Historic insect outbreaks in Katmai and Lake Clark

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Outline

- Recent bark beetle activity in SC Alaska
- Historic spruce beetle activity in Lake Clark and Katmai National Parks and Preserves
- Evidence for climate-beetle interactions

Widespread bark beetle activity in western North America

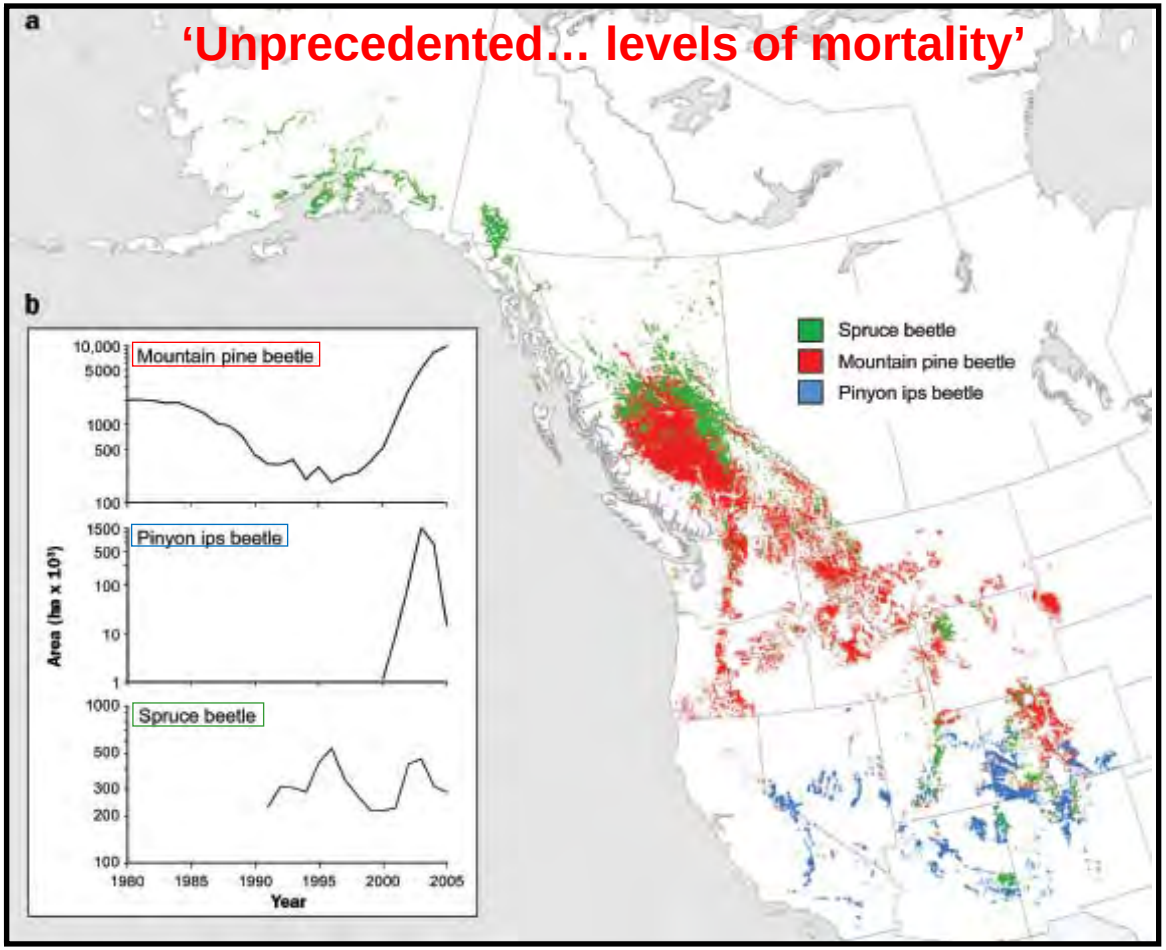
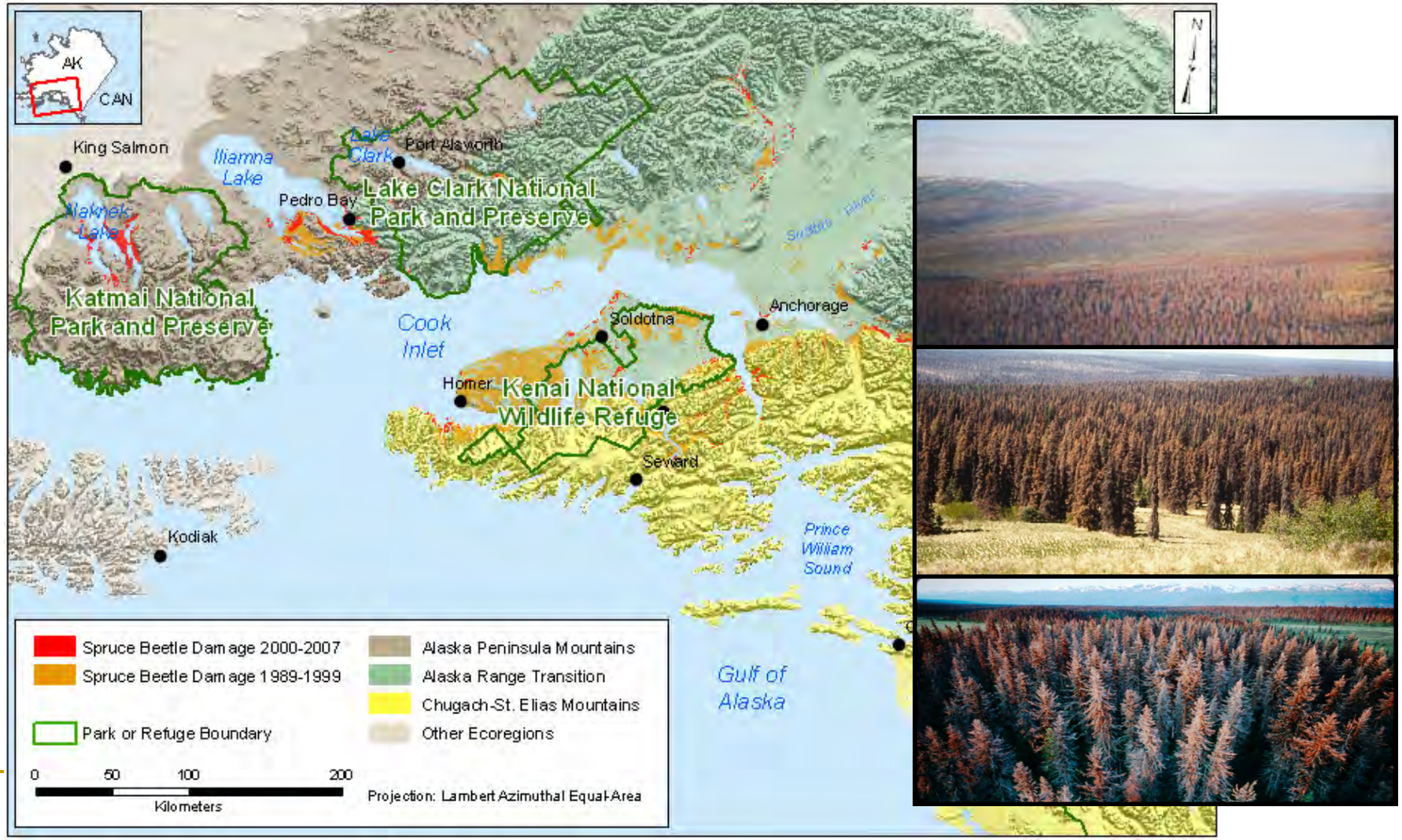


Figure source: Raffa et al. 2008, *Bioscience*

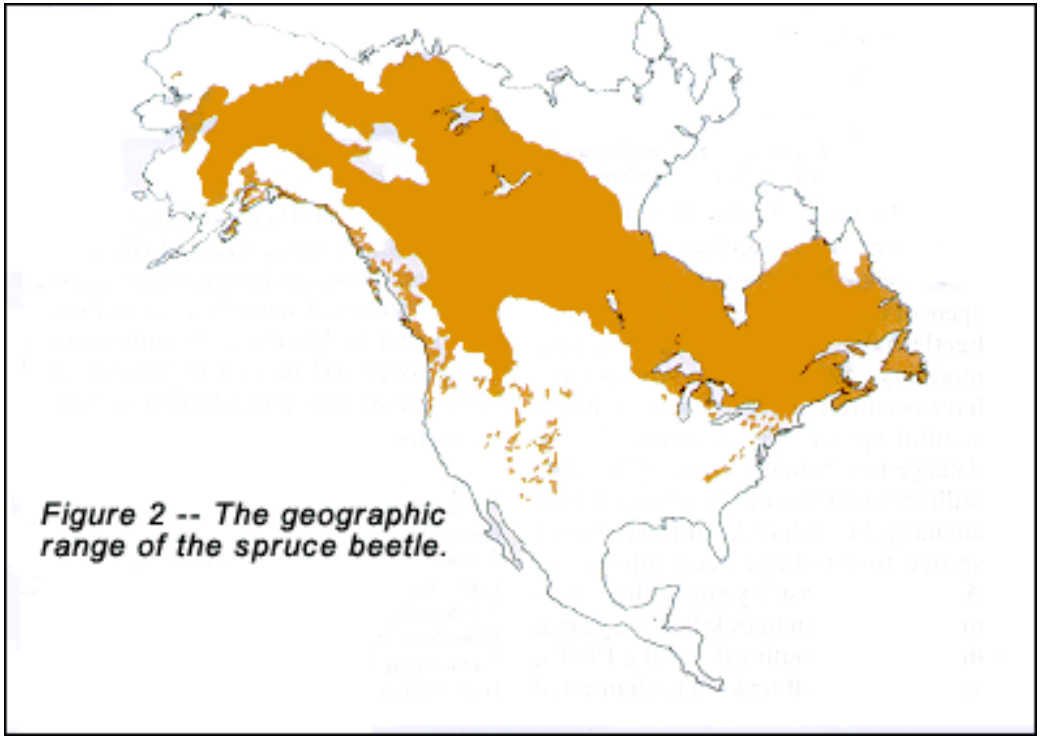
Forest health concerns in Alaska

Spruce bark beetle has killed > 1.2 million ha (3 million acres) of spruce forest in south-central Alaska (1989 – 2007)



Photos courtesy of Ed Berg (bottom photo by Peter Essex)

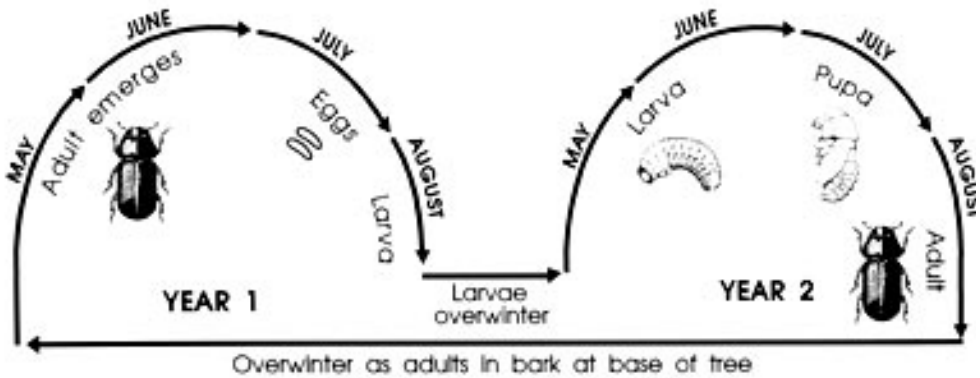
Spruce bark beetle (*Dendroctonus rufipennis*) geographic range



- Can attack all species of spruce within its range
- In Alaska, primarily white *(Picea glauca*) & Lutz spruce (*Picea x lutzii*)

Figure source: Holsten et al. 1999. Forest Insect & Disease Leaflet 127, U.S.D.A. Forest Service

Spruce beetle life cycle



* 1 - 3 year life cycle depending on location

An adult spruce beetle.

