

Spruce Beetle and Climate Change

Robert Hodgkinson, R.P.F., R.P.Bio.

Forest Entomologist

Omineca & Northeast Regions

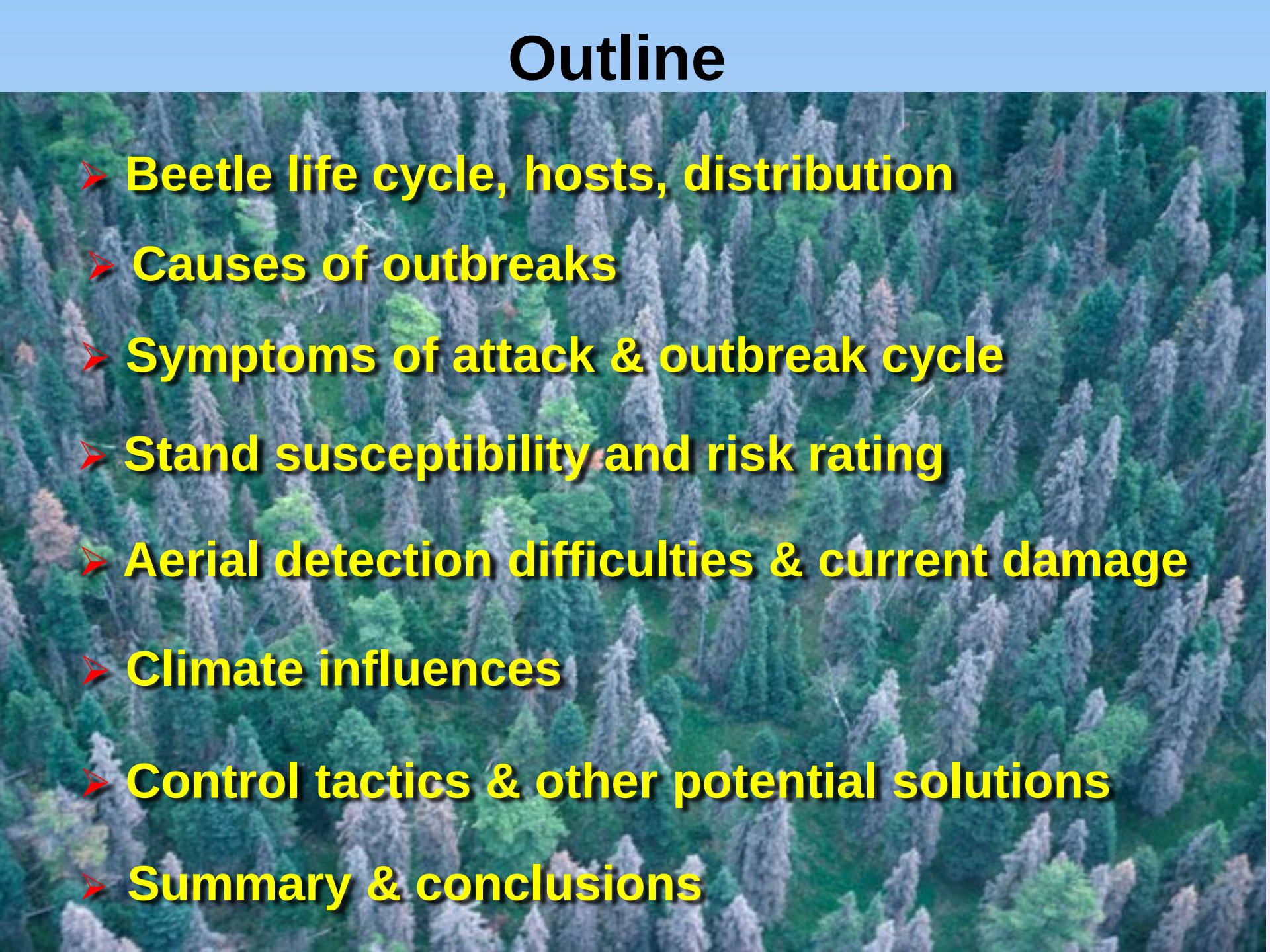
B.C. Ministry of Forests & Natural Resource Operations

Prince George





Outline

- 
- **Beetle life cycle, hosts, distribution**
 - **Causes of outbreaks**
 - **Symptoms of attack & outbreak cycle**
 - **Stand susceptibility and risk rating**
 - **Aerial detection difficulties & current damage**
 - **Climate influences**
 - **Control tactics & other potential solutions**
 - **Summary & conclusions**

Spruce Beetle

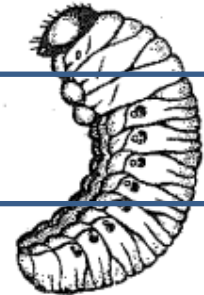
(85% + on 2-year cycle)

Life Cycle

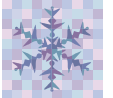
Eggs



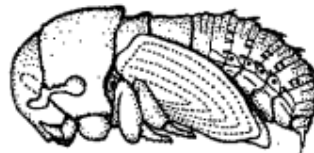
Larvae



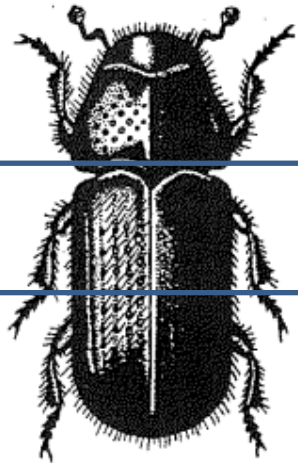
Overwinter



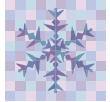
Pupae



Adults



Overwinter





Interior spruce is a shallow-rooted species

Strong winds in November 2010 caused widespread blowdown & stem breakage along both sides of Williston Lk.

Optimal breeding site for attacking adults

Spruce Blowdown - Mackenzie District

: IMG_0111 23 Nov 2010 11:08:19
55° 41' 5.26" -123° 30' 5.94"

High winds on Nov. 17, 2010





While some blowdown occurred in large patches, other groups of trees and some single trees fell into shade or partial shade.

