Introduction to PNW Ecosystems

I. Physical & Chemical (Abiotic) Environment of WA

1. Where are we? : global / continental position
2. An overview of our place: regional geography & landforms
3. How are landforms created?
4. The importance of geology at multiple scales
5. Climate

II. Ecological Zones of WA

1. Ecoregions
2. Ecoregions: a virtual field trip
3. Environmental determinants of ecoregions

The Ecology of Washington

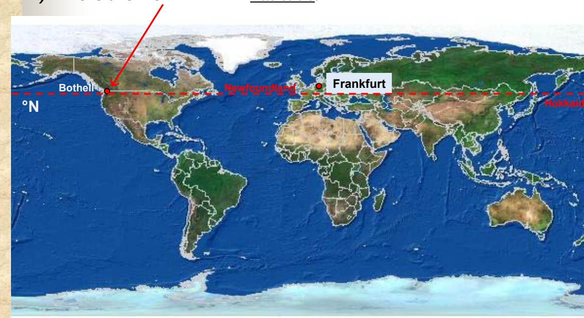
I. Abiotic Environment of WA

1. Global / Continental Position
2. Regional Geography & Landforms
3. Forces Behind Landforms
4. Geology
5. Climate

I. Abiotic Environment of WA

1. Global / Continental Position

A) Where are we ? Latitude:



I. Abiotic Environment of WA

1. Global / Continental Position

A) Where is WA ?

Continental Position: Coastal Maritime

Global / Continental Position

B) What are the ecological implications of our position?

It affects our

I. Present-day Climate

1) Precipitation & Temperature
2) Daily & Seasonal Changes

II. Past Environment

1) Past Climate
2) Geological history
(and hence present day geology)

Global / Continental Position

B) What are the ecological implications of our position?

It affects our

I. Present-day Climate

1) Precipitation & Temperature
   - A. Atmospheric circulation
   - B. Oceanic circulation
   - C. Maritime influences

2) Daily & Seasonal Changes

II. Past Environment

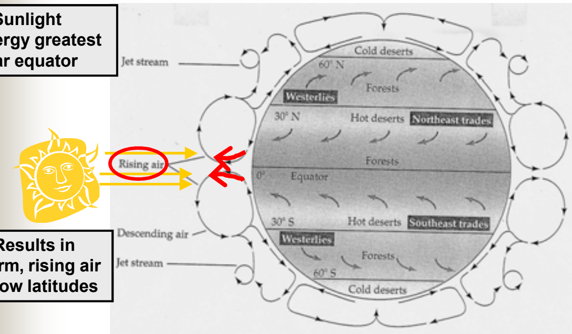
1) Past Climate

2) Geological history

Atmospheric Circulation is a major determinant of global precipitation & temperature patterns

1. Sunlight energy greatest near equator

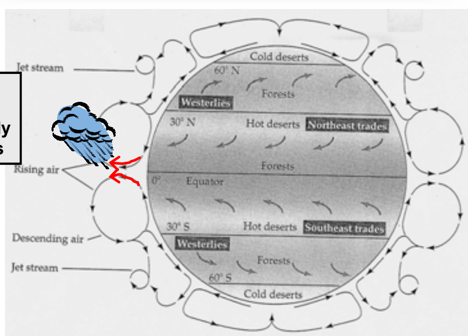
2. Results in warm, rising air at low latitudes



Campbell (2001)

Atmospheric Circulation is a major determinant of global precipitation & temperature patterns

3. Rising air cools & rain falls abundantly at low latitudes



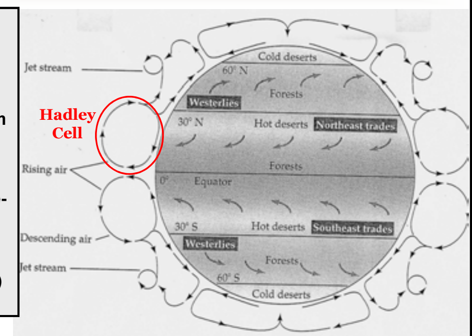
Campbell (2001)

Atmospheric Circulation is a major determinant of global precipitation & temperature patterns

4. Rising air leaves low pressure area behind.

Surface air from N and S flow into area.