Spruce beetle eggs along side of egg gallery.

Spruce beetle larval galleries.

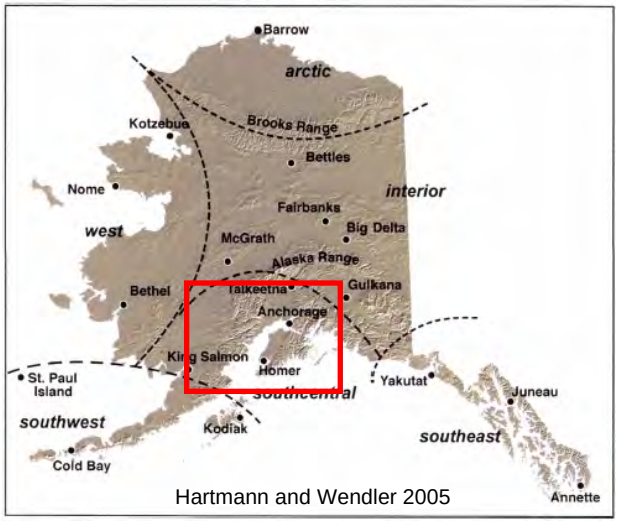
Actual size ~ ¼ inch long & 1/8 inch wide

Actual size ~ 2.5 to 12 inches long

Photos from: Holsten et al. 1999. Forest Insect & Disease Leaflet 127, U.S.D.A. Forest Service

Life cycle figure from: Alberta.ca (forests) website

Increasing temperatures & beetle activity



Hartmann and Wendler 2005

Total Change in Mean Seasonal and Annual Temperature (°F), 1949 - 2008

Region	Location	Winter	Spring	Summer	Autumn	Annual
Arctic	Barrow	6.5	4.4	2.8	3.4	4.3
Interior	Bettles	8.5	4.6	1.8	1.1	3.9
	Big Delta	8.2	3.5	1.2	-0.2	3.4
	Fairbanks	7.7	3.8	2.3	-0.4	3.3
	McGrath	7.4	4.8	2.7	0.6	3.9
West Coast	Kotzebue	6.6	1.8	2.5	1.6	3.1
	Nome	4.4	3.6	2.5	0.6	2.8
	Bethel	6.6	5.0	2.3	0.1	3.6
	King Salmon	8.1	4.7	1.8	0.6	3.8
	Cold Bay	1.5	1.8	1.8	0.9	1.5
	St Paul	1.0	2.4	2.8	1.3	1.9
Southcentral	Anchorage	6.8	3.6	1.6	1.4	3.1
	Talkeetna	8.9	5.4	3.1	2.4	5.0
	Gulkana	8.1	2.4	0.9	0	2.8
	Homer	6.3	4.0	3.4	1.7	3.9
	Kodiak	0.9	2.3	1.2	-0.4	1.0
Southeast	Yakutat	4.9	3.1	1.8	0.3	2.6
	Juneau	6.6	3.1	2.1	1.4	3.3
	Annette	3.9	2.5	1.7	0.2	2.1
	Average	6.0	3.5	2.1	0.9	3.1

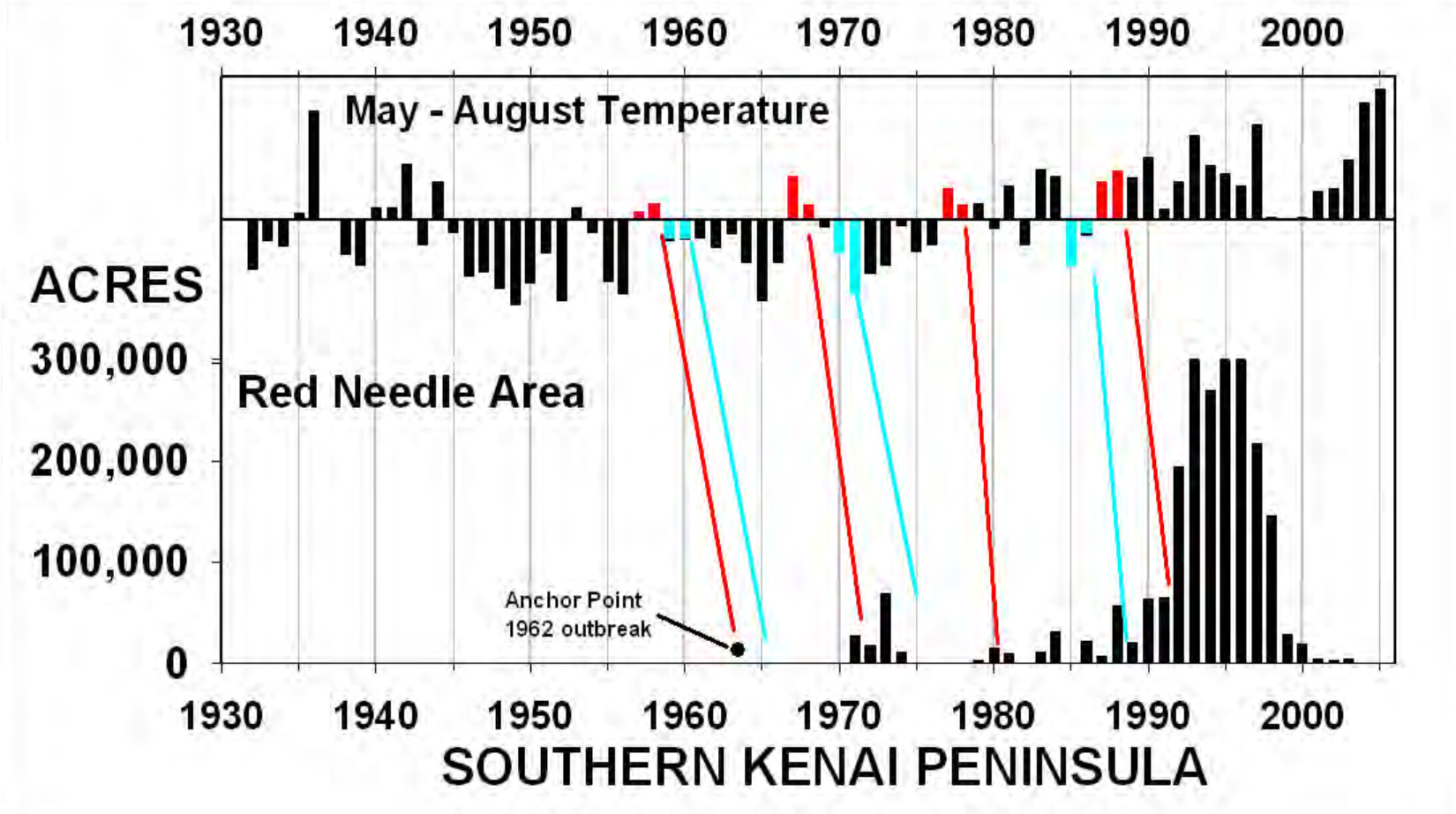
Alaska Climate Research Center — Geophysical Institute, University of Alaska Fairbanks

Darren Blackford

Warm summers support shorter life cycles. Warm winters increase survival.

http://climate.gi.alaska.edu/climtrends/change/tempChange.html

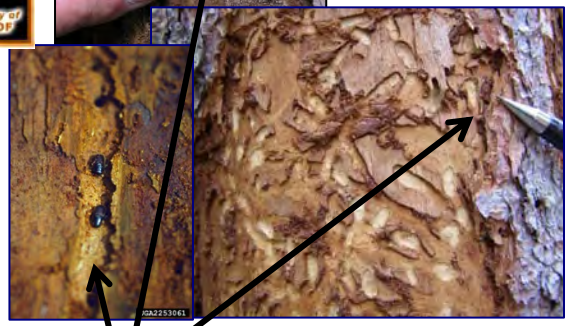
Runs of warm and cool summers on Kenai



Evidence of infestation

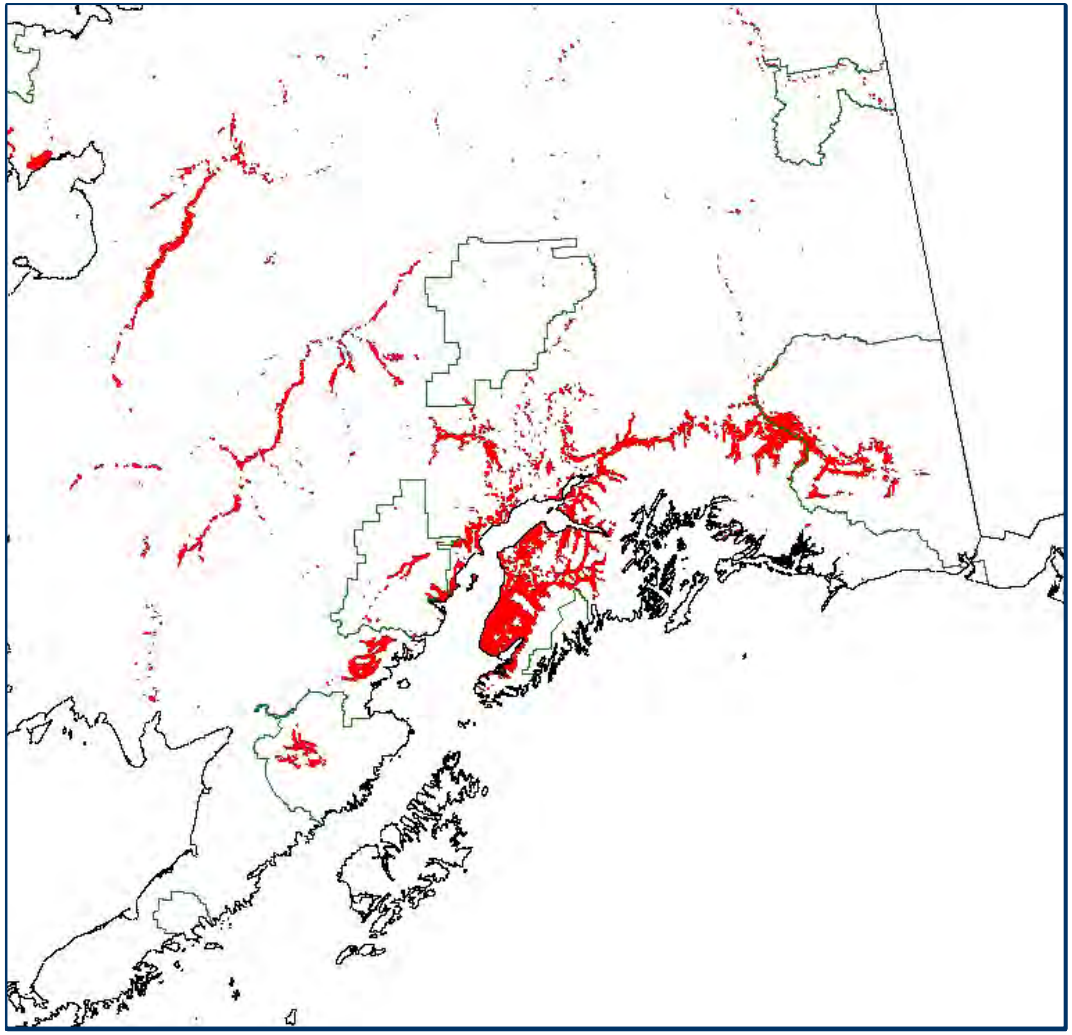
- Boring dust at holes & base of tree
- Pitch tubes & galleries
- Bleeding pitch
- Red needles