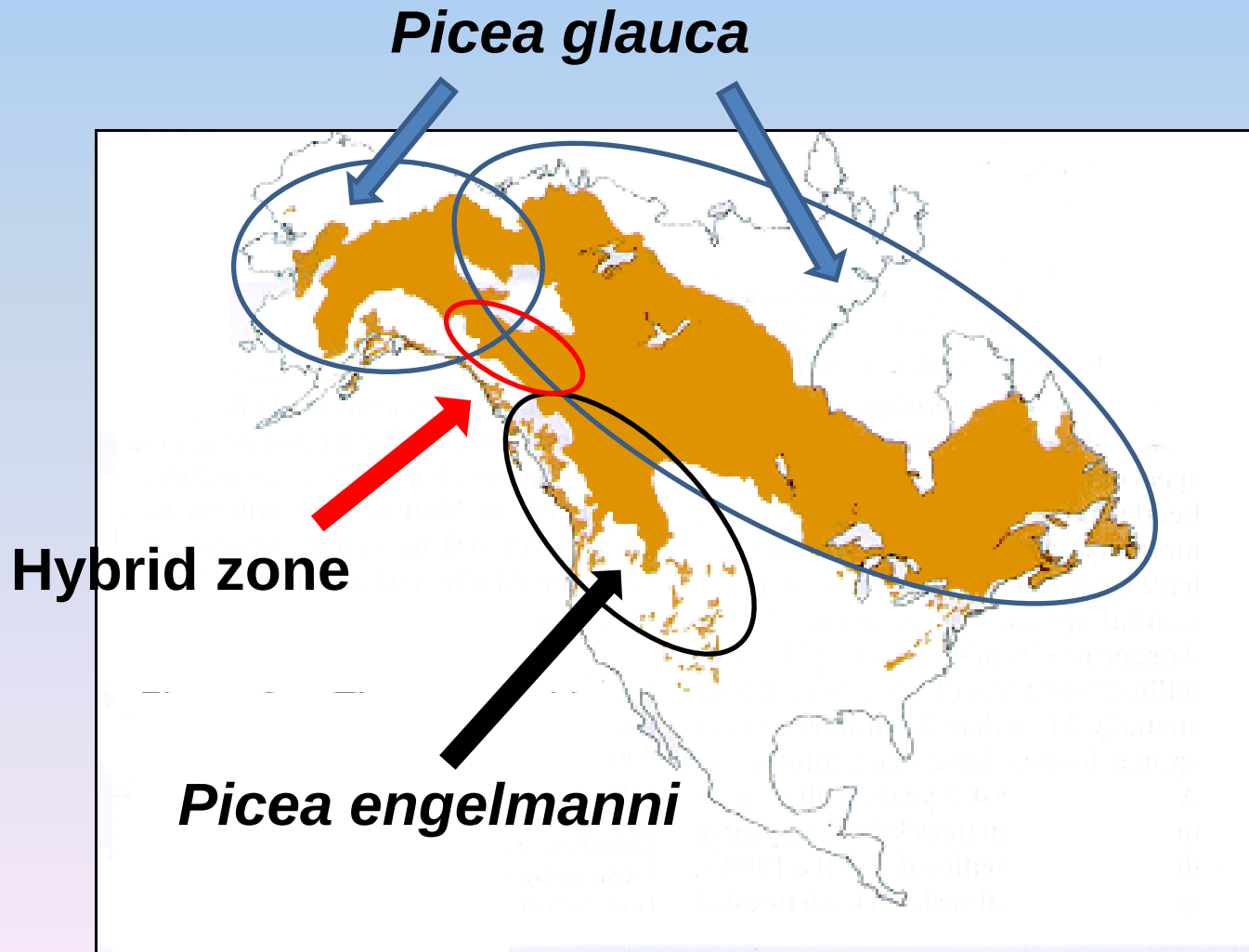


Blowdown on certain sides of spruce clearcuts are common



Attacks on standing spruce often take 2 or more years after blowdown

Current Spruce Beetle Distribution in North America



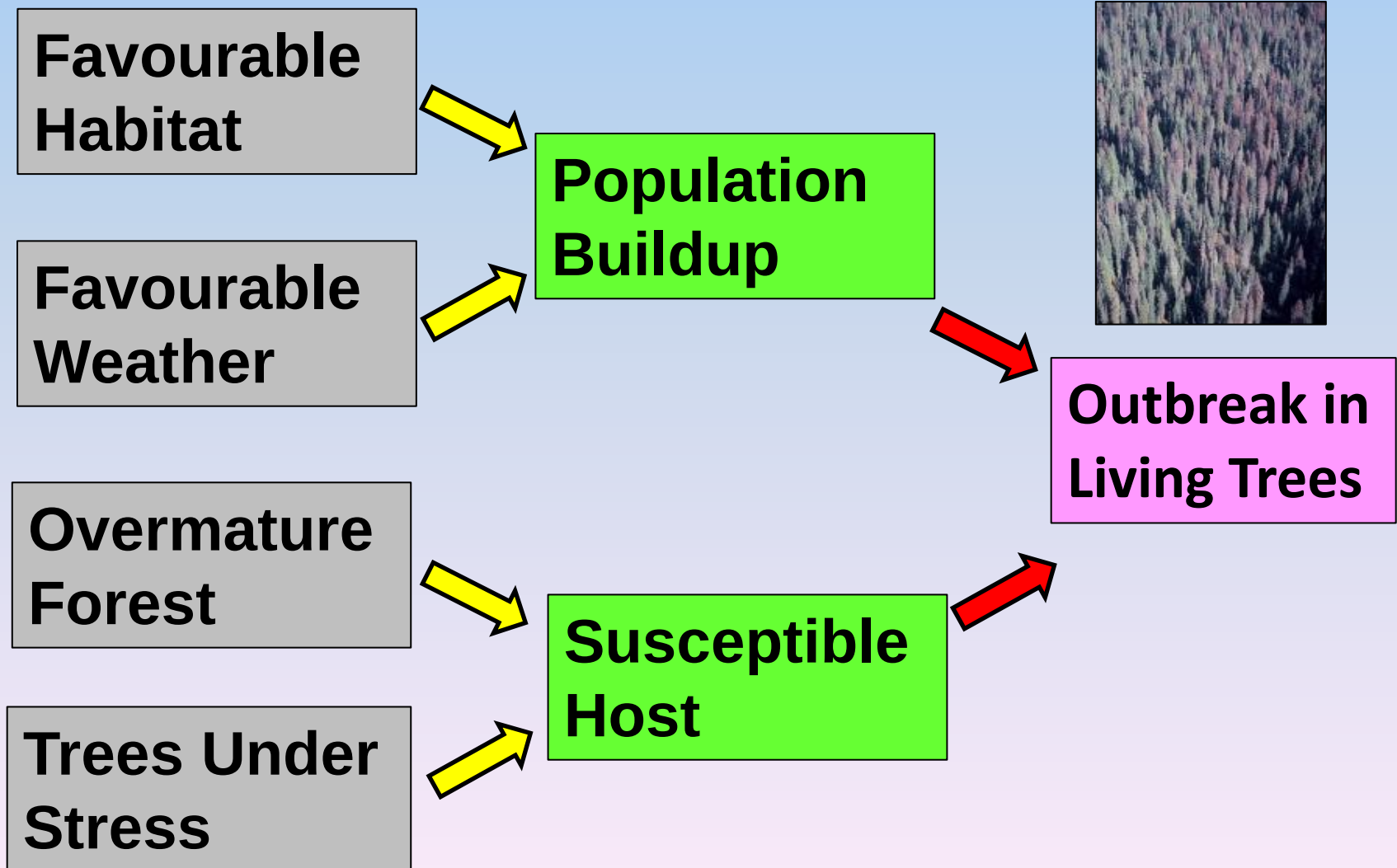
In a 2013 US study, although minimum cool season temperature and maximum warm season temperature were important in modelling spruce beetle range expansion, habitat variables of spruce basal area and spruce composition were more influential for predicting spruce beetle expansion.

Habitat variables that characterized current spruce beetle susceptibility changed as future temperatures increased.