Results in large-scale circular flow of air masses (Hadley Cells)

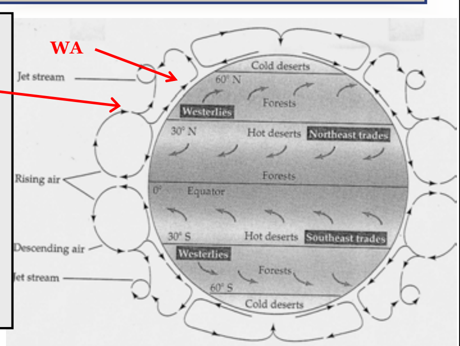


Campbell (2001)

Atmospheric Circulation is a major determinant of global precipitation & temperature patterns

5. Hadley Cells create dry latitudes of descending air at about 30 °N & S

WA sits at the edge of another rising air mass region – hence the tendency for higher levels of precipitation.

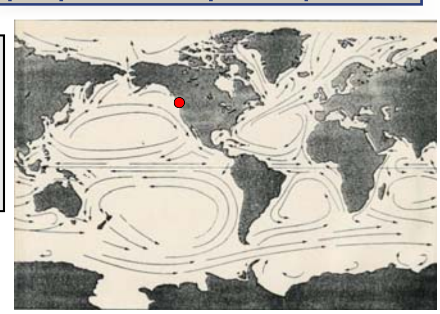


Campbell (2001)

Oceanic Circulation can be a major determinant of regional precipitation & temperature patterns

Ocean currents determine the temperature of surface waters.

This has large influences on coastal climates



Ricklefs (1997)

ENSO: El Nino – Southern Oscillation Events

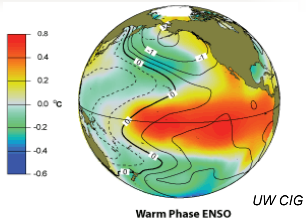
ENSO Events

El Niño *(warm phase)*

Warm surface water in the central & eastern Pacific

La Niña *(cool phase)*

Cool surface water in the central & eastern Pacific

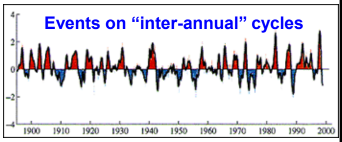


UW CIG

ENSO PNW Climate Impacts

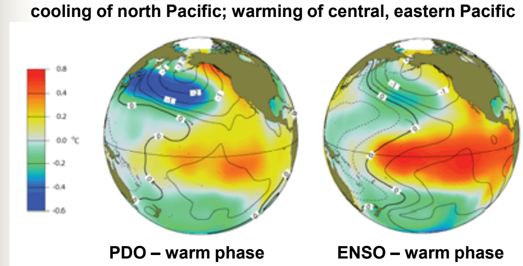
El Niño *(warm phase)*
Warmer & drier winter

La Niña *(cool phase)*
Cooler & wetter winter



PDO: Pacific Decadal Oscillations

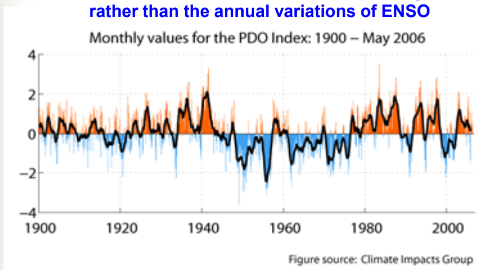
Similar to El Niño events, warm-phase PDO events show cooling of north Pacific; warming of central, eastern Pacific



UW CIG

PDO: Pacific Decadal Oscillations

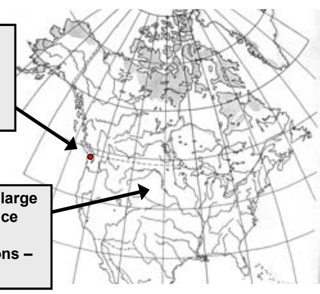
But PDO Oscillations are decades – long; rather than the annual variations of ENSO



Our coastal position results in strong maritime influences on our regional precipitation & temperature patterns

Our coastal location allows large water body to moderate temperature extremes – a maritime climate

Locations further from large water bodies experience larger seasonal temperature fluctuations – continental climates



Global / Continental Position

B) What are the ecological implications of our position?