Bark Beetle Holes



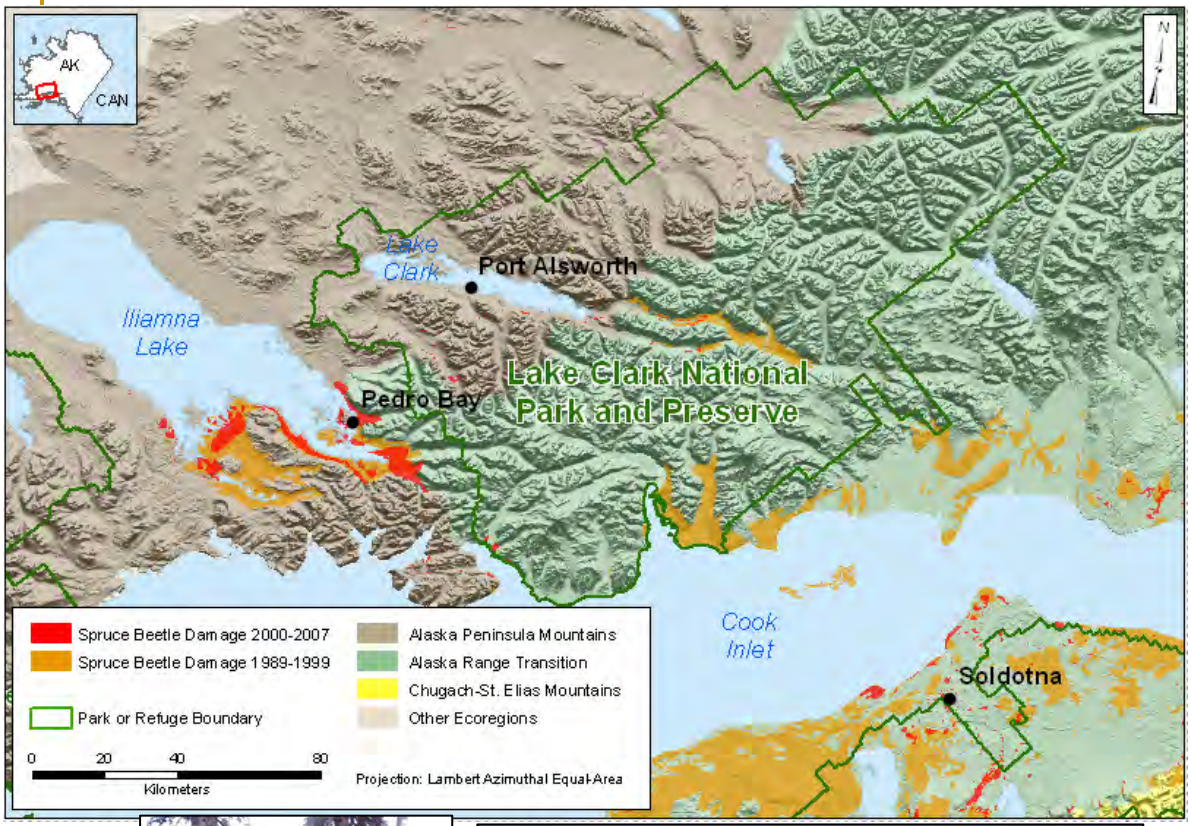
Bark Beetle Galleries

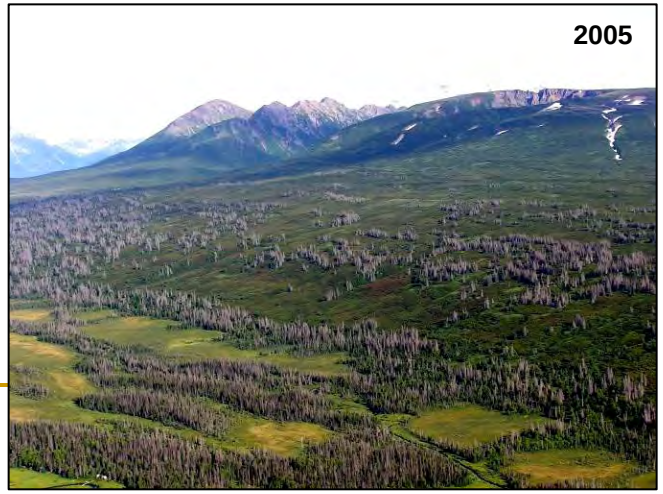
Spruce bark beetle damage (1989-2007)



USFS/Alaska DNR Forest Health Monitoring Clearinghouse - http://agdc.usgs.gov/data/projects/fhm/