DeRose et al. 2013

Causes of Spruce Beetle Outbreaks



Spruce Beetle Adult



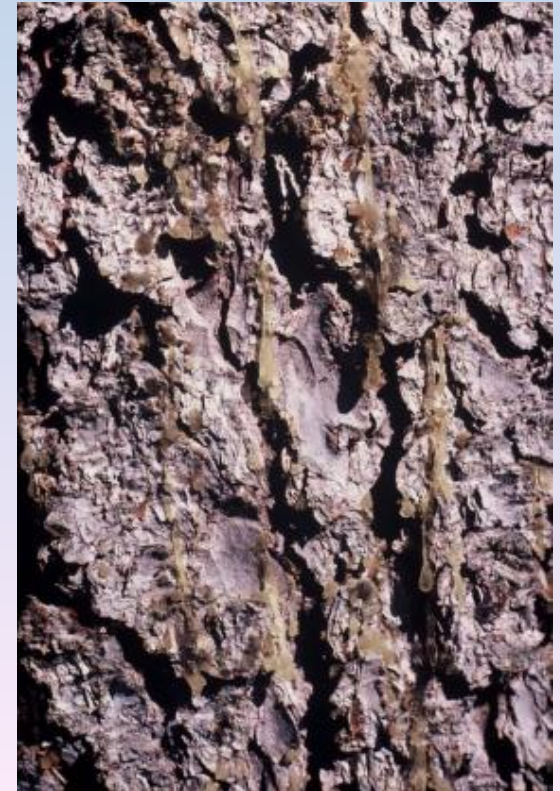


**Boring dust & frass
from an attacking
spruce beetle adult
on interior spruce in
early June**



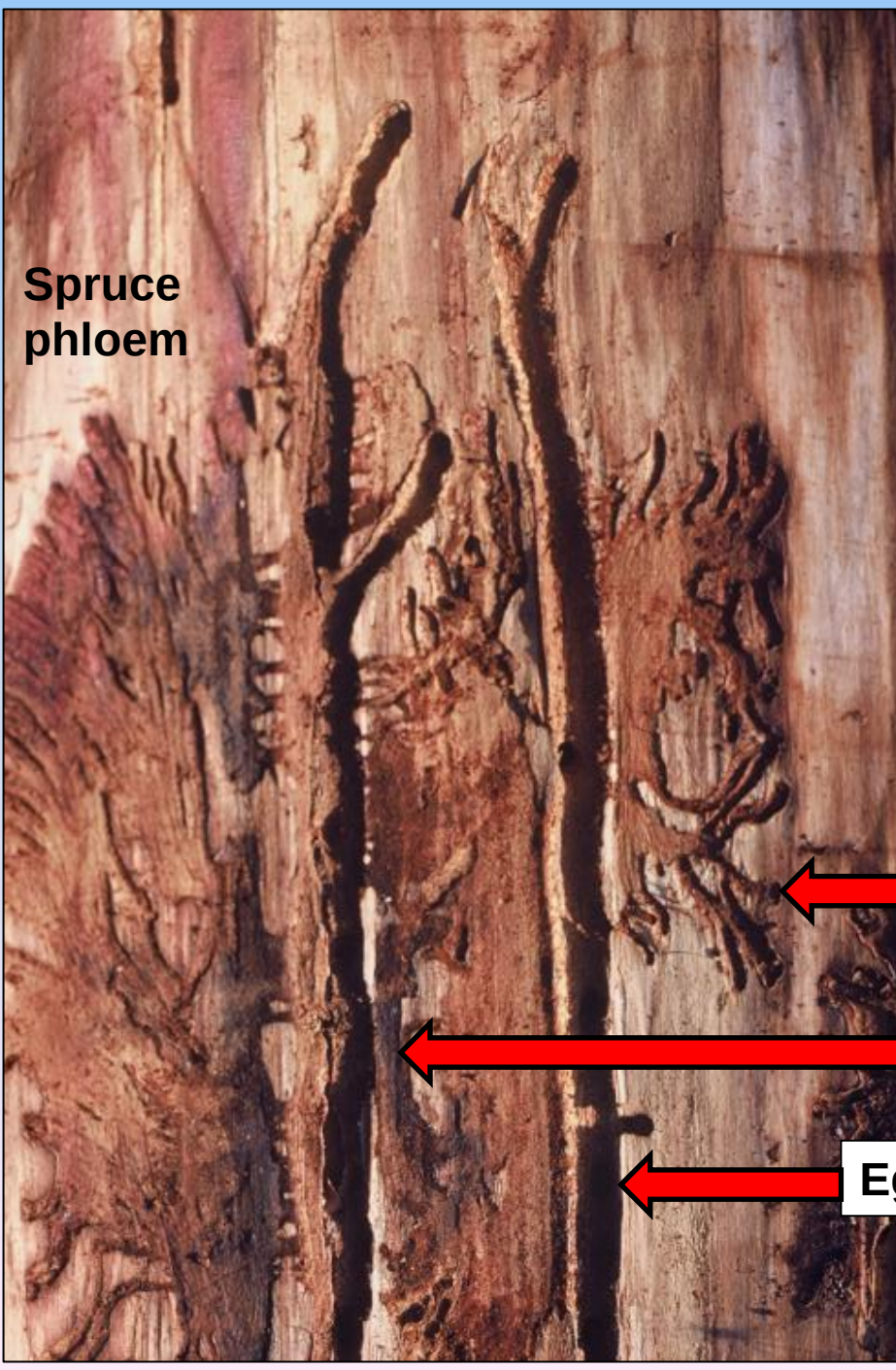
**With
occasional
clear resin
streams that
darken in time**

**Some rusty-brown pitch
tubes are common**



Newly attacking spruce beetle adults on fresh blowdown



A close-up photograph of a piece of spruce wood. The wood is light brown with a vertical grain. Several dark, winding galleries are visible, which are the paths of spruce beetles and their larvae. The wood shows signs of decay and discoloration, particularly a blueish-grey stain, which is caused by blue stain fungi. The texture of the wood is rough and uneven.

Spruce
phloem

**Newly constructed
spruce beetle egg
galleries & larval
galleries in spruce
phloem**

**Blue stain fungi
vectored into gallery
systems**

Larval galleries

Blue stain fungi

Egg gallery

Blue stain fungi



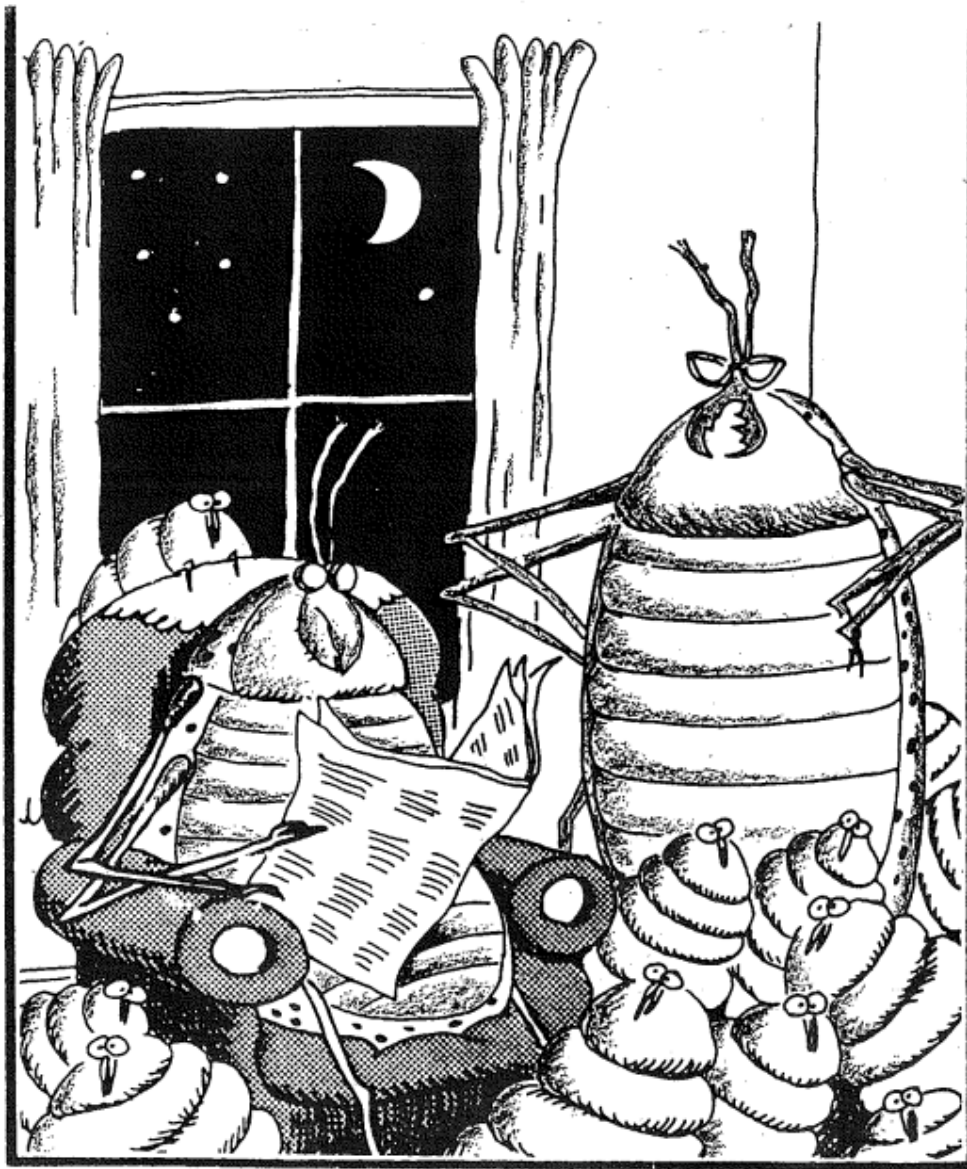


The combined effects of egg & larval gallery construction & blue stain fungi kill the tree