It affects our

I. Present-day Climate

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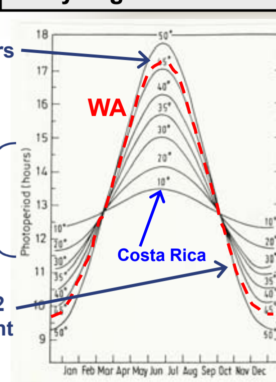
II. Past Environment

1) Past Climate

2) Geological history

Daylength & Seasonality



Ricklefs (1997)

Ecological implications

of seasonal variation in daylength

Global / Continental Position

B) What are the ecological implications of our position?

It affects our

I. Present-day Climate

1) Precipitation & Temperature

2) Daily & Seasonal Changes

II. Past Environment

1) Past Climate

2) Geological history

Our location defines our past environments

Global Position

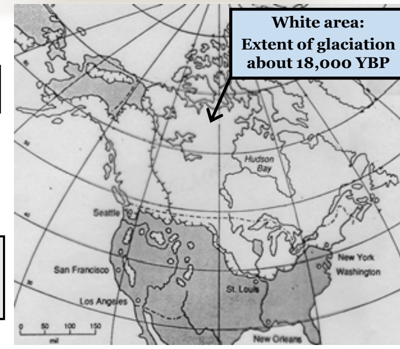
Present Climate

Past Climate

History of Geological Processes

Past Organisms & Ecosystems: our biogeographical template

White area: Extent of glaciation about 18,000 YBP



Global / Continental Position

B) What are the ecological implications of our position?

It affects our

I. Present-day Climate

1) Precipitation & Temperature

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II. Past Environment

1) Past Climate

2) Geological history

Our location defines our past geological history

Our Tectonic Setting

The Ecology of Washington

I. Abiotic Environment of WA

1. Global / Continental Position
2. **Regional Geography & Landforms**
3. Forces Behind Landforms
4. Geology
5. Climate

Regional Geography

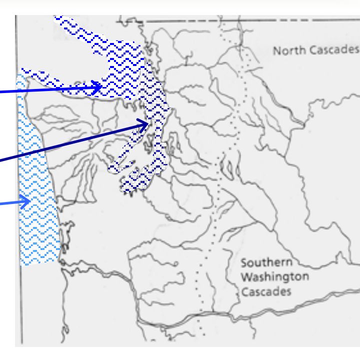
A) Water Bodies:

Marine

Strait of Juan de Fuca
San Juan Islands
Strait of Georgia

Puget Sound

Pacific Ocean

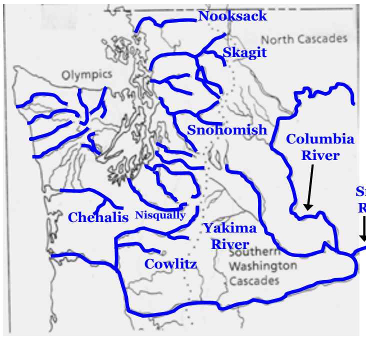


Regional Geography

A) Water Bodies:
Freshwater

Major Streams of WA

East side	West side
Columbia	Columbia
Snake	Cowlitz
Yakima	Chehalis
Spokane	Nisqually
Okanogan	Puyallup
	Green
	Snoqualmie
	Snohomish
	Stillaguamish
	Skagit
	Nooksack
	Skokomish
	Quinault
	Hoh

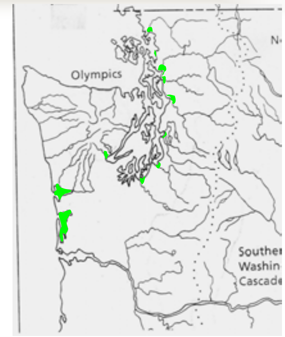


Regional Geography

A) Water Bodies:
Marine / Freshwater

Major Estuaries of Western Washington

Grays Harbor
(Chehalis River)
Willapa Bay
(Willapa & Naselle Rivers)
Nisqually River
Puyallup River
Cedar / Green River
Snohomish River
Stillaguamish River
Skagit River
Nooksack River
Skokomish River



