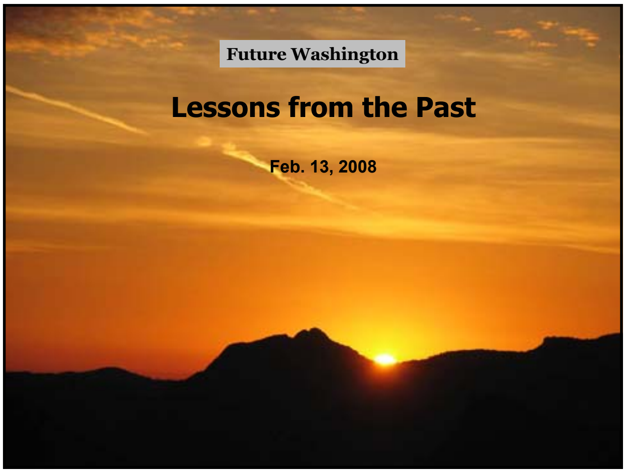
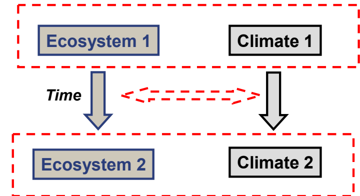


Looking for Lessons from the Past

How have ecosystems changed with climate changes in the past?



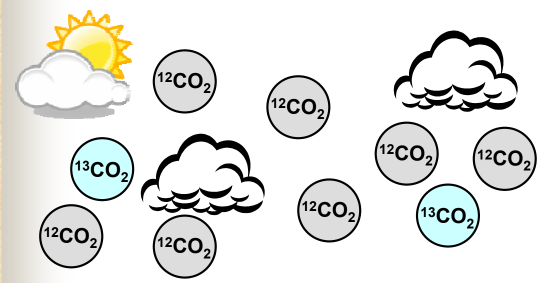
Do ecosystems vary in a predictable way with climate?

How does the timing of ecosystem changes compare to the timing of climate change?

Past vegetation communities are reconstructed – HOW?

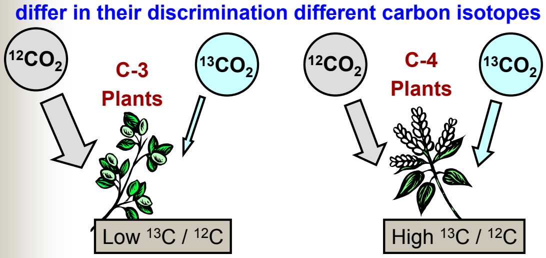
Using Stable Isotopes to Reconstruct Past Ecosystems

There are two major stable isotopes of carbon in the carbon dioxide of the atmosphere



Using Stable Isotopes to Reconstruct Past Ecosystems

There are two major forms of photosynthesis that differ in their discrimination different carbon isotopes



Using Stable Isotopes to Reconstruct Past Ecosystems

Collect sample representing past conditions → Buried soil layer / Fossilized herbivore material

Test isotope ratio

Hypothetical result → High ^{13}C / ^{12}C

Infer dominant plant species type

Infer environmental conditions

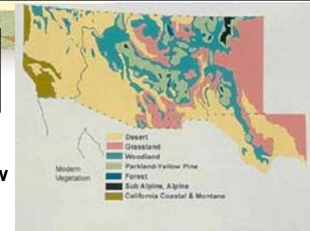
Using Packrat Middens to Reconstruct Past Ecosystems

Bushy-tailed woodrat (*Neotoma cinerea*)