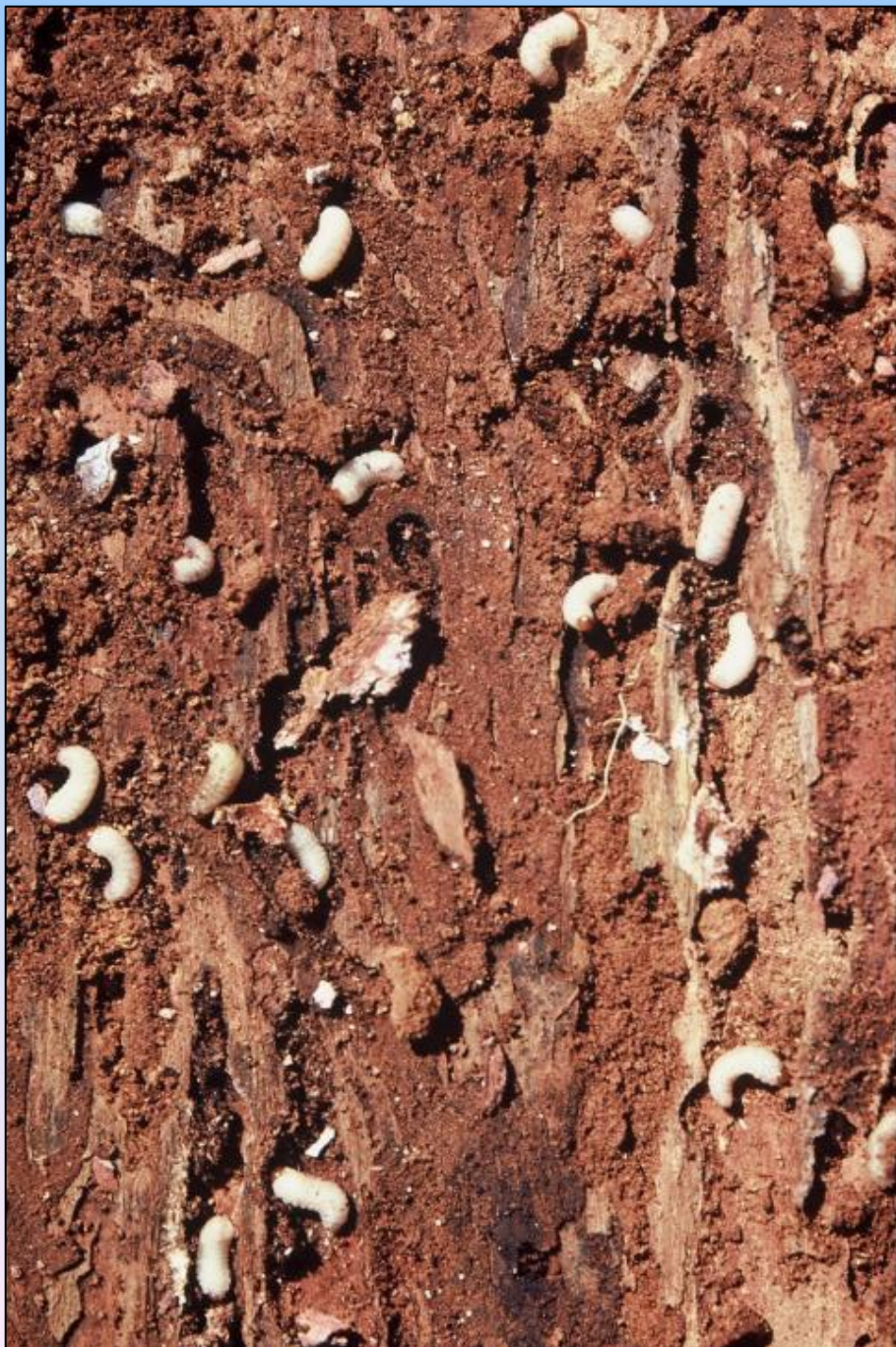


**4th stage (or
instar) larvae in
spruce phloem**





“I’m leaving you, Charles . . . And I’m taking the grubs with me.”



The combined effects of larval feeding and blue stain fungi destroy the phloem and kill the tree



Spruce Beetle Pupa



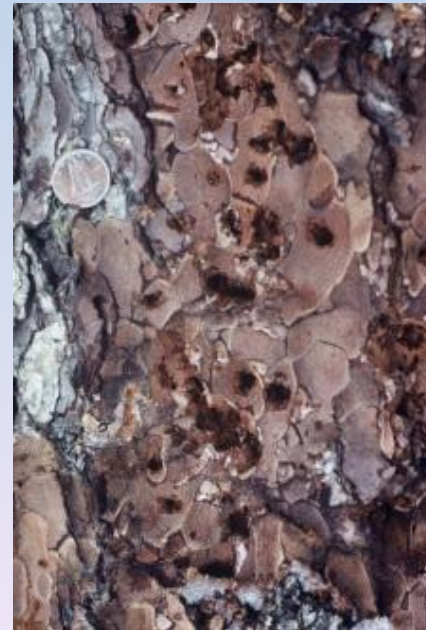
Spruce beetle immature adults



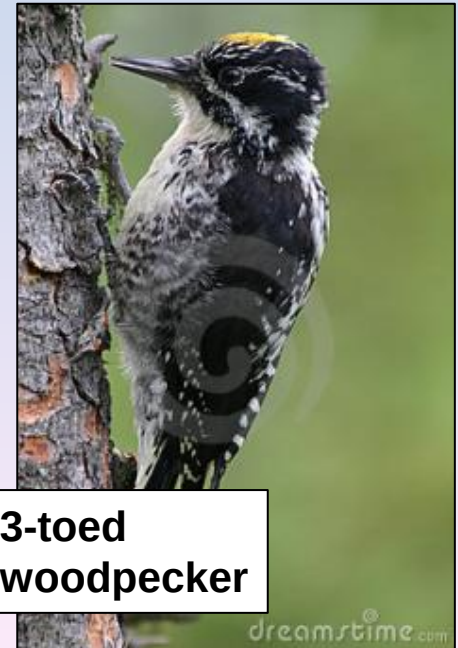
**Newly mature adults fly to
attack spruce starting in
early June**



Signs of woodpeckers searching for spruce beetle larvae in spruce the first winter after beetle attack.



"Test holes"



**3-toed
woodpecker**



Most spruce beetle have a 2-year life cycle and overwinter as larvae the first winter.

Before the second winter, 40-60% of immature adults emerge from the bole and crawl to below the duff line to hibernate in the tree's root collar.

Here they escape cold temperatures and woodpeckers



Felling spruce that were attacked the previous year by spruce beetle (on a 2-year cycle) in the second summer tends to reduce emergence for hibernation behavior by 69 - 88%.

Therefore, that many more beetles are removed during subsequent early-winter sanitation harvesting.

Hodgkinson et al. 2015 (unpubl.)

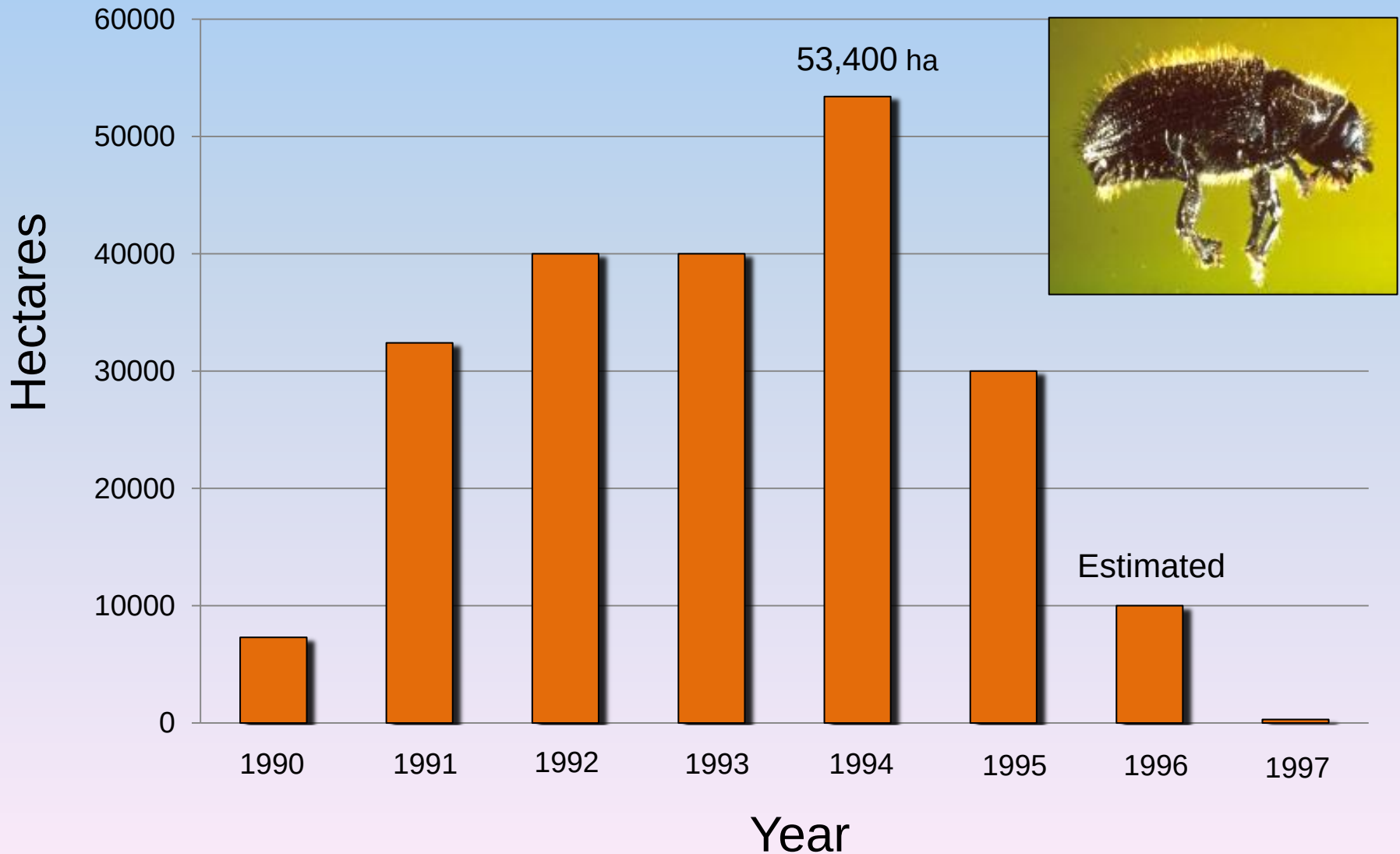


In winter when air temperatures are less than 0°C, a woodpecker can eat up to 2200 spruce beetle larvae per day to keep up its caloric needs.