I. Abiotic Environment of WA

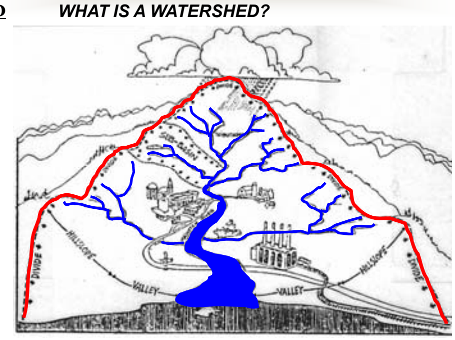
1. WA Geography & Features

B) Landscape Units:
Watersheds

WHAT IS A WATERSHED?

Watersheds

WATERSHED ***WHAT IS A WATERSHED?***



Murdoch & Cheo (1999)

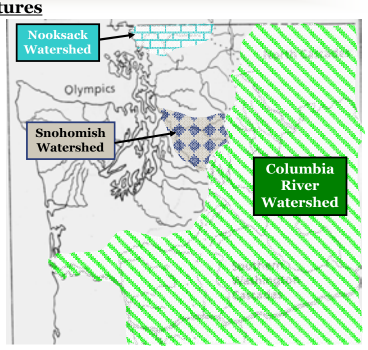
I. Abiotic Environment of WA

1. WA Geography & Features

B) Landscape Units:
Watersheds

Major Watersheds of Washington

Columbia
Chehallis
Willapa & Naselle
Nisqually
Puyallup
Cedar / Green
Snohomish
Stillaguamish
Skagit
Nooksack
Skokomish



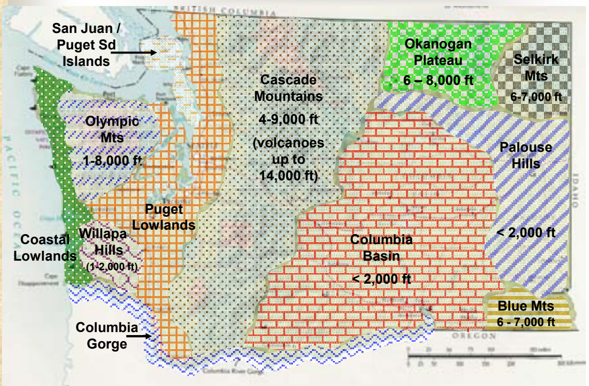
I. Abiotic Environment of WA

1. WA Geography & Features

B) Landscape Units: Physiographic Regions

Note: These are arbitrary physiographic divisions for use in our class. Many different schemes exist.

Physiographic Regions of WA



I. Abiotic Environment of WA

1. Global / Continental Position
2. Regional Geography & Landforms
3. **Forces Behind Landforms**
4. Geology
5. Climate

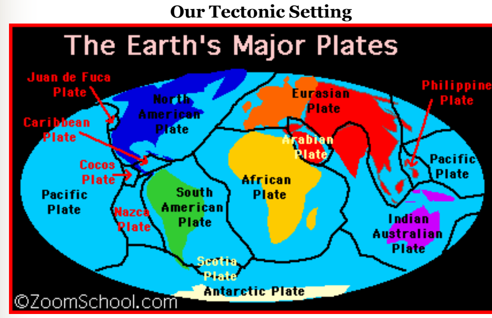
3. Forces Behind Landforms

1. Building the Landscape: Tectonic Processes
   - A) Terrane accretion
   - B) Folding & uplift
   - C) Volcanism
2. Processes Reshaping the Landscape
   - A) Continental Ice
   - B) Mountain Glaciers
   - C) Water
   - D) Wind

Forces That Shape Our Land

1. Building the Landscape: Tectonic Processes

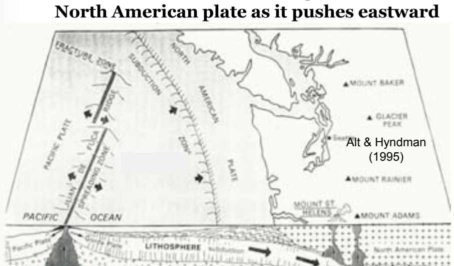
Our Tectonic Setting



Forces that Shape our Land

1. Tectonic Processes

Subduction – the Pacific Plate is being forced down under the North American plate as it pushes eastward