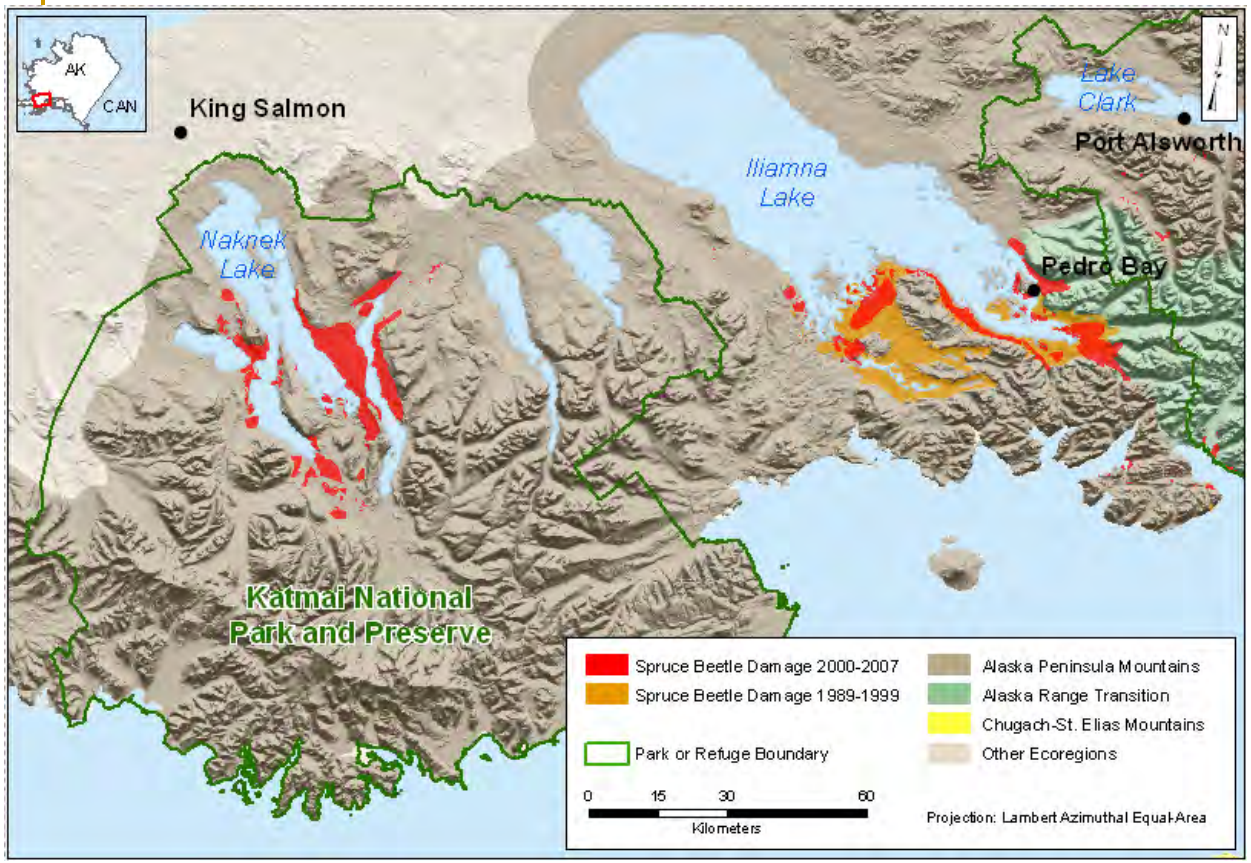
Current activity: Lake Clark

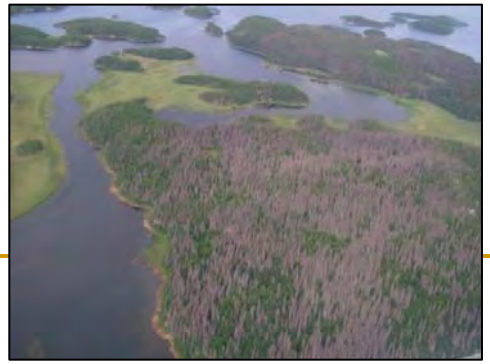




Photos courtesy of Amy Miller

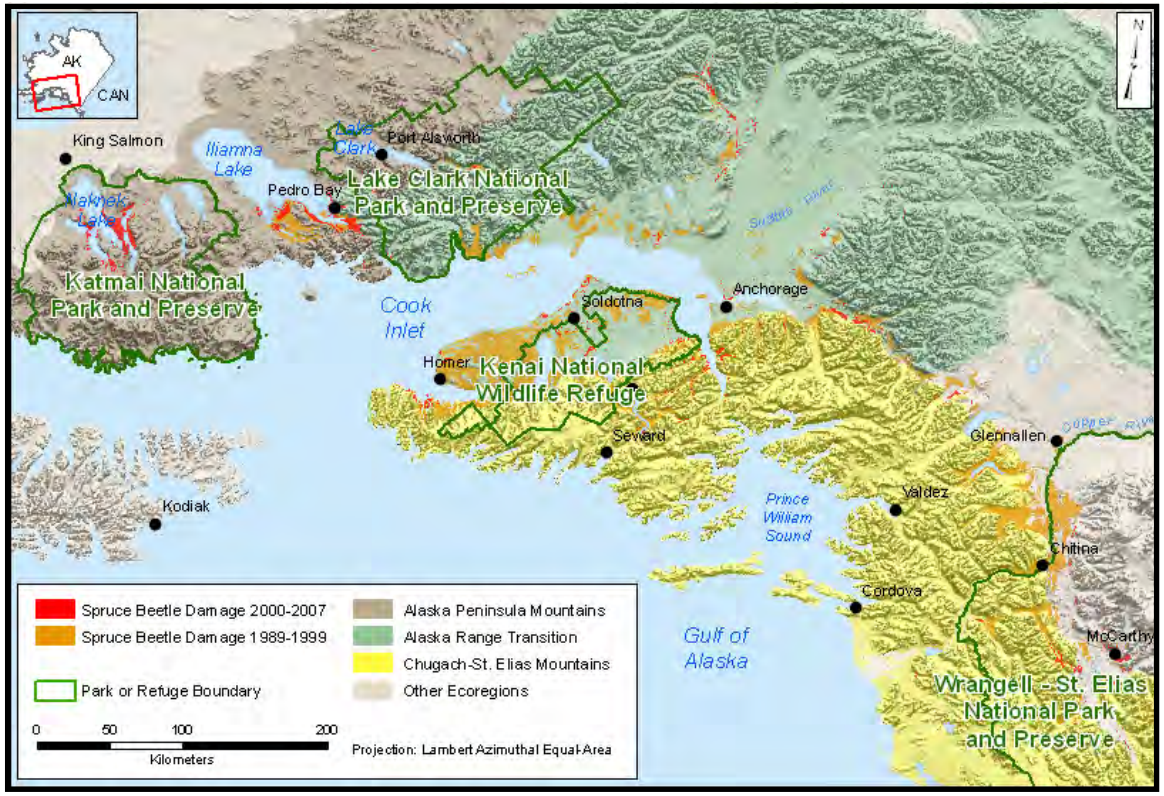
Current activity: Katmai





Photos courtesy of Amy Miller and Ed Berg

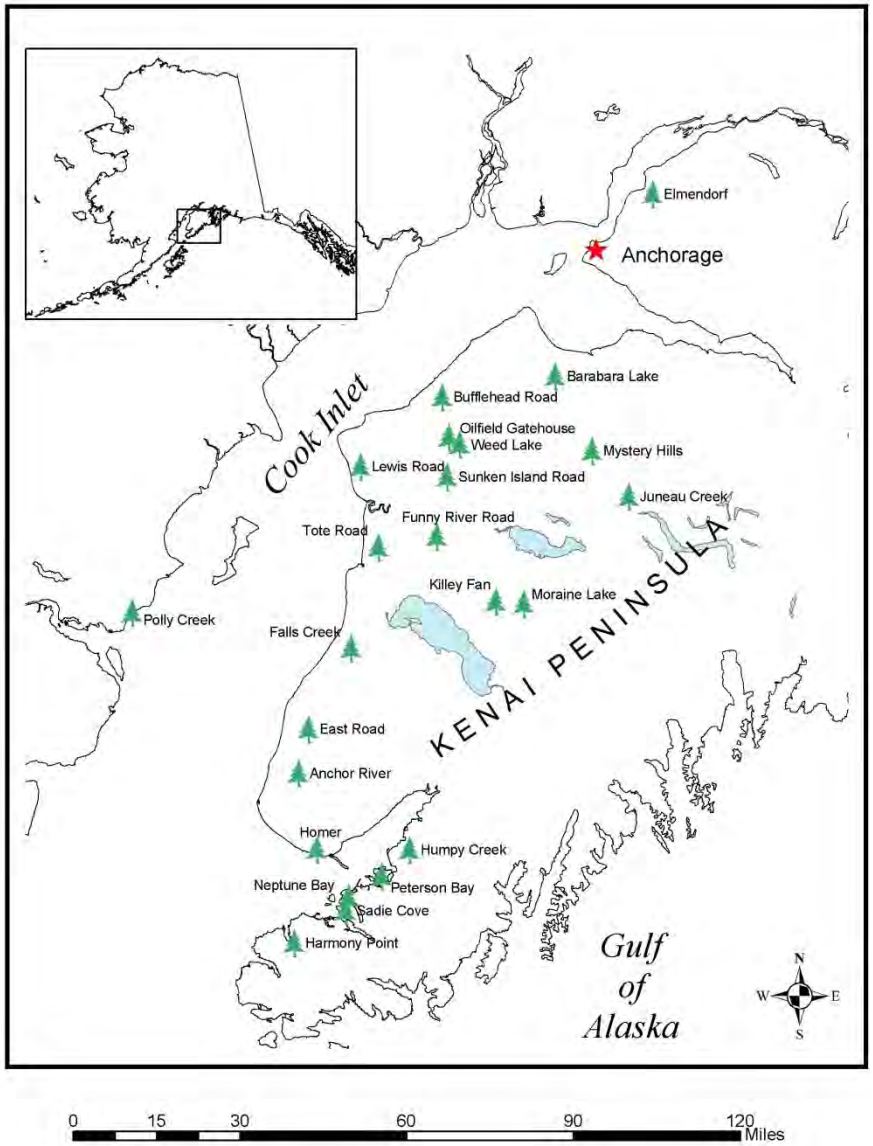
Questions



- Is there evidence of previous insect activity across south-central Alaska?
- What is the relationship between climate and insect disturbance?
- How different are current outbreaks from those historically?

Historic beetle activity: Kenai Peninsula

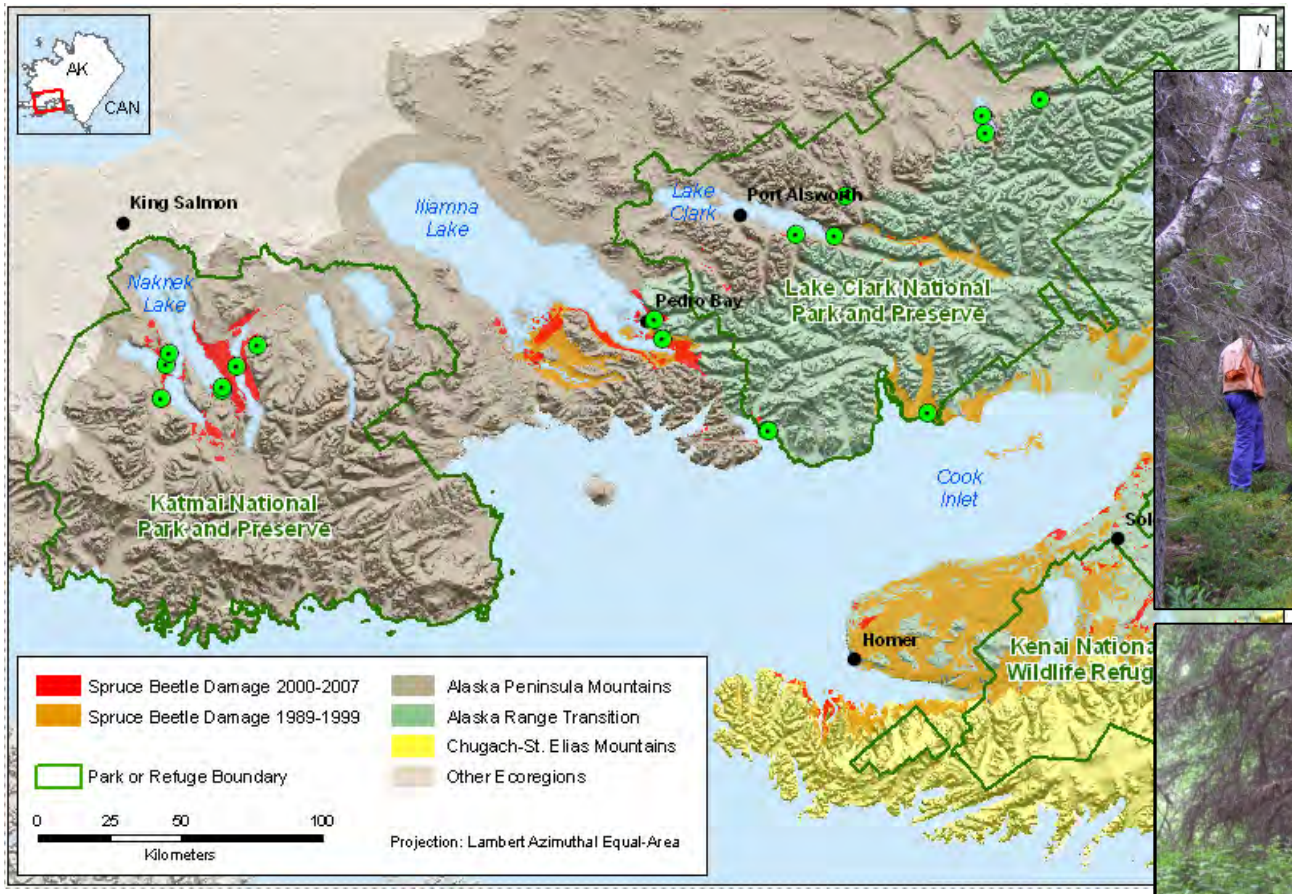
- Widespread outbreaks 1810s, 1850s, 1870-80s, 1910s, 1970-80s
- Recent outbreaks (1971-1996) linked to multi-year warm summers



Map courtesy of Ed Berg

Berg et al. 2006. Spruce beetle outbreaks on the Kenai Peninsula, Alaska, and Kluane National Park and Reserve, Yukon Territory: Relationship to summer temperature and regional differences in disturbance regimes. *Forest Ecology and Management* 227: 219-232.

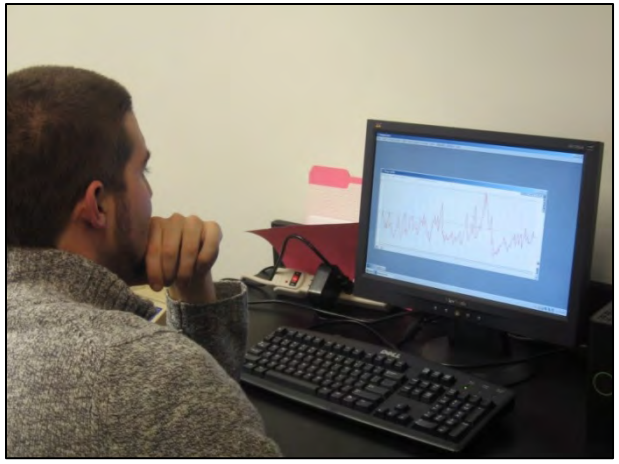
Study sites – Lake Clark and Katmai



15 sites

n = 1384 tree cores

What can tree rings tell us?



← Tree center

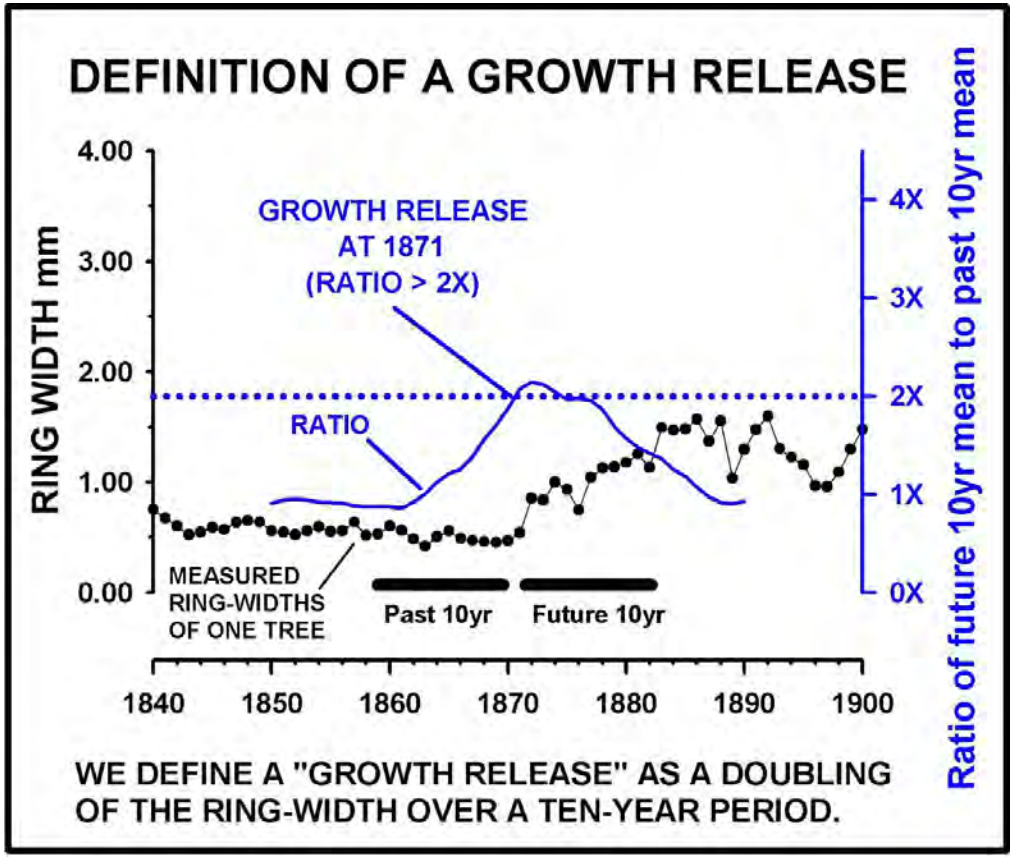
Bark →

Releases in growth from stand-thinning event

Identifying a 'growth release'