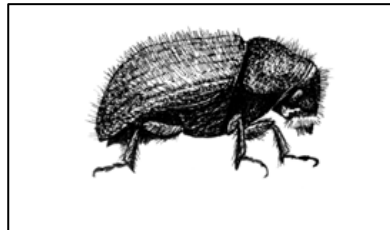
However, even though woodpeckers can directly or indirectly kill 90-95% of the beetles in a tree, the remaining beetles are sufficient to perpetuate the outbreak.

Woodpecker territoriality plays a part.

Duration and Severity of Previous Spruce Beetle Outbreak in Mackenzie District



The Last Spruce Beetle Outbreak Cycle in Mackenzie



Endemic
population

1989

Incipient
population

1990

Outbreak

1994

1991-1993

1995

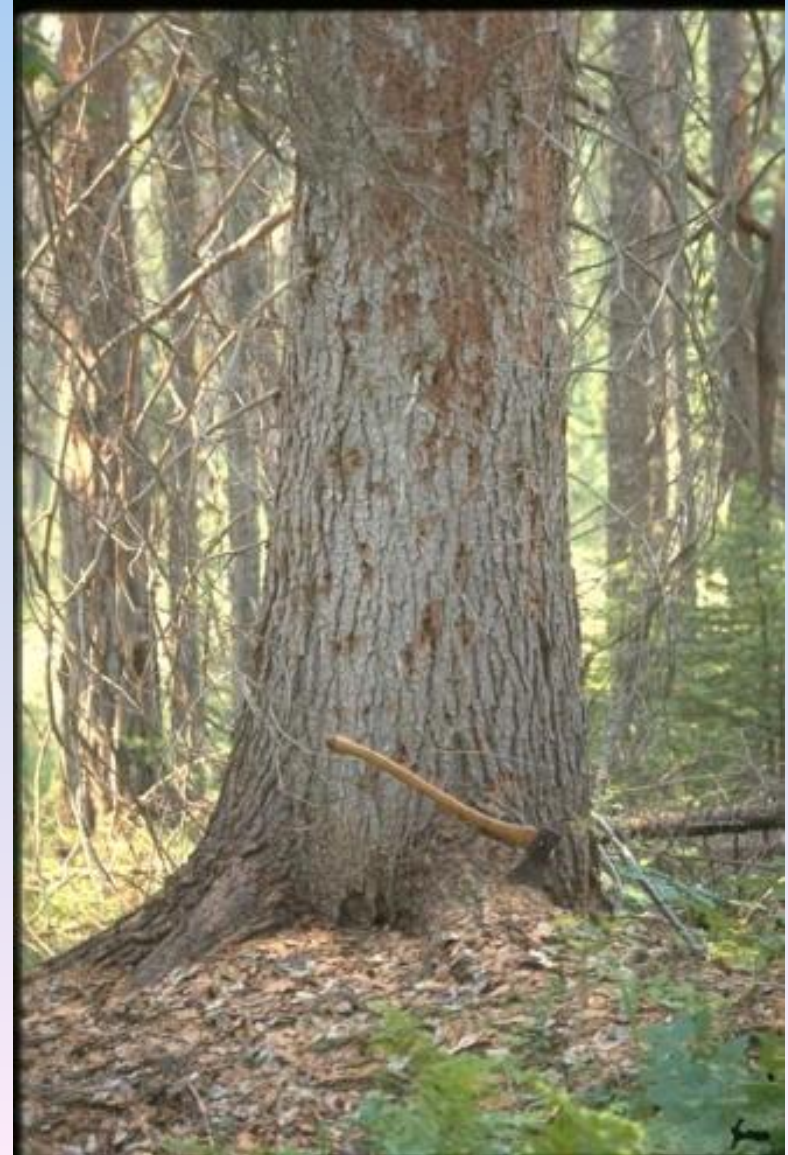
Outbreak
collapse

1997



Host Susceptibility

Host will die if subjected to 2-3 spruce beetle attacks per 400 cm² of bark at dbh, decreasing vertically thereafter to a height of 9 m.



Order of Host Susceptibility is:

- 1) Spruce in creek bottoms
- 2) Better stands of spruce on benches & ridges
- 3) Poorer stands of spruce on benches & ridges
- 4) Mixed stands of spruce & pine
- 5) Stands containing all immature spruce



Susceptibility & Risk Rating

Characteristics Related to Stand Susceptibility:

- 1) Site quality**
- 2) Stand age**
- 3) Stand density (growth rate)**
- 4) Percentage of susceptible spruce basal area**
- 5) Stand location, i.e., elevation, latitude, longitude & aspect**



Characteristics Related to Beetle Population Pressure:

1) Standing infested spruce

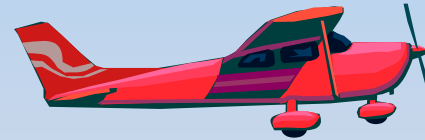
2) Windthrow

3) Logging (breeding material)

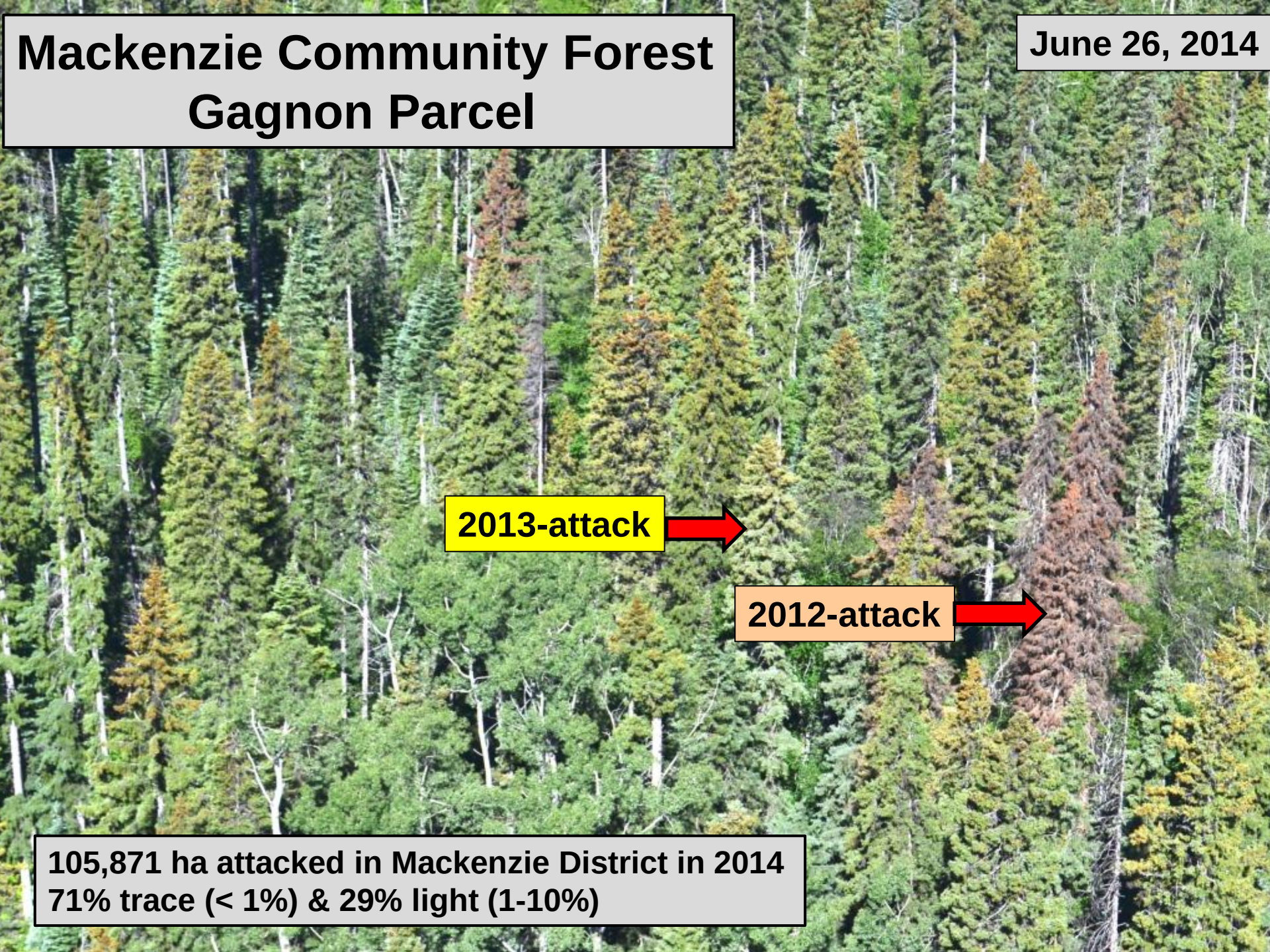
4) Fire History (breeding material)



Attacked spruce often show no symptoms of damage from aerial observation for 12-18 months after attack. This makes aerial detection of recent attack difficult.