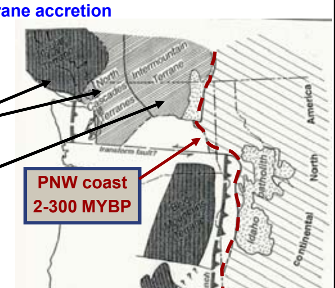
Protruding pieces of crust on the Pacific Plate are scraped off and accrete onto the shoreline ("terranes")

Forces that Shape our Land

1. Tectonic Processes

(A) Creating Landforms: terrane accretion

Tectonic terrane:
A piece of crustal rocks separated from its original plate



Terrane accretion

↓

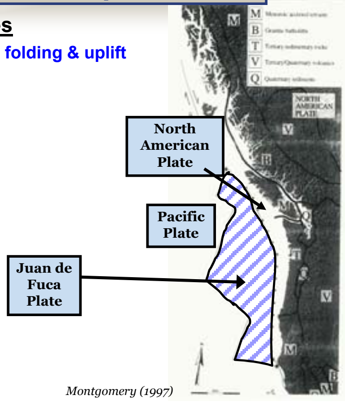
Complex geology

Alt & Hyndman (1995)

Forces that Shape our Land

1. Tectonic Processes

(B) Creating Landforms: folding & uplift



Montgomery (1997)

Forces that Shape our Land

1. Tectonic Processes

(C) Creating Landforms: volcanism

Old Basin & Range Basalt Flows:
13 - 16 MYBP

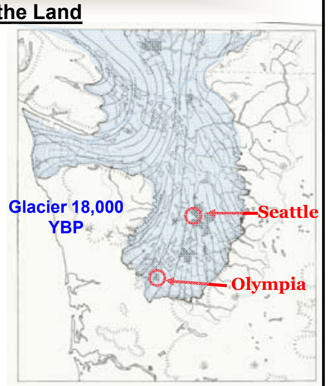
Modern Cascade Volcanoes:
3 – 500,000 YBP

Alt & Hyndman (1994)

Forces that Shape our Land

2. Processes Reshaping the Land

(A) Continental Ice



Kruckeberg (1991)

Forces that Shape our Land

2. Processes Reshaping the Land

(B) Mountain Glaciers

- **Mountain carving**
- **Moraines**

Forces that Shape our Land

2. Processes Reshaping the Land

(C) Water

1) Hill & valley local topography

2) Mountain valley topography

Water & Ice interact with geology to create unique landscapes

Forces that Shape our Land

Erosional forces interact with geology to define habitat diversity in the Olympic Mountains

Core Sedimentary Rocks

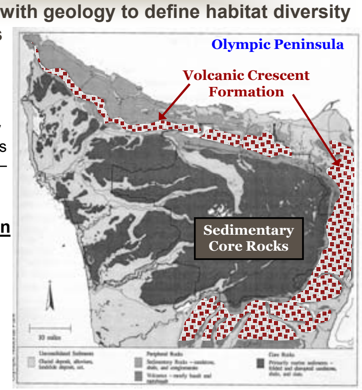
Easily erodable

Siltstones & shales eroded away leaving gently angled sandstones to dominate. Topography gentle – low habitat complexity

Volcanic Crescent Formation

Resistant to erosion

Steeply angled basalts result in more rugged topography - different habitats & habitat complexity



McNulty (1996)

Forces that Shape our Land

2. Processes Reshaping the Land

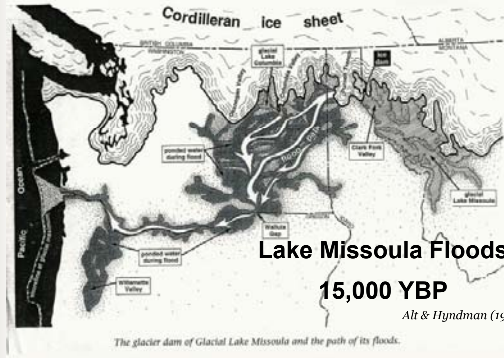
(C) Water

1) Hill & valley local topography
2) Mountain valley topography
3) Eastern WA scablands & coulees

Forces that Shape our Land

2. Processes Reshaping the Land

(C) Water Great Floods reshaping the lands of Eastern WA



The glacier dam of Glacial Lake Missoula and the path of its floods.

