak patterns.

From: Whitfield. 2002. Environment Canada Meteorological Service

A close-up photograph of two western balsam bark beetles (Dryocoetes confusus) on the rough, reddish-brown bark of a tree. The beetles are dark brown to black, elongated, and have a slightly textured surface. They are positioned vertically, one above the other, with their heads pointing towards the top of the frame.

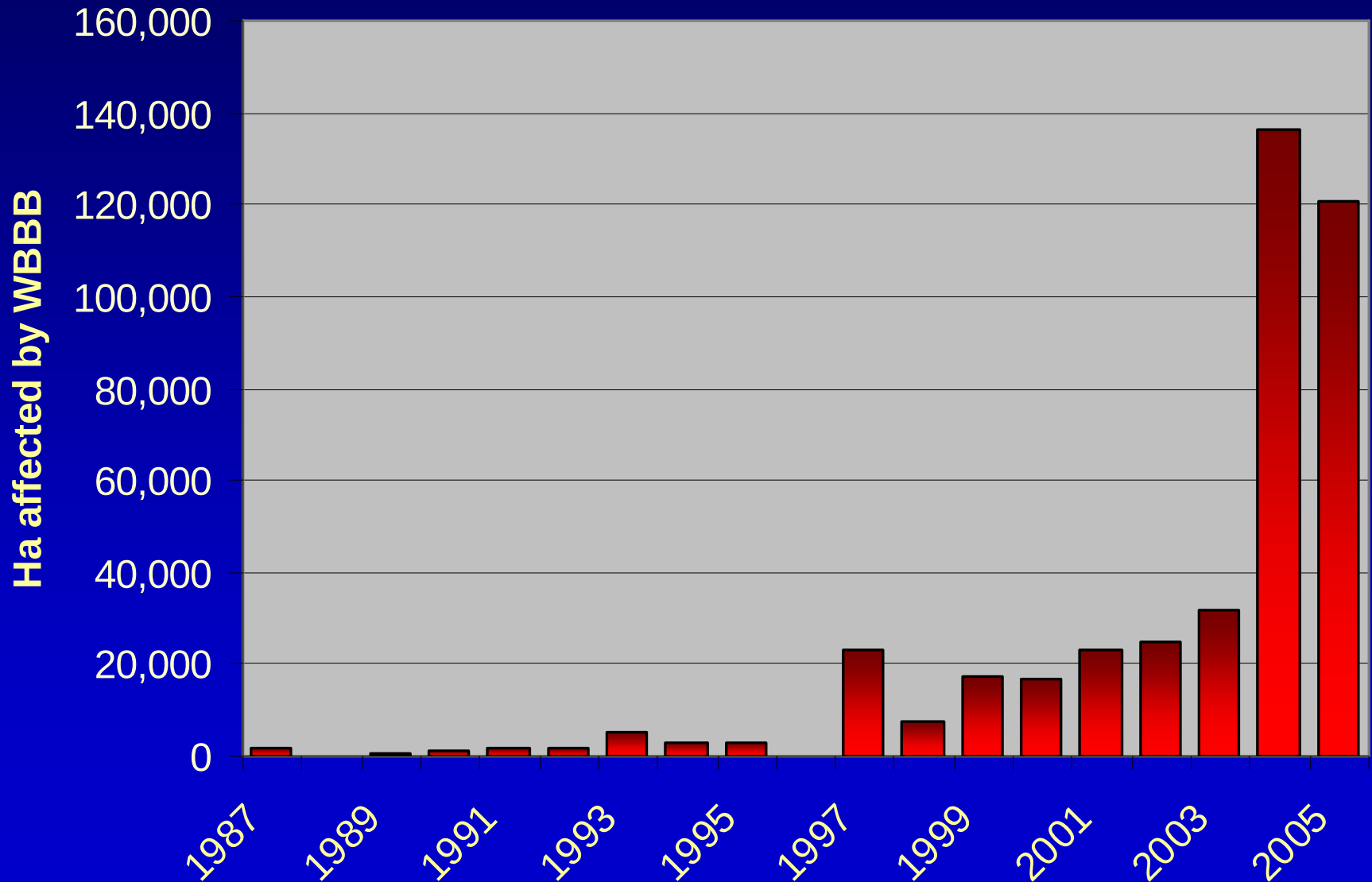
The western balsam bark beetle, *Dryocoetes confusus*, is the most dominant successional force in subalpine fir forests.