Trees then turn off-colour (or chlorotic green), then yellow



Mackenzie Community Forest Gagnon Parcel

June 26, 2014

2013-attack

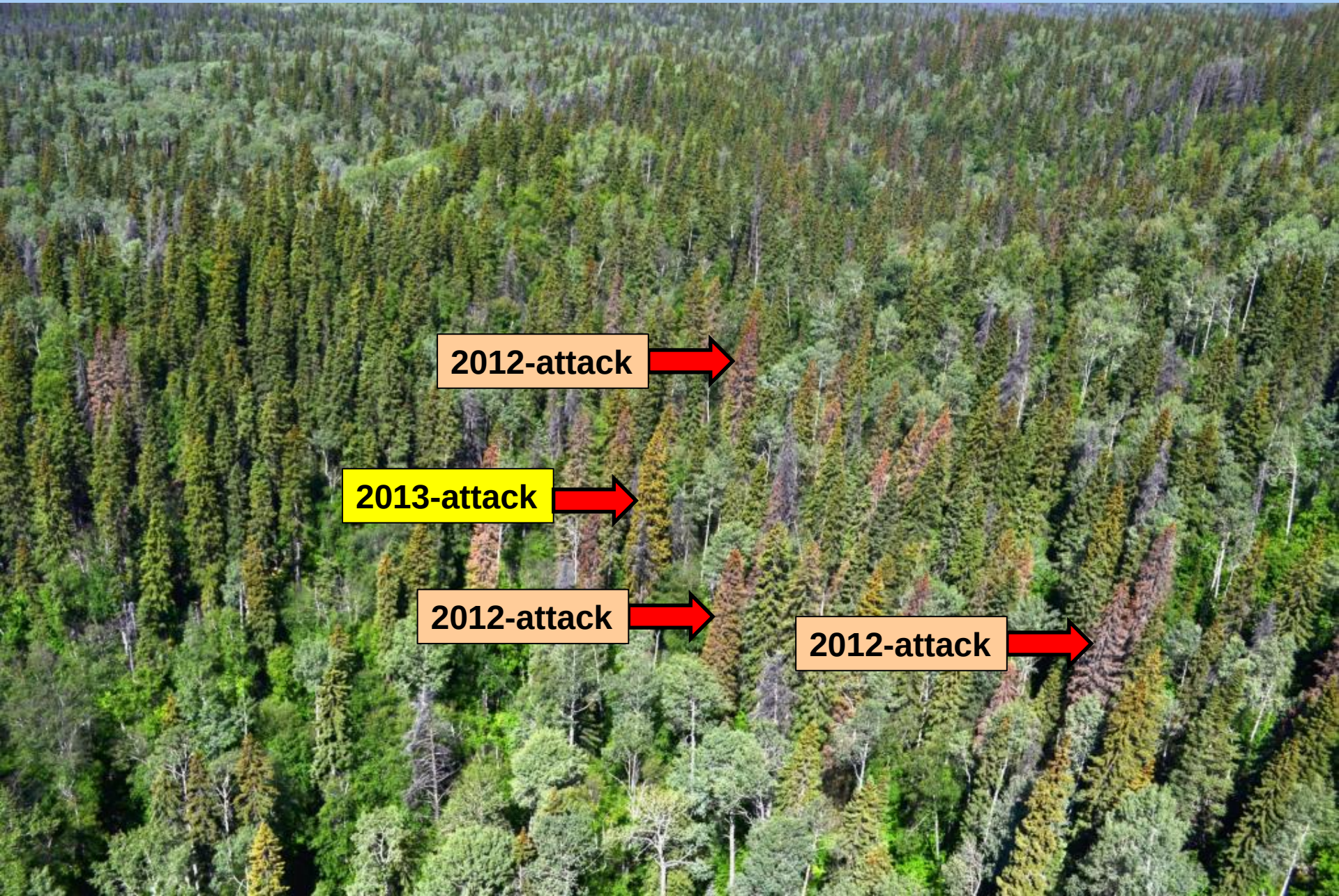


2012-attack



105,871 ha attacked in Mackenzie District in 2014
71% trace (< 1%) & 29% light (1-10%)

Heather-Dina Lakes Prov. Park - June 26, 2014



2012-attack

2013-attack

2012-attack

2012-attack

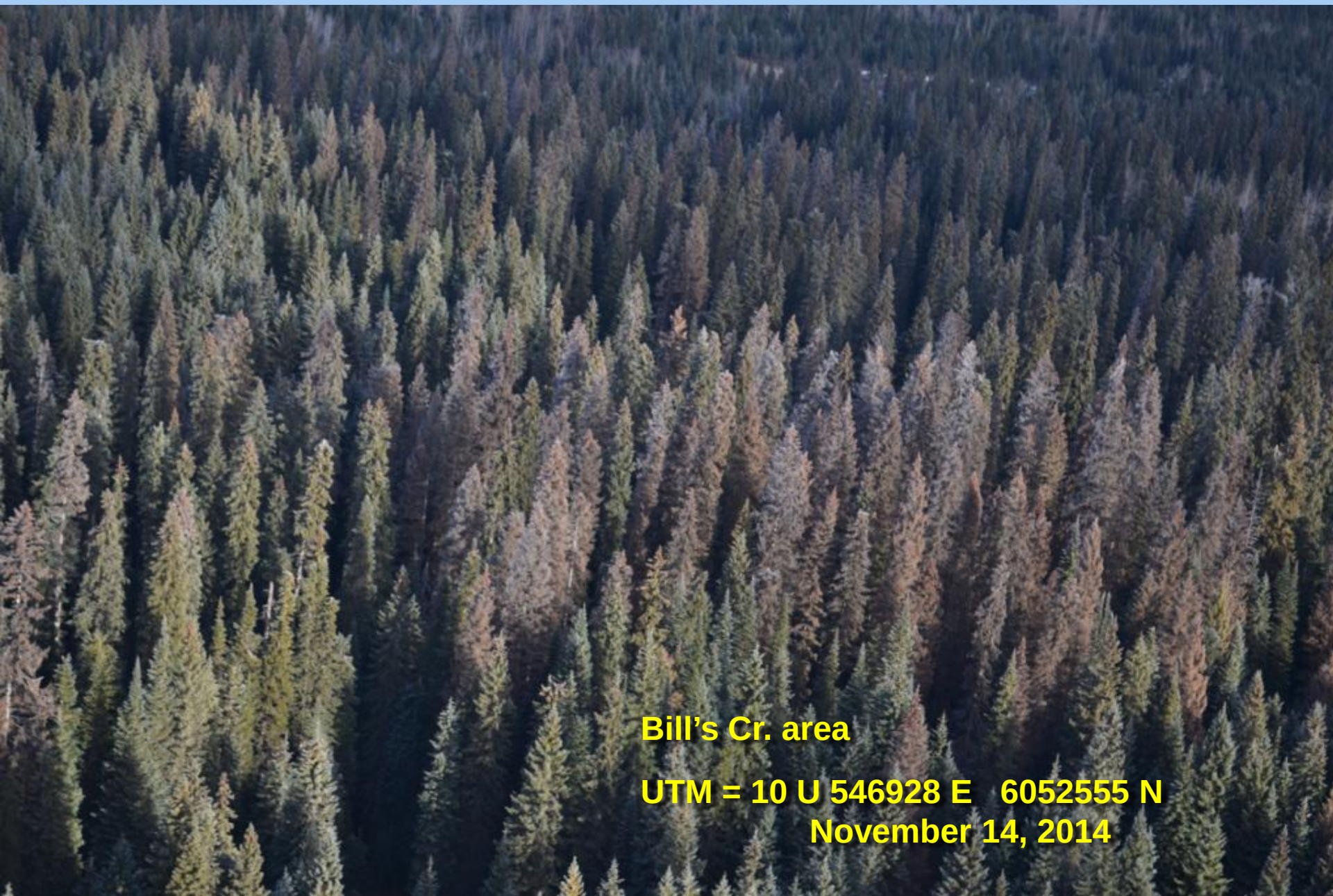
Spruce blowdown in Prince George District