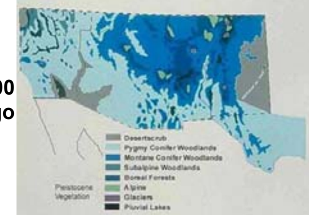
http://www.ncdc.noaa.gov/paleo/

Using Packrat Middens to Reconstruct Past Ecosystems

Vegetation now

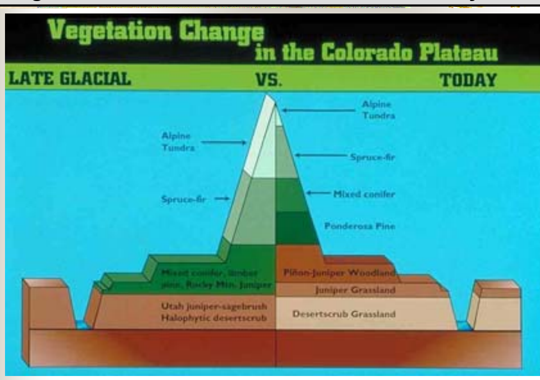


Vegetation 18,000 years ago



http://www.ncdc.noaa.gov/paleo/

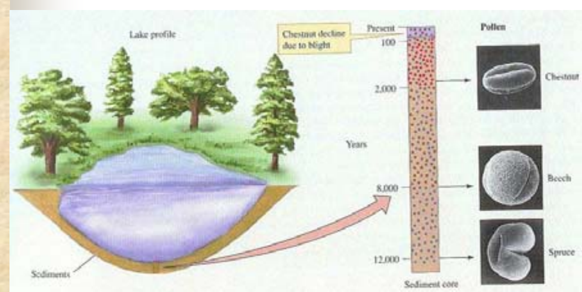
Using Packrat Middens to Reconstruct Past Ecosystems



http://www.ncdc.noaa.gov/paleo/

Using Pollen & Macrofossils to Reconstruct Past Ecosystems

Palynology:



Molles (2004)

Using Pollen & Macrofossils to Reconstruct Past Ecosystems

Taking the cores

Photo: Bowdin University

Photo: University of Northern Ireland

Using Pollen & Macrofossils to Reconstruct Past Ecosystems

Examining the cores

www.pastperfect.info

Using Pollen & Macrofossils to Reconstruct Past Ecosystems

Extracting the pollen

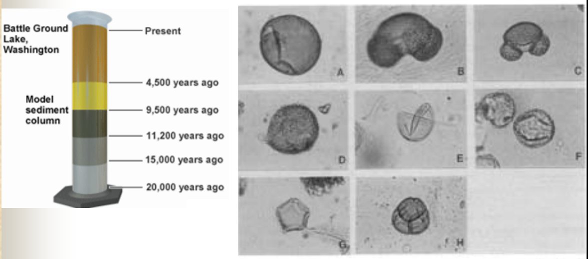


Figure 9.2. Common pollen types of the coastal rain forest: (*a*) Douglas-fir; (*b*) Sitka spruce; (*c*) lodgepole pine; (*d*) western hemlock; (*e*) western redcedar; (*f*) Garry oak; (*g*) red alder; (*h*) salal. Parts *a, b, c, d,* and *h* magnified about 300 times; parts *e, f,* and *g* magnified about 750 times. (Photo courtesy of R. Hebda.)

Hebda & Whitlock (1997)

Using Pollen & Macrofossils to Reconstruct Past Ecosystems

Reading the pollen results: a pollen diagram

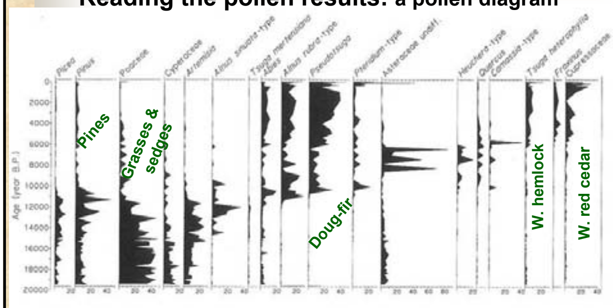


Figure 9.7. Simplified pollen diagram from Battle Ground Lake, southern Puget lowland, Washington. *Source:* Barnosky (1985a).