Growth release criteria:
- Doubling ring-width ratio
- 10-year window

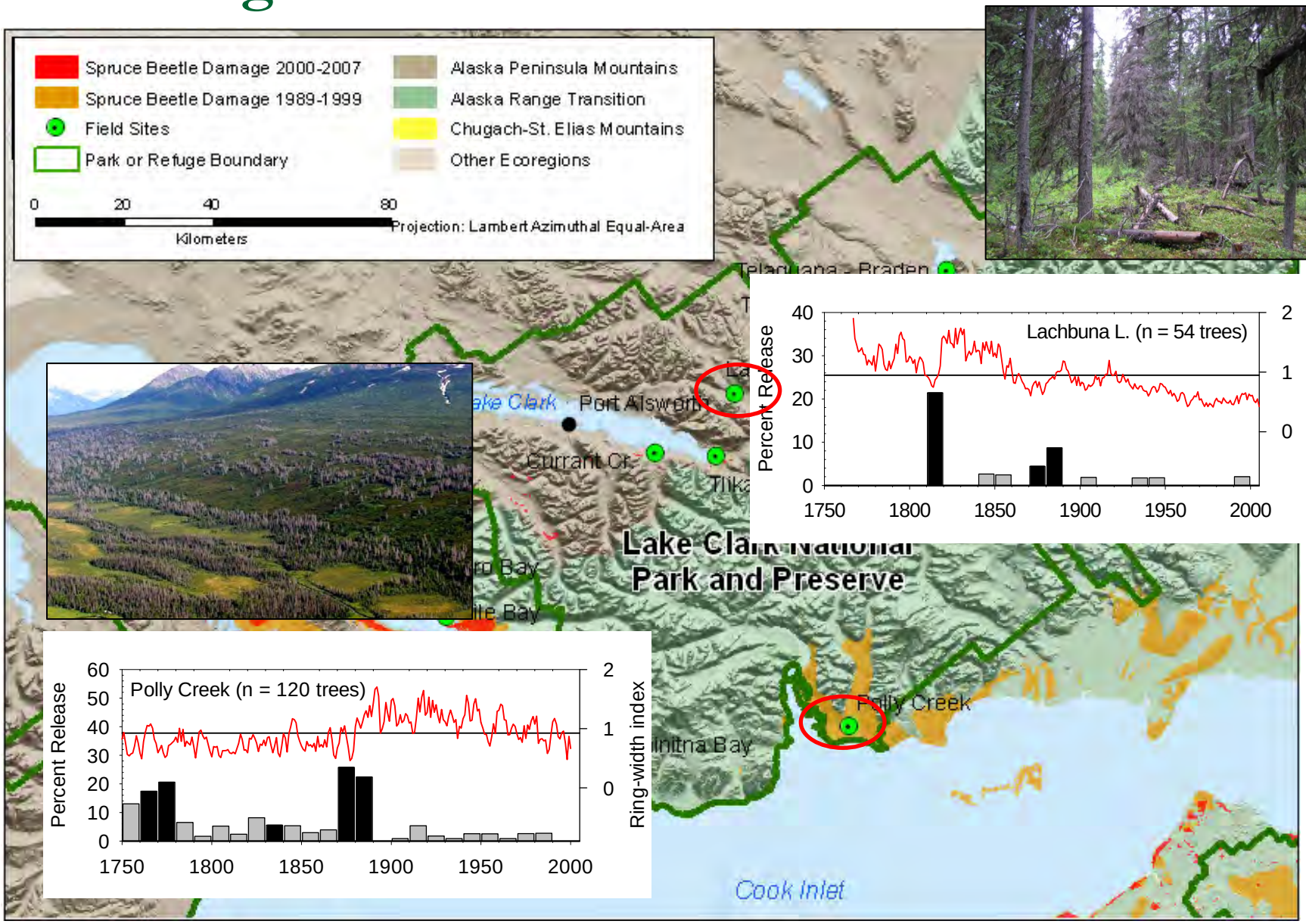
Evidence:
- Initiation year (tree)
- Release period (stand)