Studies show the mortality pattern caused by *D. confusus* mirrors the size and pattern of spruce found within these ecosystems, creating small and medium size gaps where Bl, Sx and other species can be found regenerating.

D. confusus appears to seek out stressed trees within a stand thus creating a very different spatial pattern of mortality from that of other bark beetles.

The pattern and periodicity of mortality is changing - within the normal range? Or beyond?

Ha affected by western balsam bark beetle in the old Kamloops Region (1987-2005)





When does chronic become epidemic?

Increasing mortality.

Longer periods of high in-stand mortality.



2-year cycle budworm (?)
is stressing both hosts
through defoliation.

Climate (temp & moisture)
is stressing both hosts.

Both bark beetles take
advantage of this
opportunity.

All typically 2-year life
cycles but when conditions
are optimum can switch to
one year cycle . . . Thus
populations increase more
rapidly.

4. Research and management - planning, responding, risk taking

Trees begin to die, some live and dead trees blow down creating small gaps in the forest canopy. An interesting aspect of this dynamic is the sequence and magnitude of mortality and blow down as it relates to insect colonization and stand succession.

The challenge to managers is to determine when natural, and acceptable stand losses are exceeded. In recent years there are signs that succession is being accelerated.

Some of the more notable examples are seen in "edge" or transitional ecosystems.

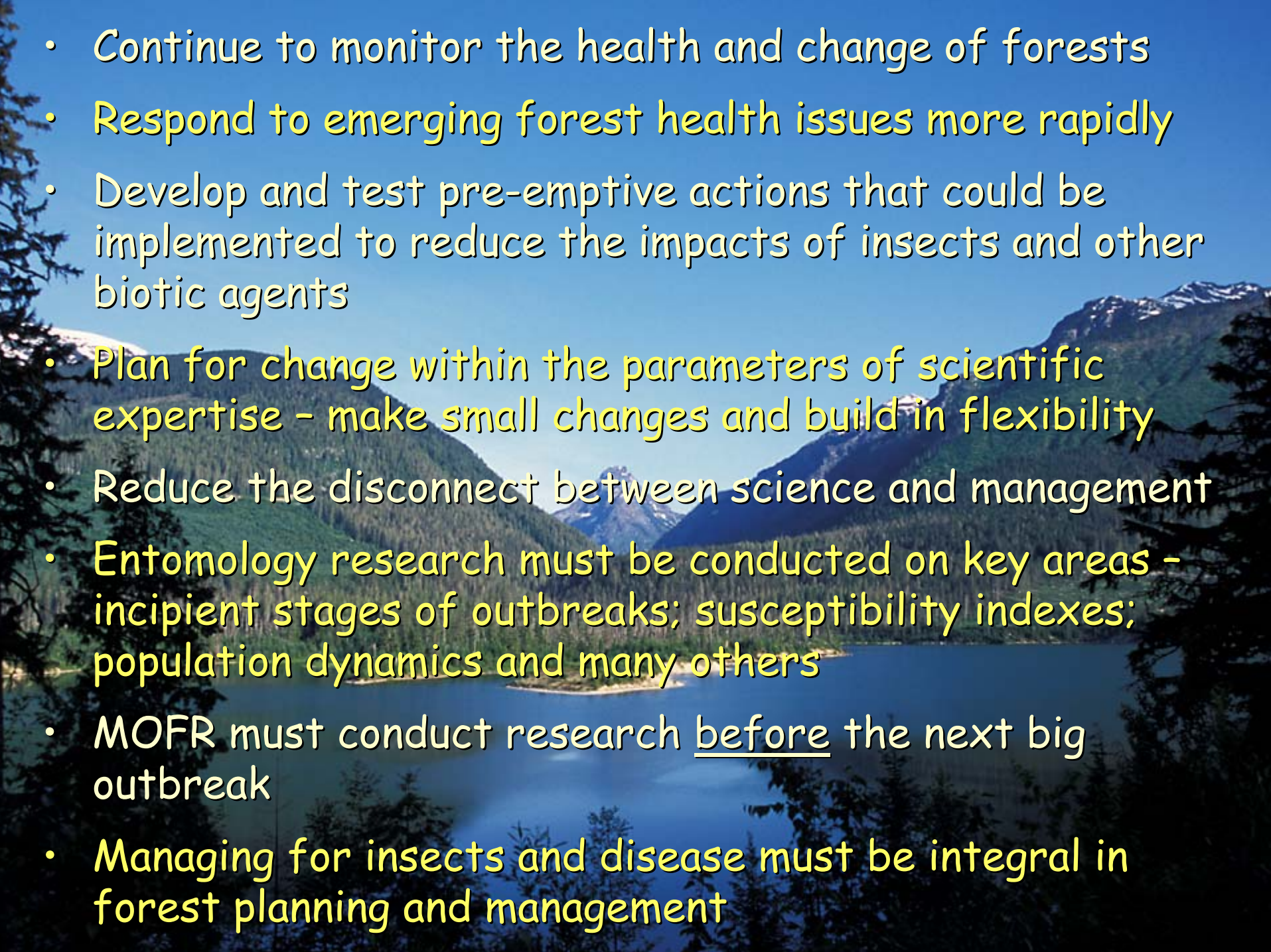
Research, planning, policy - not the panacea