From Parkland to Forest – south of the glaciers

Using Pollen & Macrofossils to Reconstruct Past Ecosystems

Looking at ecosystem changes since the last major glaciation

LGM –

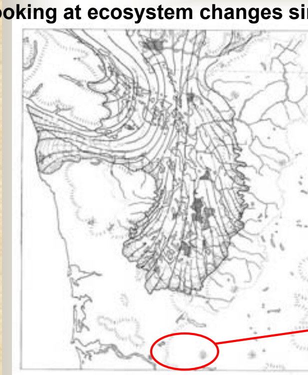
Last Glacial maximum

(~ 20,000 YBP)

Brubaker (1988)

Using Pollen & Macrofossils to Reconstruct Past Ecosystems

Looking at ecosystem changes since the last major glaciation



LGM –

Last Glacial maximum

In Puget Lowlands

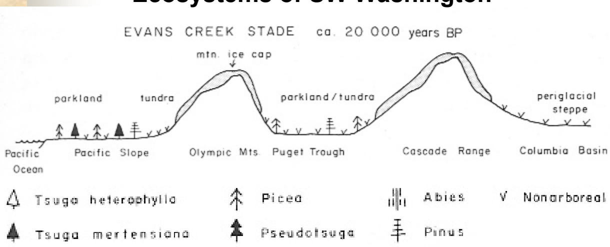
(~ 16,000 YBP)

SW WA research sites

Kruckeberg (1991)

Using Pollen & Macrofossils to Reconstruct Past Ecosystems

Ecosystems of SW Washington



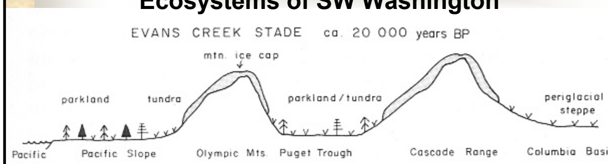
Low elevations: open woodlands of cold-tolerant high-elevation trees

No Douglas-fir or western hemlock or western red cedar

Whitlock (1992)

Using Pollen & Macrofossils to Reconstruct Past Ecosystems

Ecosystems of SW Washington



What do we know of the climate here 20,000 YBP?

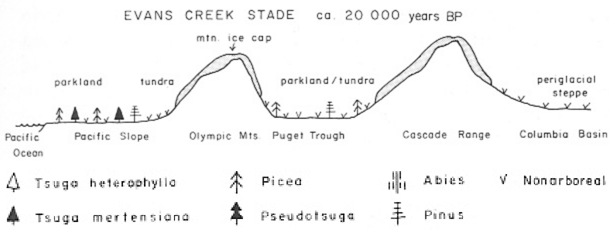
1.

2.

3.

Using Pollen & Macrofossils to Reconstruct Past Ecosystems

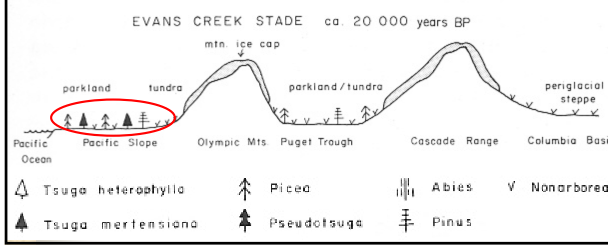
Ecosystems of SW Washington



These ecosystems GENERALLY fit with a picture of a cooler, drier climate

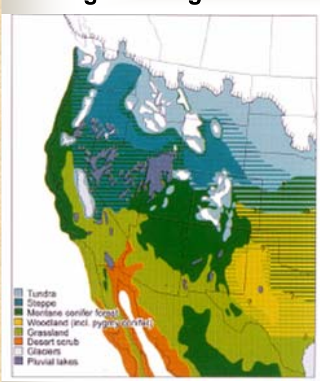
HOWEVER:

Lesson 1: **some past communities have no modern day analogues:**



Using Pollen & Macrofossils to Reconstruct Past Ecosystems

Regional vegetation at LGM (21,000 YBP)



LGM =
Last Glacial Maximum

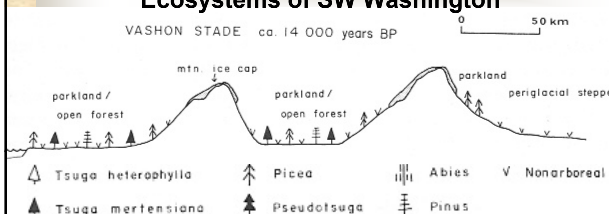
Tundra & parkland dominated near ice sheet

Conifer forest restricted to south (moister & warmer)

Whitlock (2003)