Bill's Cr. area

**UTM = 10 U 548098 E 6052767 N
November 14, 2014**

Spruce beetle damage in Prince George District

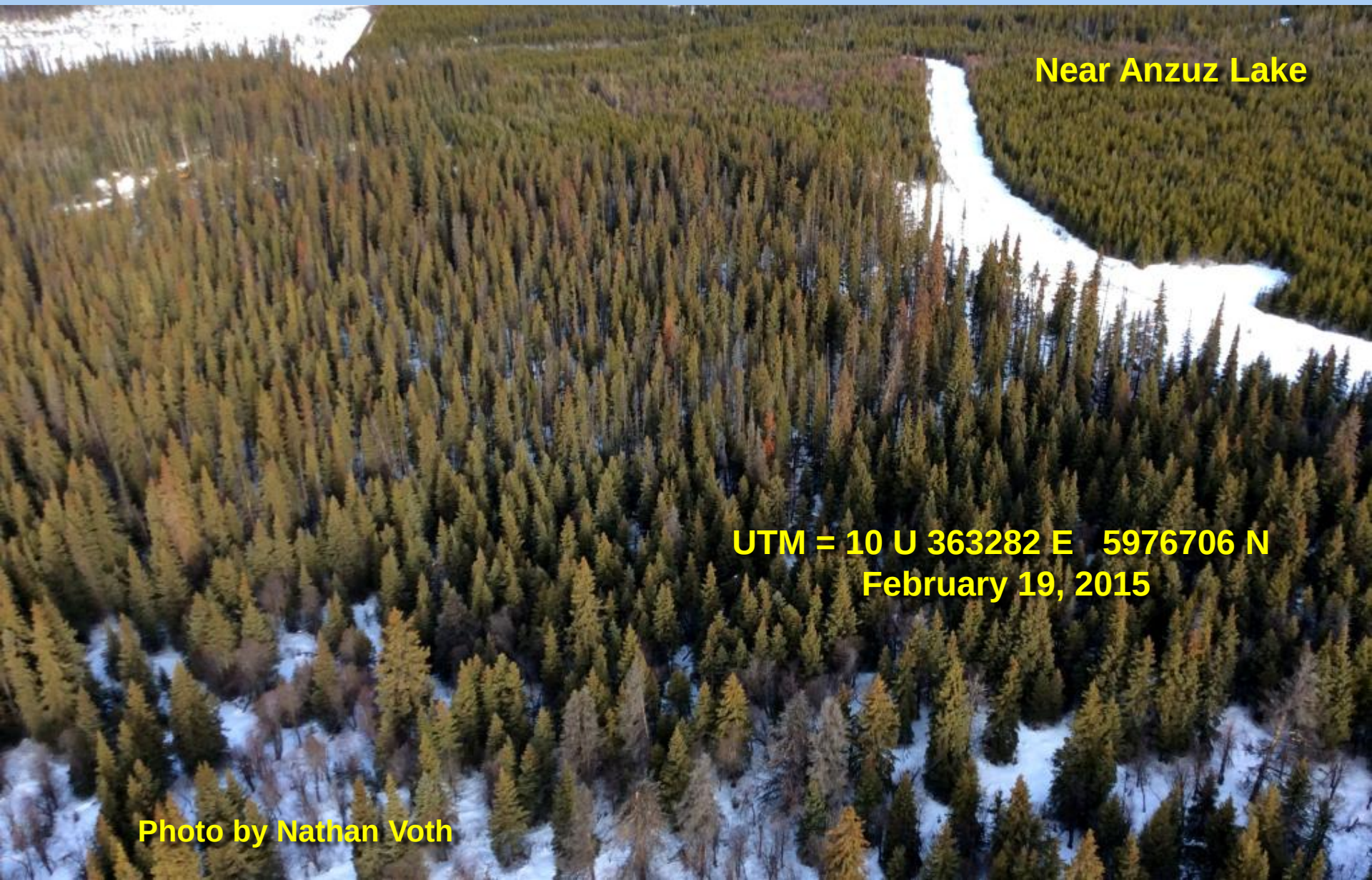


Bill's Cr. area

UTM = 10 U 546928 E 6052555 N

November 14, 2014

Spruce beetle damage in Vanderhoof District



Near Anzuz Lake

UTM = 10 U 363282 E 5976706 N
February 19, 2015

Photo by Nathan Voth

**Sx fully attacked in 2013.
Photo taken July 20, 2014**



**Same tree re-photographed
on Sept. 17, 2014**

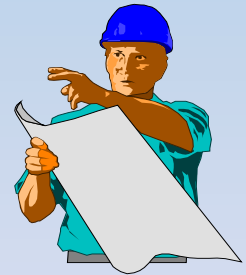


**Further photograph
on Oct. 2, 2014**

**Photo by
Miodrag
Tkalec**

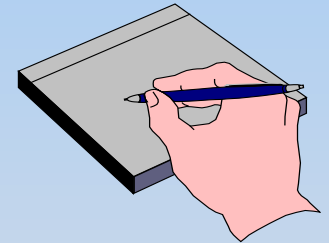


Ground survey crews finding recently attacked spruce



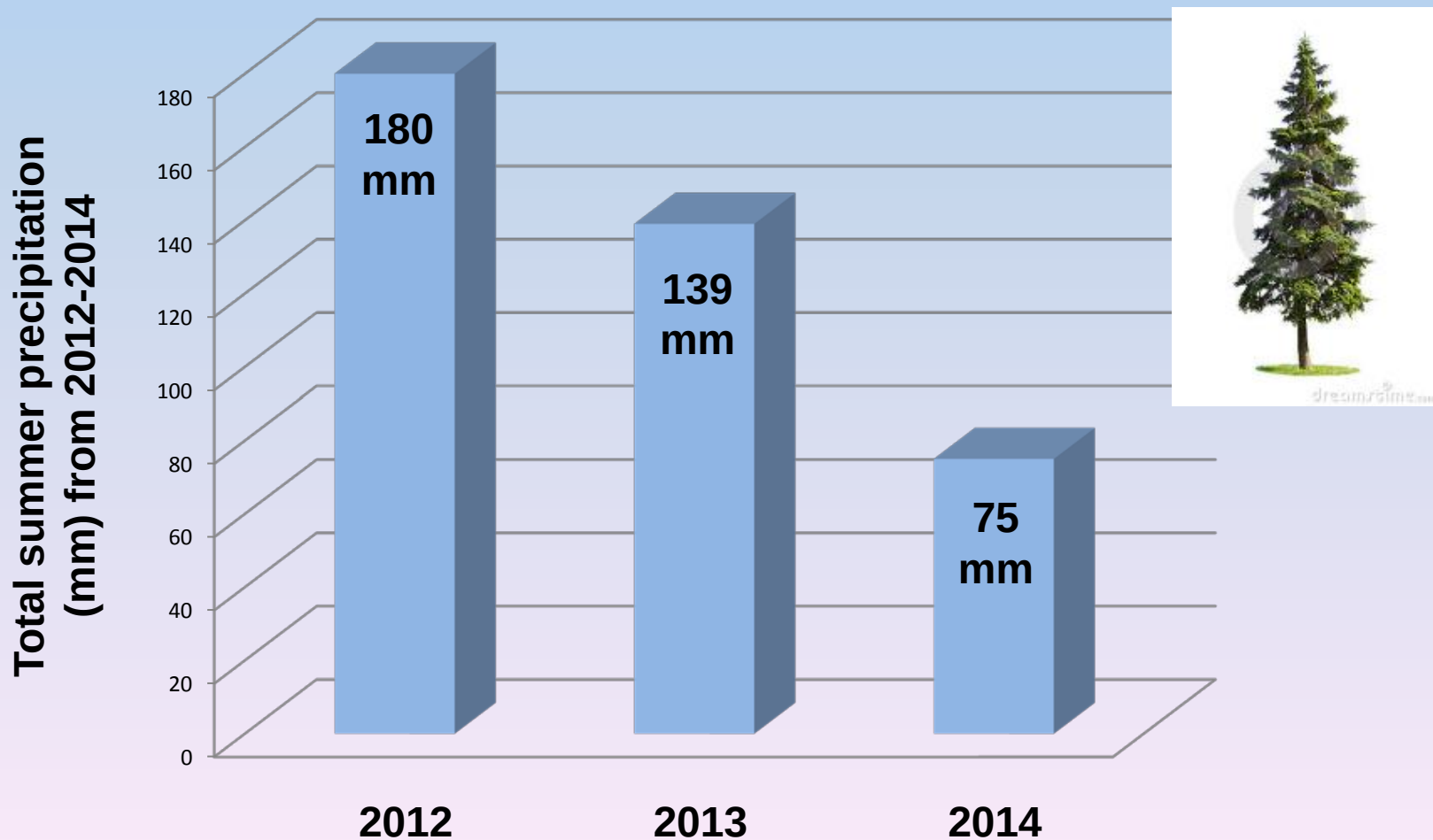
Reasons for increasing spruce beetle population in Mackenzie District