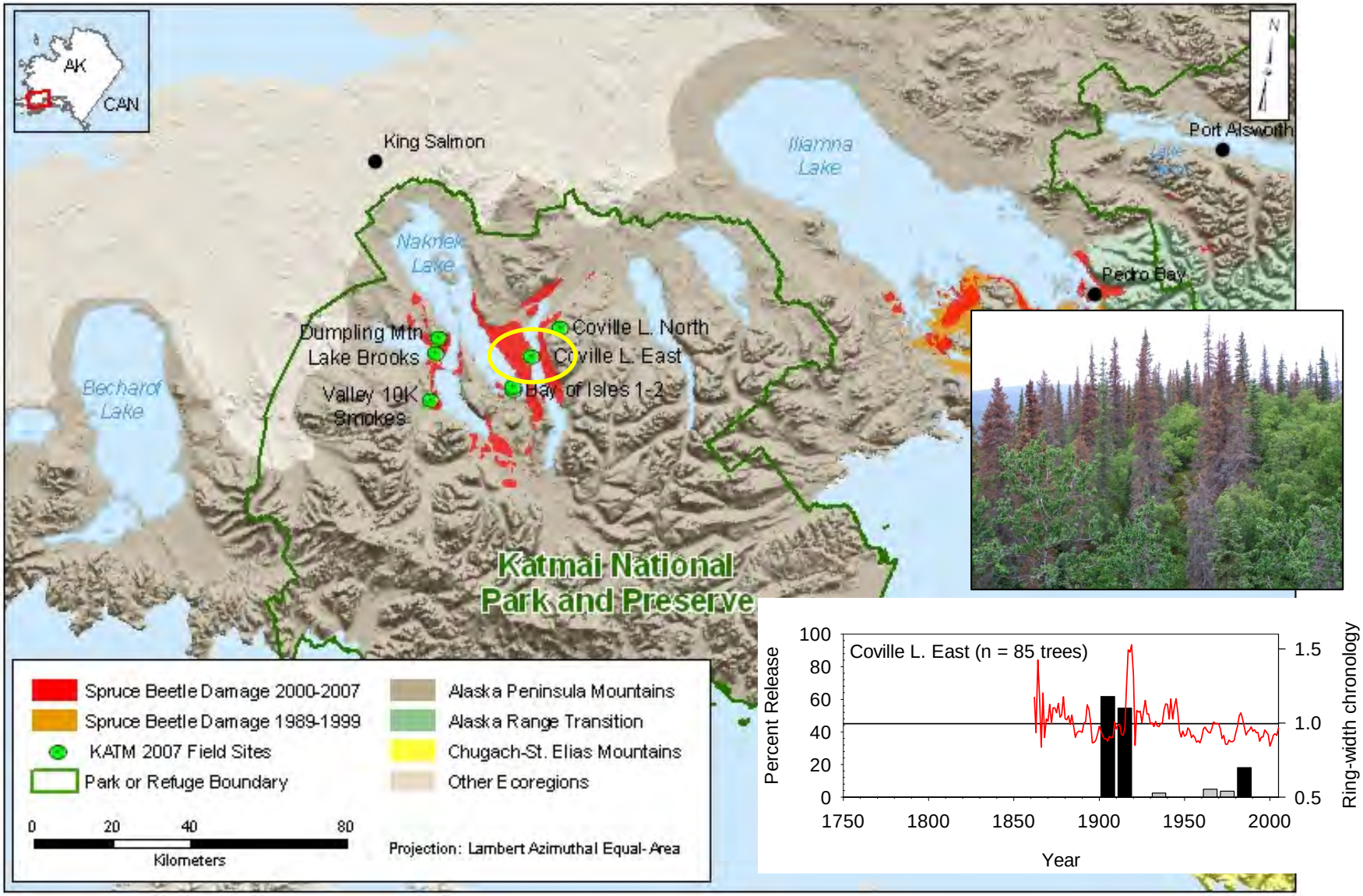
Tree center ← → Bark

Figure from Berg et al. 2006

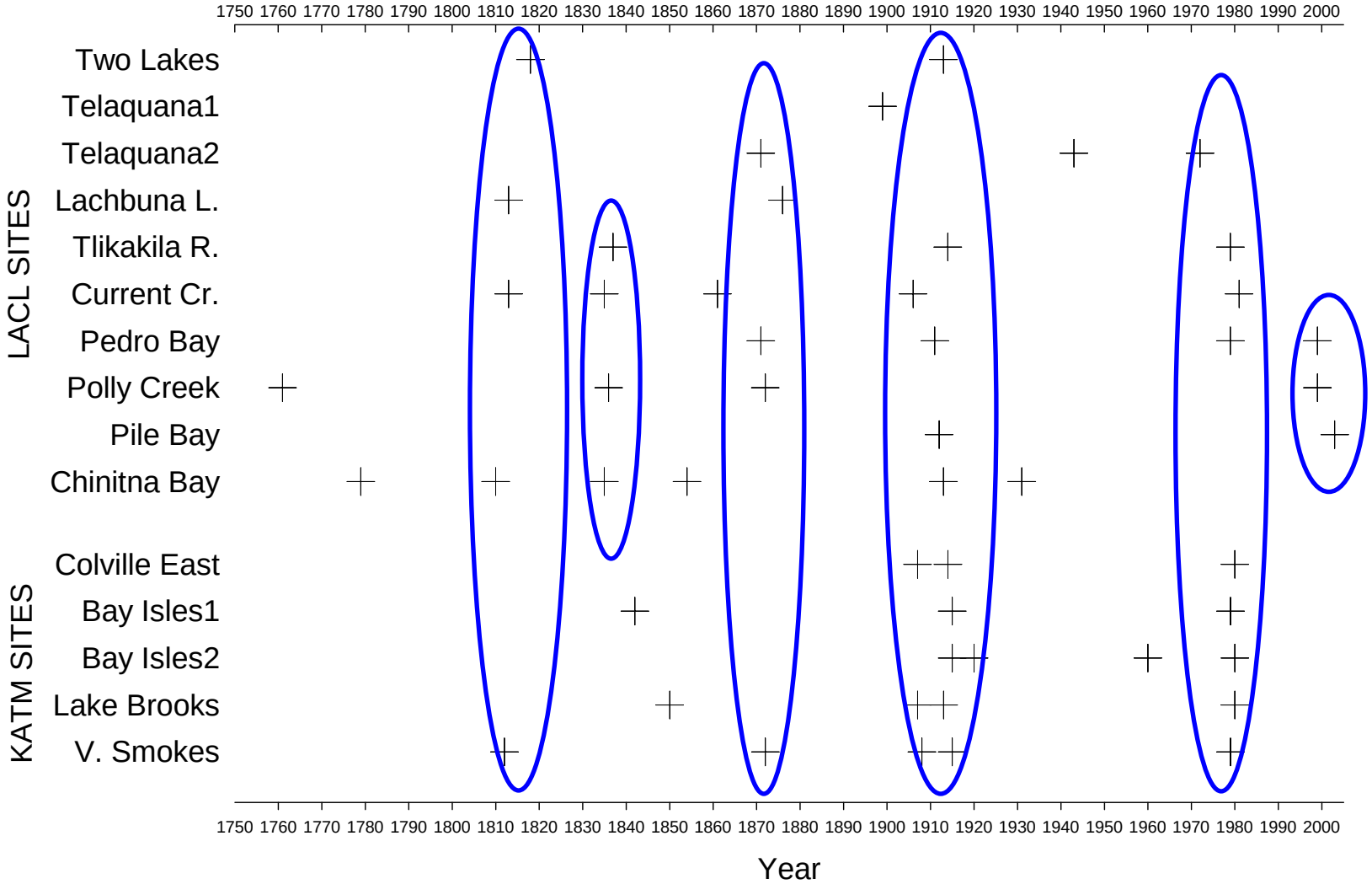
Tree-ring records: Lake Clark - Iliamna



Tree-ring record: Katmai

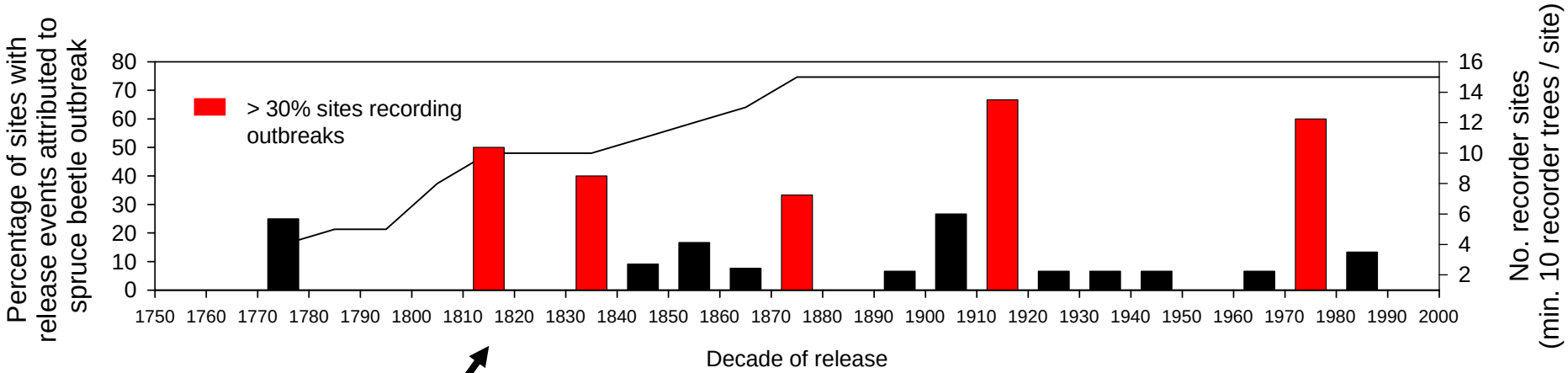


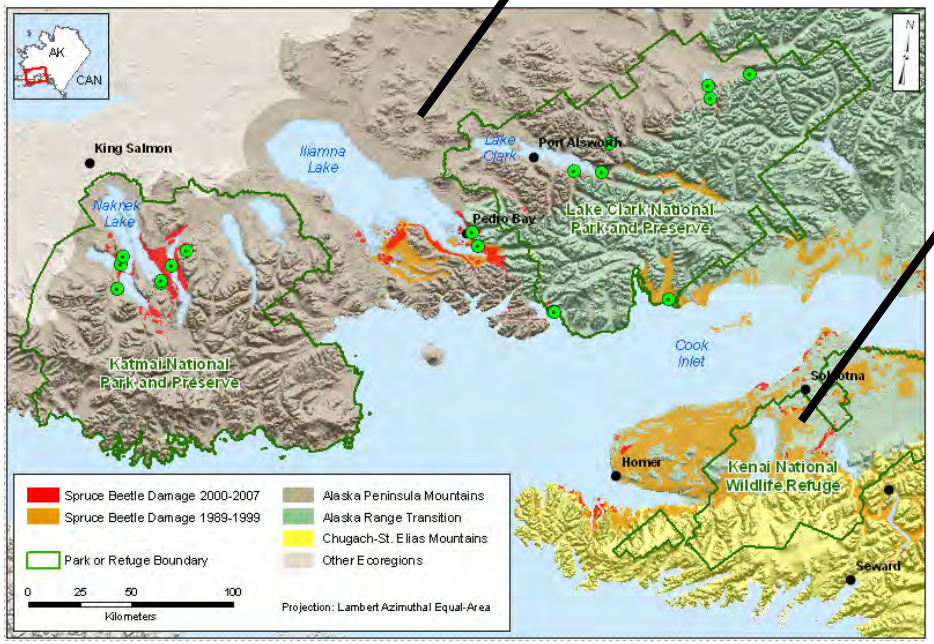
Growth releases recorded across sites



Initiation year of significant release period
(growth release 2x for 10-year window compared to prior 10 years)

Synchrony in spruce beetle outbreaks: Alaska & Kenai Peninsulas



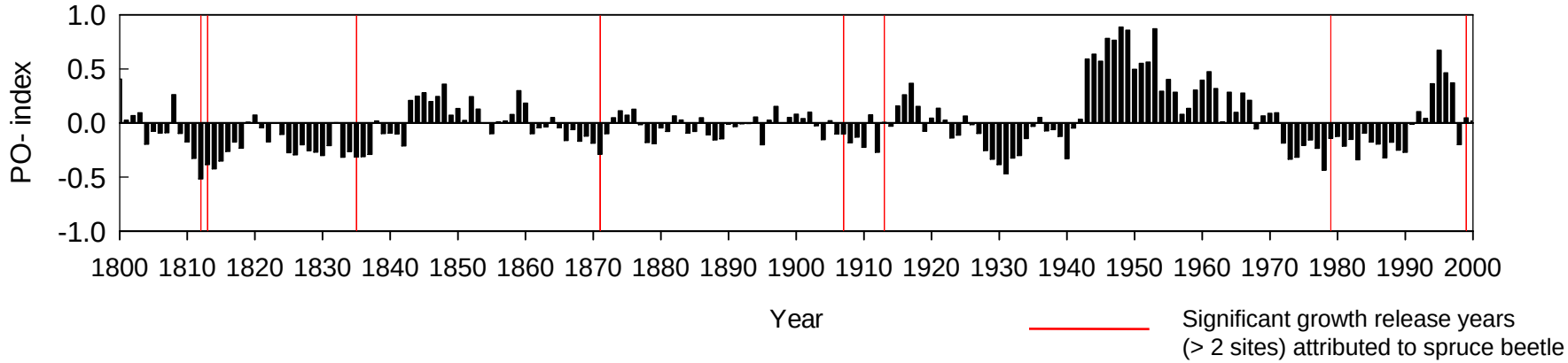


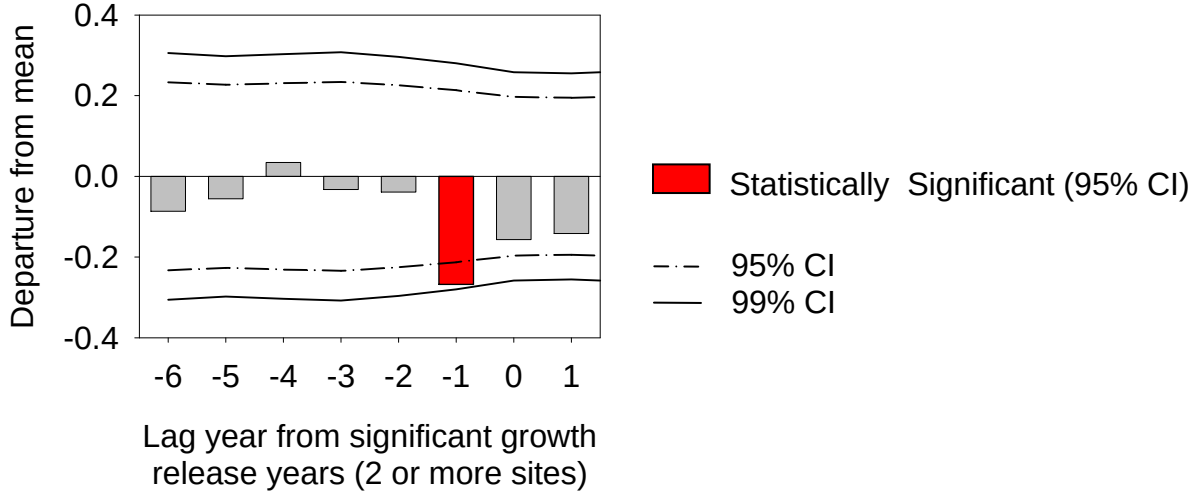
Kenai Peninsula regional outbreaks
N = 23 sites

- 1810s (48% sites)
- 1870s-80s (74% sites)
- 1910s (61% sites - northern Kenai)
- 1970s (54% sites - northern Kenai)

Berg et al. 2006, *Forest Ecol. & Management*

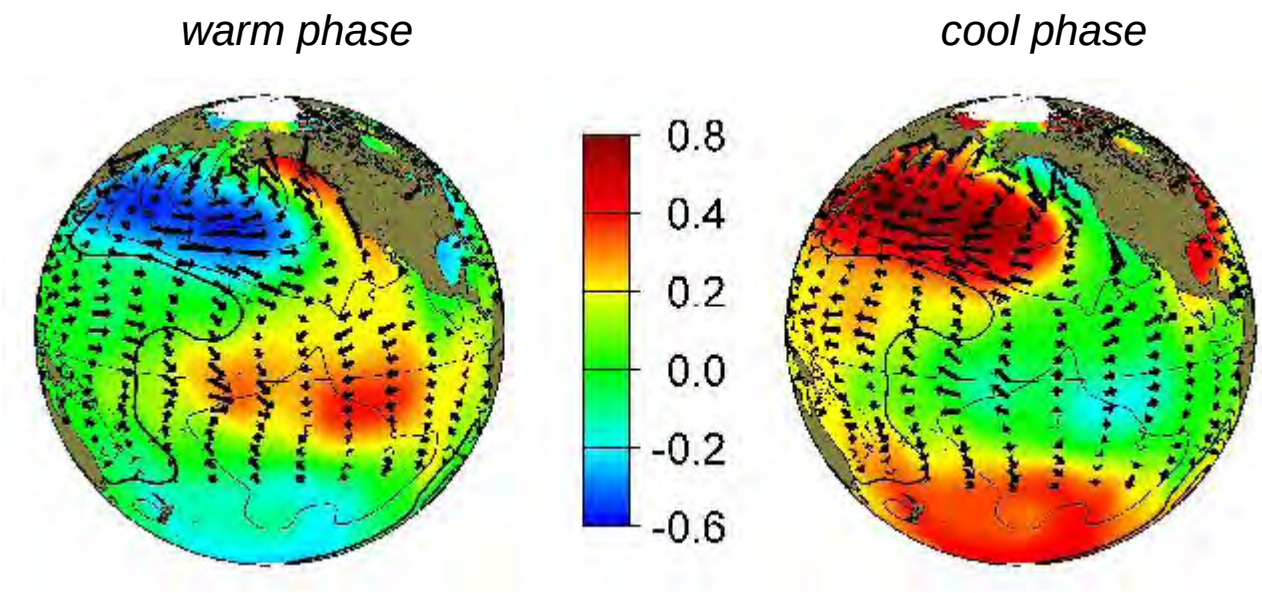
Testing for a relationship between beetles & climate