Using Pollen & Macrofossils to Reconstruct Past Ecosystems

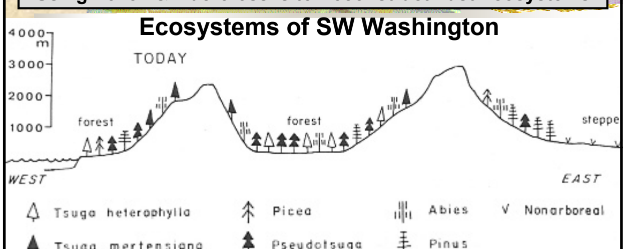
Ecosystems of SW Washington



- **Near glacial maximum in Puget Lowlands**
- **Temperate climate trees in Puget Lowlands indicates**
  - Warming
  - More moisture (shift in jet stream with retreat of larger ice sheet)
- **More communities unlike modern ones**

Using Pollen & Macrofossils to Reconstruct Past Ecosystems

Ecosystems of SW Washington



- **Extensive forest development of modern forests (3 -4,000 YBP)**
  - Follows shift in jet stream to modern climate
  - Mountain hemlock heads uphill (warming)
- **Note forest development even on east slopes**

A closer look over the past 20,000 years – some general trends make sense

K Yr BP	Climate	SW WA (470')	Puget Trough
2	Modern	Western hemlock	Western hemlock
4			
6	Warmer, drier	Gary oak, Douglas-fir woodland	Douglas-fir, western hemlock
8	Much warmer, drier		
10		Temperate-montane forest	Western hemlock, Sitka spruce, Grand fir, Douglas-fir
12	Cooler, drier	Subalpine forest	
14			Western hemlock, Sitka spruce
16	Colder, much drier		Alpine tundra
18			

Cool, moist forests of a moderate, wet modern climate

Transition from moist to warm, dry forests

HYPSITHERMAL PERIOD

Alpine & subalpine communities in cool, dry climate

Data: Whitlock et al. (2003)

K Yr BP	Climate	SW WA (470')	Puget Trough
2	Modern	Western hemlock	Western hemlock
4			
6	Warmer, drier	Gary oak, Douglas-fir woodland	Douglas-fir, western hemlock
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12	Cooler, drier	Subalpine forest	
14			Western hemlock, Sitka spruce
16	Colder, much drier		Alpine tundra
18			

Lesson 2:

Data: Whitlock et al. (2003)

Predictable change in vegetation form: Warming in the 20th Century leads to conversion from tundra to forest in Sweden

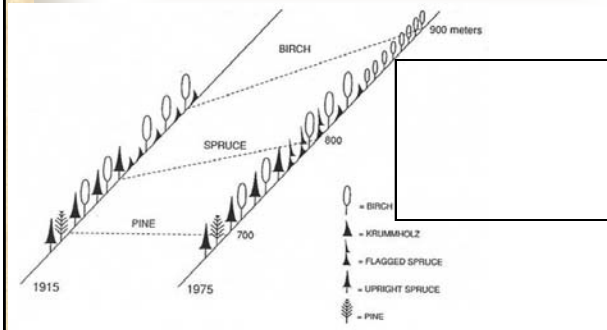
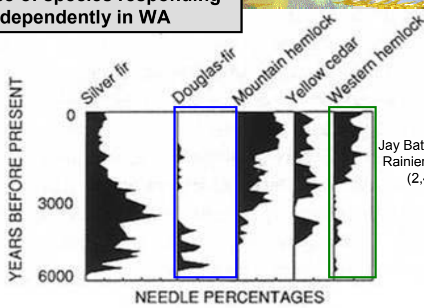


Figure 3-14. Comparison of 1915 and 1975 tree-line elevations of three species in the Handolan Valley, Sweden (after Kullman 1983).

Brubaker (1988)

Evidence of species responding independently in WA



Jay Bath Pond, Mt Rainier Natl Park (2,400 ft)

Douglas-fir & Western hemlock occupy similar ranges in modern WA forests

But their response to changes is VERY different here

Another lesson?