- **Susceptible host = older, even-aged, spruce-leading stands**
- **Widespread scattered spruce blowdown in Nov. 2010 windstorm = optimal spruce beetle host**
- **Several warm winters with protective snowpacks = very low spruce beetle mortality**
- **Declining below average summer precipitation from 2013 - 2014 = more tree stress**



Total Summer Precipitation in Mackenzie District from 2012-2014

Summer average from 1971-2014 (with adjustments) = 163 mm





Recent spruce beetle outbreaks have caused extensive mortality of spruce over more than:

- **1.2 million ha in south-central Alaska from 1989 - 2004**
- **350,000 ha in the southwestern Yukon from 1990 - 2004**

These have been linked to:

- **The direct effects of warming on beetle survival and development**
- **The indirect effects on host susceptibility**

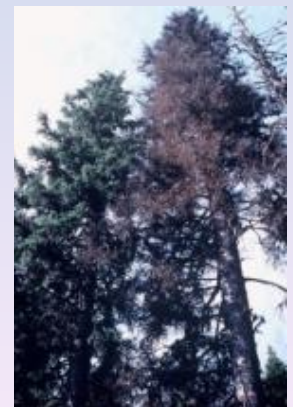
(Berg et al. 2006)

- **Heat accumulation associated with unusually warm summers caused a shift from the predominant 2-year cycle to 1-year cycle beetles, thereby doubling the rate of increase and spread of populations.**



(Hansen and Bentz 2003, Berg et al. 2006)

- **The combination of warmer temperatures and long-term drought stress can also increase tree susceptibility**



(Barber et al. 2000)

40-60% of Spruce Stems Killed During Bowron Outbreak

Approx. 15 million m³ logged from 1981-1987

**Tumuch area
July 1984**



Winter Cutblock Adjacent to Dead Spruce in the Tumuch area

July 1984



Stumps from logging were cut as low as possible



Attacked Spruce Being Loaded onto Logging Truck



Attacked Spruce Being Hauled to Local Sawmills

Licensees compelled to harvest 25-30 years of normal annual allowable cut in 7-8 years



Conventional Trap Trees



A Trap Tree Strip Created with a Feller-Buncher



Aerial View of Trap Tree Strip



Trap Tree Strip Left Amid Temporary Retention



Trap Decks



“Grid-Baiting” with Spruce Beetle Pheromome Tree Baits



Infested spruce stands can be grid-baited with spruce beetle tree baits on a 50 x 50 m grid.

Tactic is to contain & concentrate beetles within a stand prior to sanitation harvesting of the entire baited portion.



Hold it right there young lady! Go wash off some of that pheromone!

Spruce Beetle Attacked Logs Being Removed





Other Potential Actions

- **Modify characterization of high hazard spruce stands to reflect increasing beetle presence in stands with lower basal area and spruce composition.**
- **Delay aerial overview surveys & detailed heli-GPS surveys until late-Sept. to enhance spotting of 2014-attacked spruce.**
- **Wherever suitable, fell previous-year attacked Sx to reduce emergence for hibernation prior to upcoming winter logging.**



Climate-Related References

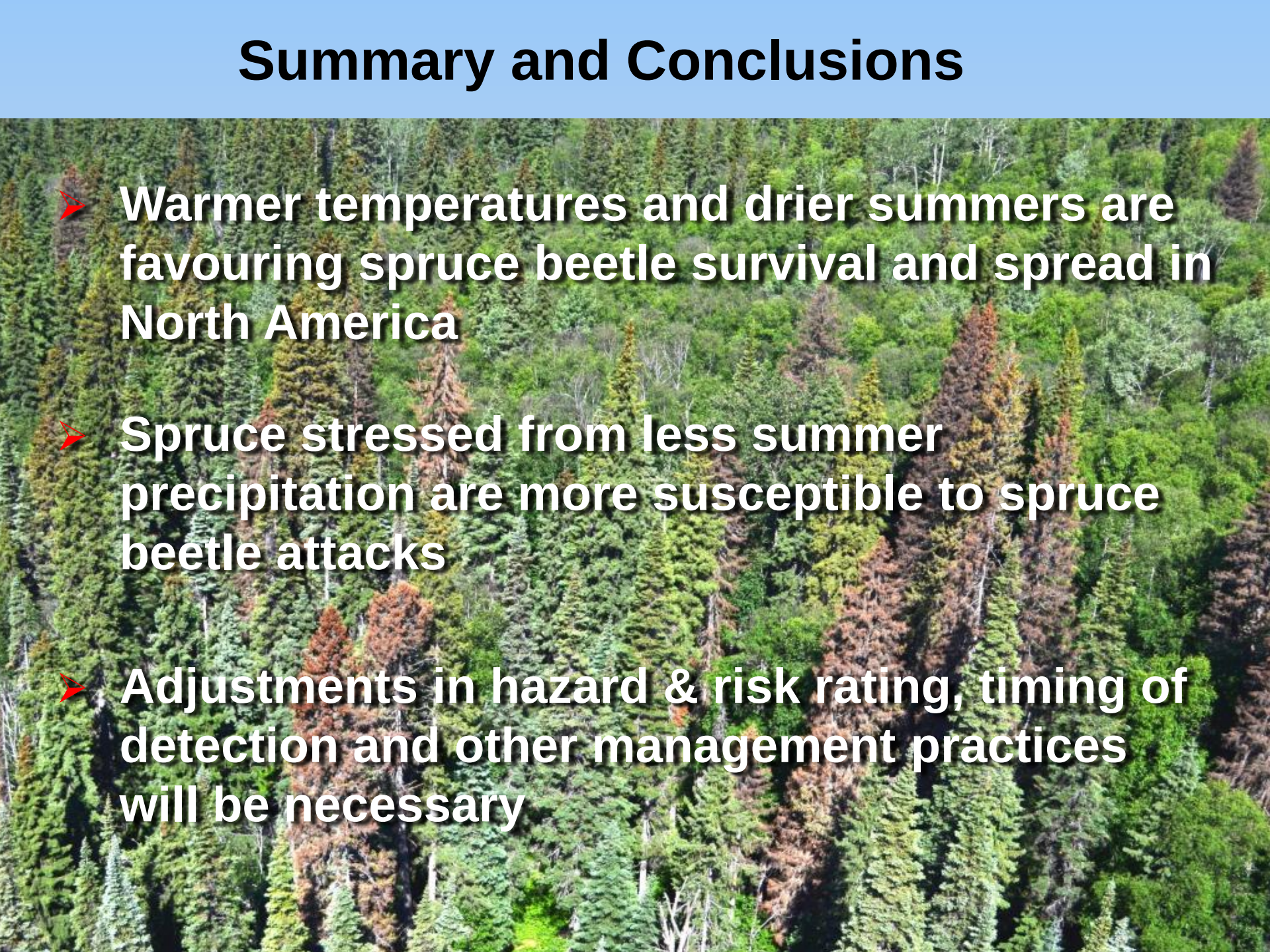
Barber, V.A., G.P. Juday, and B.P. Finney. 2000. Reduced growth of Alaskan white spruce in the twentieth century from temperature-induced drought stress. *Nature* 405: 668-673

Berg, E.E., J.D. Henry, C.L. Fastie, A.D. De Volder, and S.M. Matsuoka. 2006. Spruce beetle outbreaks on the Kenai Peninsula, Alaska, and Kluane National Park and Reserve, Yukon Territory. Relationship to summer temperatures and regional differences in disturbance regimes. *Forest Ecology and Management* 227: 210-232.

DeRose, R.J., B.J. Bentz, J.N. Long, and J.D. Shaw. 2013. Effect of increasing temperatures on the distribution of spruce beetle in Engelmann spruce forests of the Interior West, USA. *Forest Ecology and Management* 308: 198-206.

Hansen, E.M. and B.J. Bentz. 2003. Comparison of reproductive capacity among univoltine, semivoltine, and re-emerged parent spruce beetles (Coleoptera: Scolytidae). *Can. Ent.* 135: 697-712.

Summary and Conclusions

- 
- Warmer temperatures and drier summers are favouring spruce beetle survival and spread in North America
 - Spruce stressed from less summer precipitation are more susceptible to spruce beetle attacks
 - Adjustments in hazard & risk rating, timing of detection and other management practices will be necessary



That's It !





**“Mr. Hodgkinson, may I be excused?
My brain is full.”**

Thank You!

Any questions?