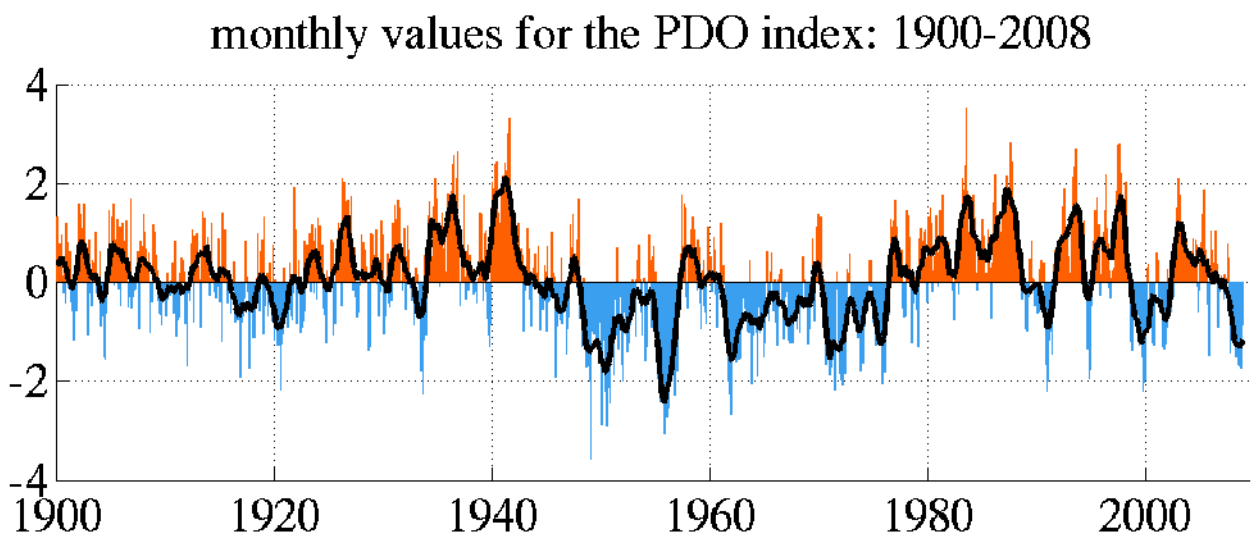




PO – index: Tree-ring growth response to temperature and precipitation in the King Salmon instrumental record (1947 to 2000).
Data from Driscoll, Wiles, D'Arrigo, Wilmking. 2006. *Geophysical Research Letters.*

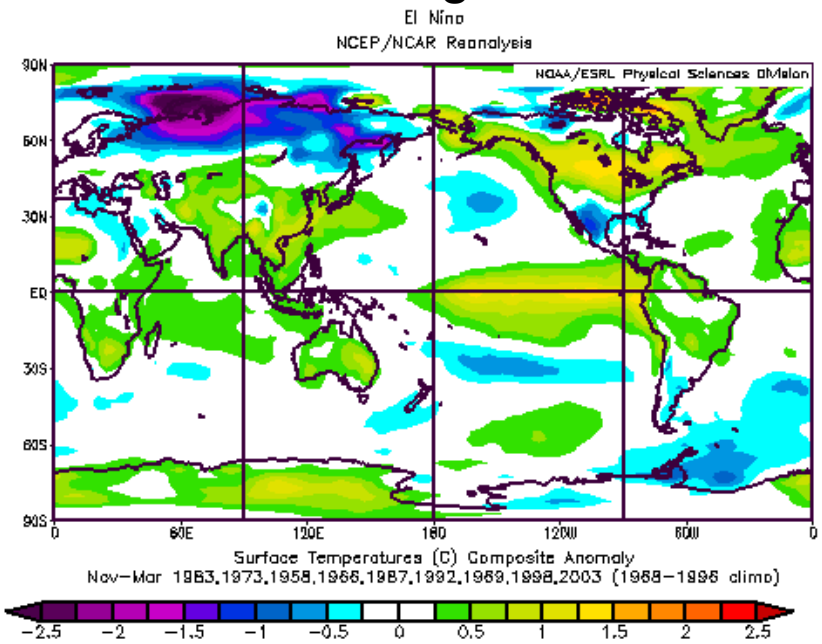
Climate proxies: Pacific Decadal Oscillation

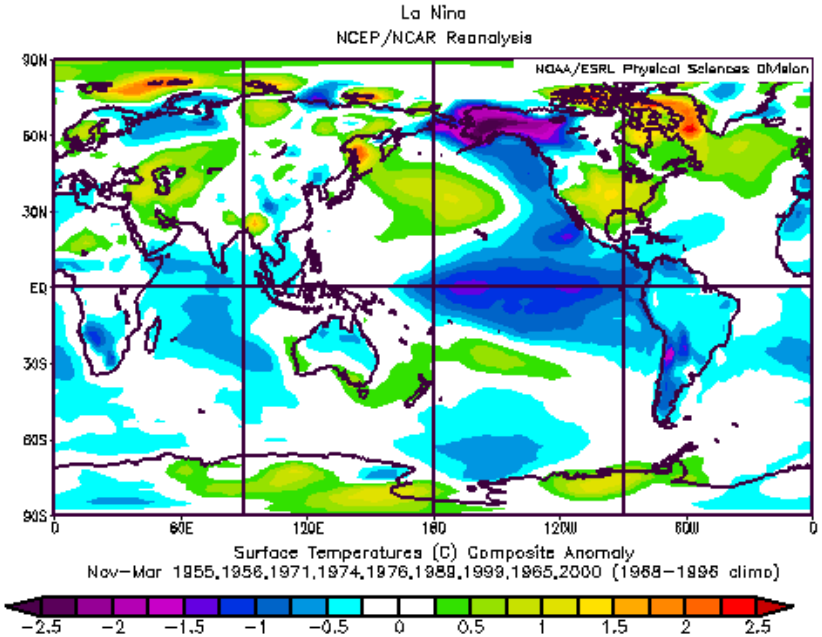


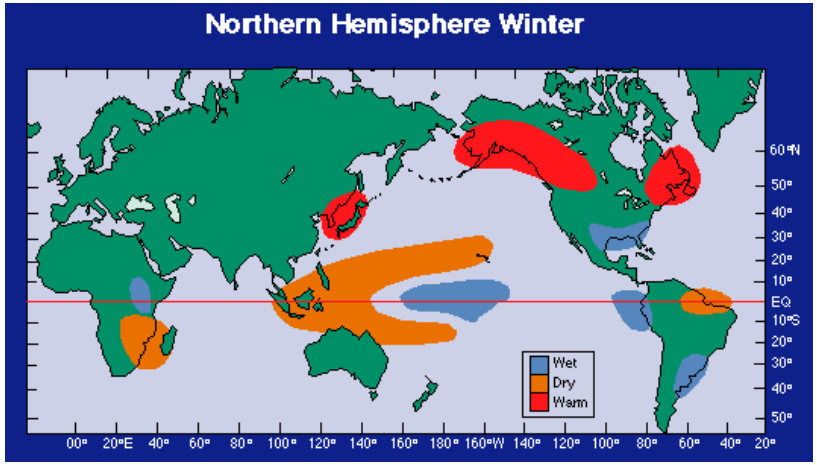


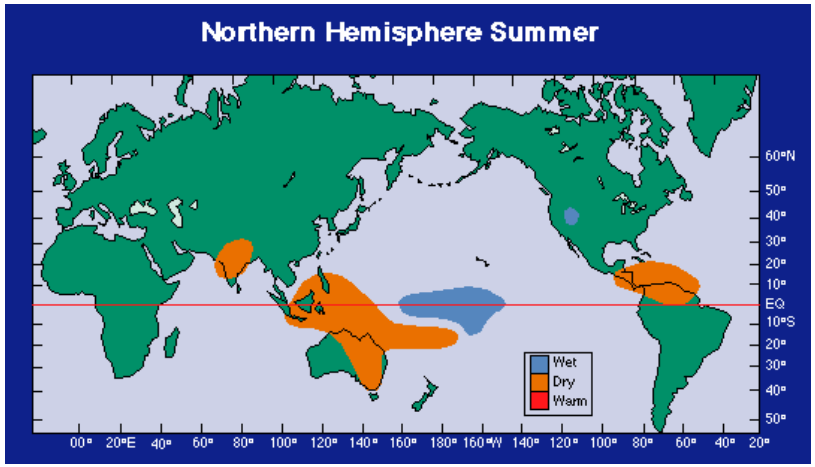
Climate proxies: El Niño-Southern Oscillation