Brubaker (1988)

Lesson 3:

"Modern species may be capable of more environmental relationships than can be deduced from observing the modern landscape, and observations of the modern landscape may be inadequate for predicting vegetation response to future environmental change"

– Brubaker (1988)

However, this case may also have to do with FIRE history as well as species' responses to climate change

K Yr BP	Puget Trough	Olympic Peninsula
2	Western hemlock forest	Western hemlock, Sitka Spruce
4		
6	Douglas-fir, western hemlock	Douglas-fir, western hemlock
8		
10	Western hemlock, Sitka Spruce, Grand fir, Douglas-fir	Lodgepole pine, sitka spruce, Douglas-fir
12		
14	Western hemlock, Sitka Spruce, pine	Western hemlock, Sitka Spruce
16	Alpine tundra	Subalpine forest
18		

Data: Whitlock et al. (2003)

Responses to climate change are not always immediate

Seedlings are usually more susceptible to environmental changes than mature plants

← Ecosystem Change

← Climate Change

Lesson 4: mature ecosystems (esp forests) may buffer against climate change and slow ecosystem response

Sediment Cores can tell you about more than vegetation

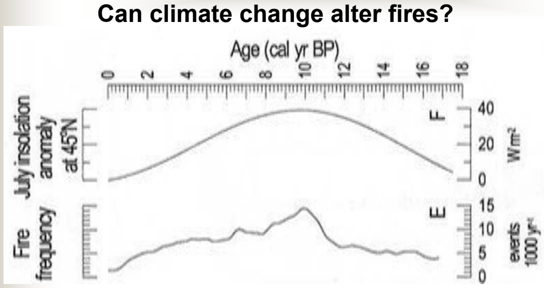
Charcoal concentration

Sediment cores can reveal fire history as well as vegetation

Millspaugh et al. (2000)

Using Sediment Cores to Reconstruct Past Disturbances

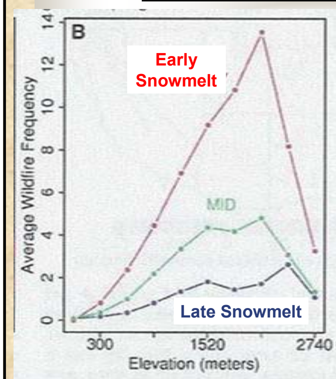
Can climate change alter fires?



A good correlation between July sunshine (& temperature) and fire frequency (Yellowstone)

Millspaugh et al. (2000)

Tying climate to fire frequency



1970 -2002 Western US

Early snowmelt years come with warmer, drier climate

Early snowmelt corresponds to greater fire frequency

Why?

Westerling et al. (2006)

Lesson 5:

Fire has a major role in structuring the ecosystems of WA

This lesson indicates that changes in climate may impart changes in frequency & intensity of fire

Lessons from the Past: a recap

Lessons revisited here – see your notes for the 5 major lessons

Lessons from the Past: a bottom line of uncertainty

Ecosystems and Time

"Ecosystem" is a familiar concept encompassing the living and physical components of a landscape at whatever spatial scale is of interest. An element of *distinctness* is implied. The ecosystem has features that distinguish it from adjacent ecosystems, implying boundaries in space.

Ecologists also recognize the dimension of time as part of the concept. The idea of a "climax" ecosystem, for example, implies that the biotic and physical components have interacted over an interval of time and assembled a web of life and land that has stability. This stable configuration can be disrupted by fire, windstorms, and disease, but eventually the climatic climax returns after a process called succession. These concepts imply that a coherent ecosystem, of which the coastal temperate rain forest climax is an example, will somehow reassemble itself no matter what the disruption. After all, this is what ecologists have observed, more or less, in the century or so they have studied ecosystems.

Hebda & Whitlock (1997)

Lessons from the Past: a bottom line of uncertainty

The perspective of a few decades or centuries has produced a false impression of ecosystem stability. Ecosystems come and go with passing millennia and sometimes even more quickly. Evolution and factors affecting biogeographic distributions alter the nature of the biotic pool available to a future ecosystem. Furthermore, the living components of an ecosystem respond individually as a region's physical circumstances, mainly its climate, change. Even if the same species reassemble into an ecosystem superficially similar to the original one, the new ecosystem cannot be exactly the same. The component species, especially plants, have evolved during the course of their history. Ecosystems do not migrate as coherent units: individual species do so by changing their ranges. Paleoecological studies clearly demonstrate that ecosystems have a finite existence in a place during an interval of time.

Hebda & Whitlock (1997)