The key to successful management of insects is through continuity of planning, monitoring and full implementation of silviculture treatments or prescriptions over the prescribed time period - which may be the rotation.

Often, good research information and recommendations that are elucidated during periods of insect damage are forgotten once the insects have subsided or the presiding forester has moved on.

Appropriate policies may be written but are they thoroughly (and thoughtfully) implemented over time?

Outbreaks will occur and damage will ensue but the level, duration and severity of damage could possibly be reduced or at least mitigated to acceptable levels.

- 
- Continue to monitor the health and change of forests
 - Respond to emerging forest health issues more rapidly
 - Develop and test pre-emptive actions that could be implemented to reduce the impacts of insects and other biotic agents
 - Plan for change within the parameters of scientific expertise - make small changes and build in flexibility
 - Reduce the disconnect between science and management
 - Entomology research must be conducted on key areas - incipient stages of outbreaks; susceptibility indexes; population dynamics and many others
 - MOFR must conduct research before the next big outbreak
 - Managing for insects and disease must be integral in forest planning and management

Be prepared - conduct necessary research in advance of the next big outbreak.



Life history traits and survival functions are among population characteristics critical to understanding the response of pests to changing environments.

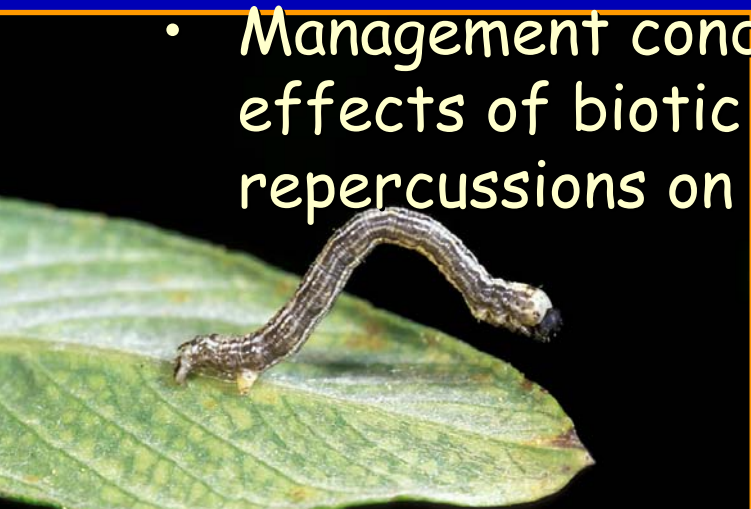
Degree day requirements for insect development is a key component to understanding response to changing climate and host resources.