Average seasonal El Niño and La Niña Anomalies



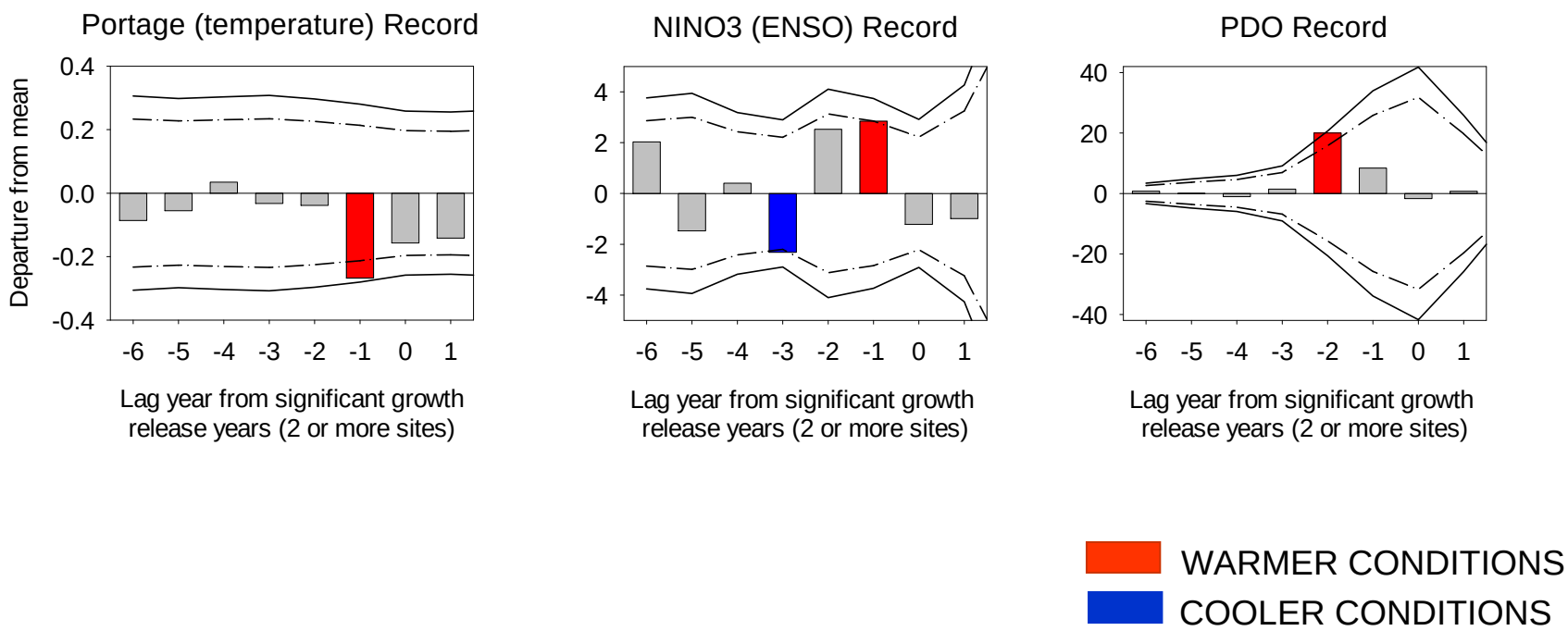






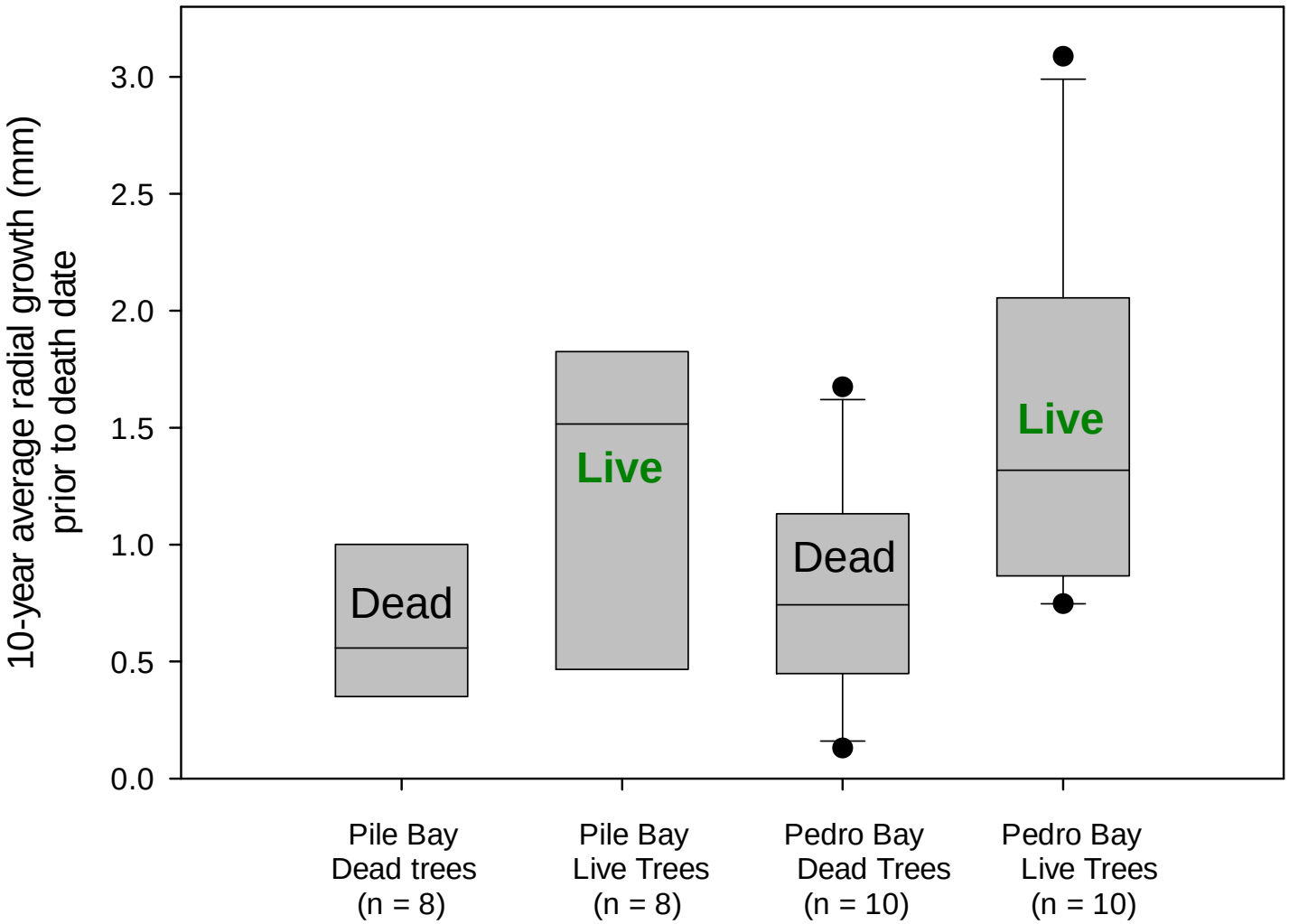
http://www.cdc.noaa.gov/enso/enso.climate.html

Beetle outbreaks vs. climate variability (1810–2003)



Portage Record (Driscoll et al. 2005 *Geophysical Research Letters*).
NINO3 reconstruction (D'Arrigo et al. 2005) and instrumental records combined using methods described in Schoennagel et al. 2008 *Ecology.*
PDO reconstruction (D'Arrigo et al. 2001) and instrumental records combined using methods described in Schoennagel et al. 2008 *Ecology.*

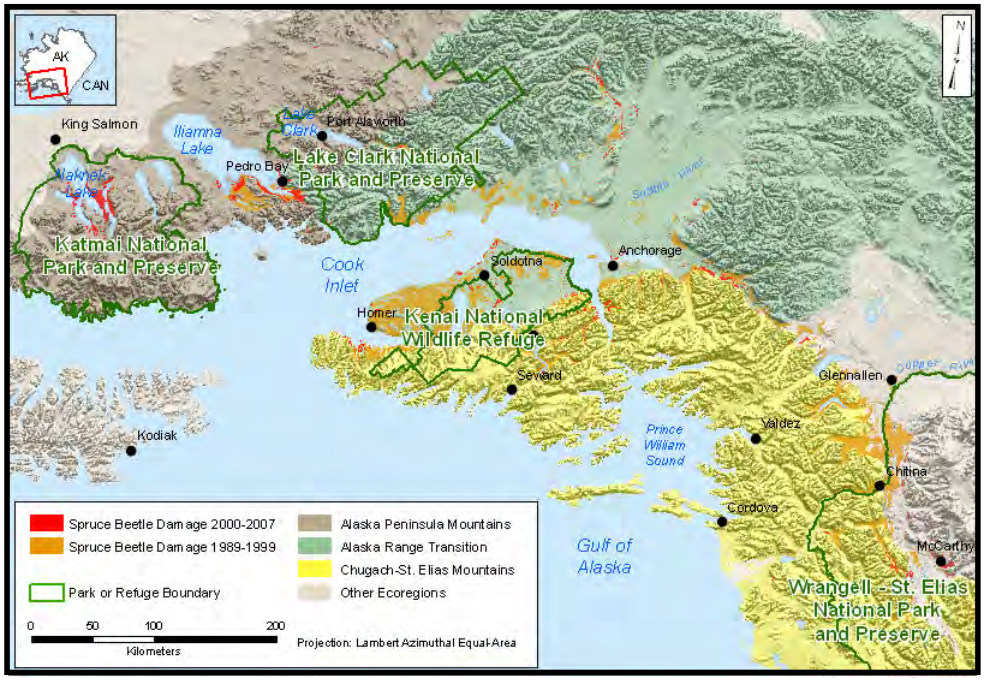
Stress kills: growth declines prior to tree death



Pile Bay
Diameter range 18-35 cm
Median 26.5 cm

Pedro Bay
Diameter range 11-41 cm
Median 28.5 cm

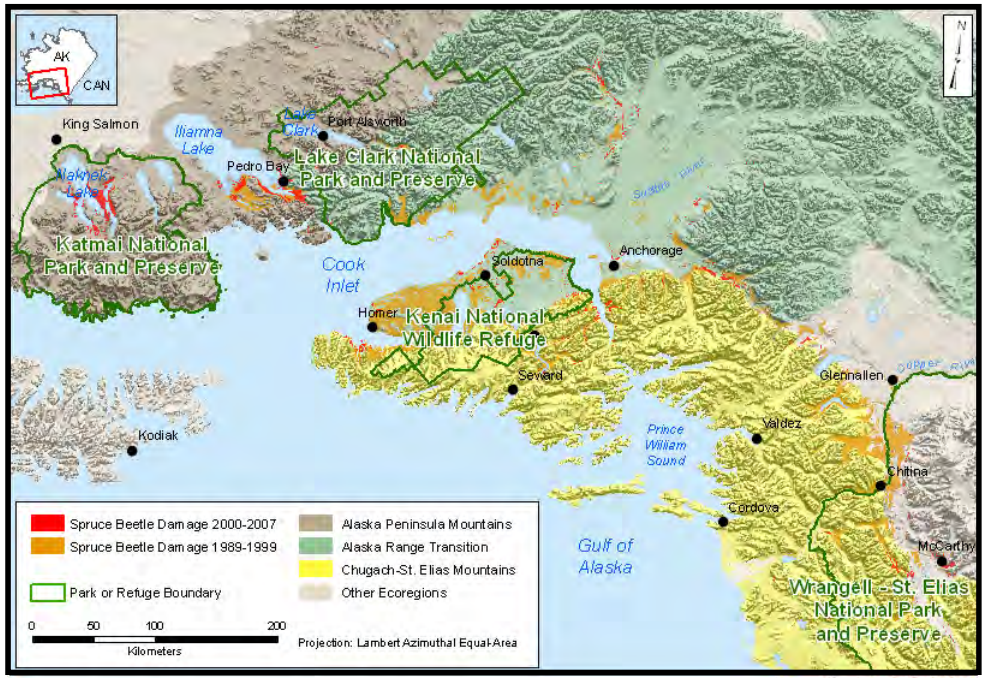
Results: Evidence for historic outbreaks



- Is there evidence of previous insect activity across south-central Alaska?

A long history of extensive synchronous spruce beetle outbreaks across south-central Alaska.

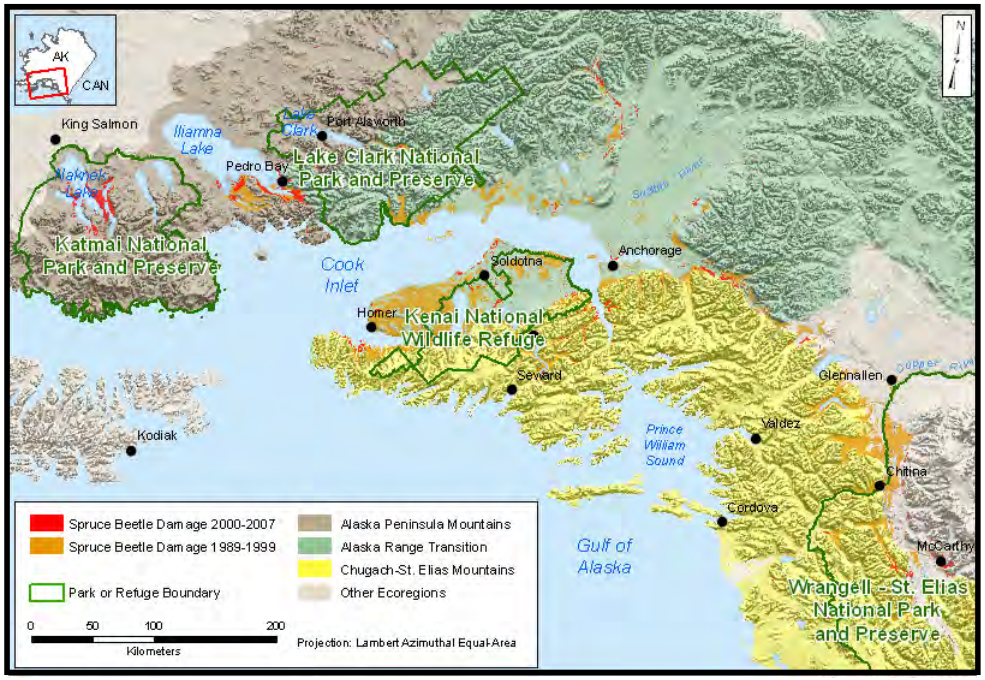
Results: Climate-beetle relationship



- What is the relationship between climate and insect disturbance?

Regional outbreaks linked to warm, dry conditions at inter-annual and decadal scales associated with ENSO and PDO.

Results: Is current outbreak representative?



- How different are current insect outbreaks from historic outbreaks?

What is 'Natural?'

- Most assessments of *ecosystem change* based on short-term (< 50 years) records
- Geographically limited information
- Disentangling *natural variability* from other trends is difficult, partially due to short time scales

Summary of findings

- Current knowledge is incomplete, but sufficient to begin addressing management concerns re: insect outbreaks
  - Recent widespread outbreaks are not outside of the range of natural variability at a stand scale
    - Spruce beetle outbreaks are a *natural* and important ecological disturbance in these ecosystems
    - Broad-scale climate variability an important driver of historic and recent outbreaks
  - However, the duration of recent and on-going spruce beetle activity may be producing higher severity effects (i.e., higher mortality) at the landscape scale

Acknowledgements

Collaborators: Ed Berg (U.S. Fish & Wildlife Service) and Amy Miller (National Park Service).
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