Limitation of some insects (i.e. budworms) is by their hosts not the insect.

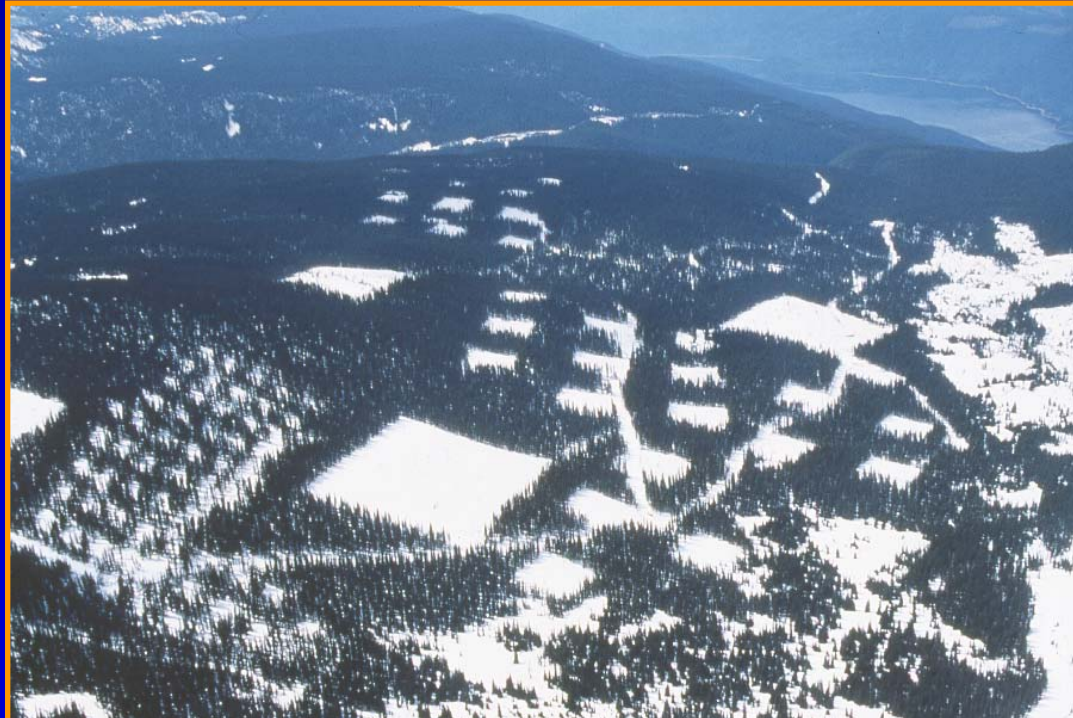


5. Summary

- Insects have short "rotations" and their hosts have long rotations - which will adapt more rapidly?
- There is already evidence of expanding insect ranges (i.e. budworms)
- Insects may already be adapting to changed environments as seen with the WSB and 2-year budworm
- Management conducted without regard to the effects of biotic agents could have negative repercussions on the health of forest ecosystems



- The mature forest resource is continuing to age and is becoming increasingly susceptible to insects
- There could already be more in-stand mortality than modeled in our remaining mature inventory
- Current and potential future forest health issues must be actively addressed in policy and management



Thank you.