Forces that Shape our Land

2. Processes Reshaping the Land

(C) Water

1) Hill & valley local topography
2) Mountain valley topography
3) Eastern WA scablands & coulees
4) Columbia River gorge
5) River deltas (estuaries):
   rivers bring in and take away sediment
   tides take away sediment

Forces that Shape our Land

2. Processes Reshaping the Land

(D) Wind

Wind-blown deposits (loess) & the Palouse Prairie

Loess →

I. Abiotic Environment of WA

1. Global / Continental Position
2. Regional Geography & Landforms
3. Forces Behind Landforms
4. **Geology: a multi-scale perspective**
5. Climate

I. Abiotic Environment

4. Geology: influences ecological systems at different spatial scales

Large scale: Tectonics	Landform creation
Medium scale: Regional	Landform modification Groundwater – surface water connections Surface rock diversity weathers into diverse soils
Small scale: microhabitats	Boulders create unique microsites Influences on erosion Soil chemistry

Modified from Montgomery (1997)

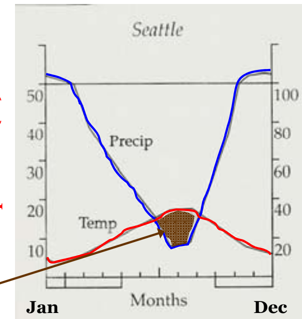
I. Abiotic Environment of WA

1. Global / Continental Position
2. Regional Geography & Landforms
3. Forces Behind Landforms
4. Geology
5. Climate

Washington Climate

1) Climate diagrams

1. Temperature
2. Precipitation
3. Drought

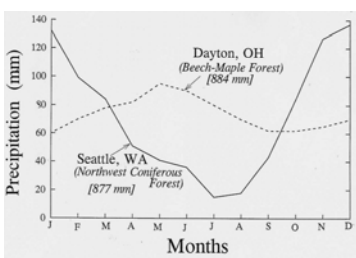


Temp > Precip

Washington Climate

2) Climate patterns

WA State: **Mediterranean Climate**

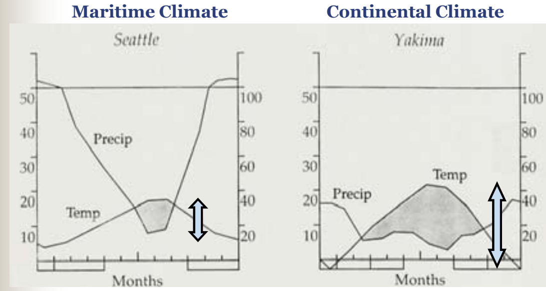


Washington Climate

2) Climate patterns

Western WA: Maritime Climate

Eastern WA: Continental Climate



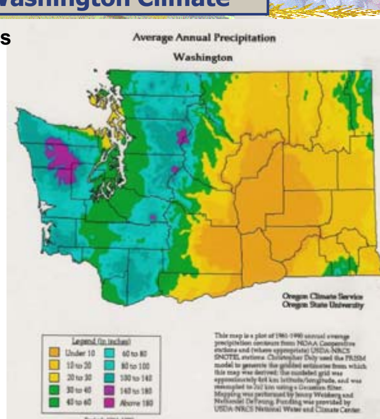
Why are these different ?

Kruckeberg (1991)

Washington Climate

2) Climate patterns

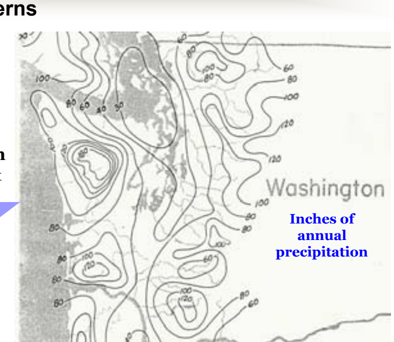
Spatial patterns in precipitation – across WA State



Washington Climate

2) Climate patterns

Prevailing Storm Track in Fall, Winter & Spring

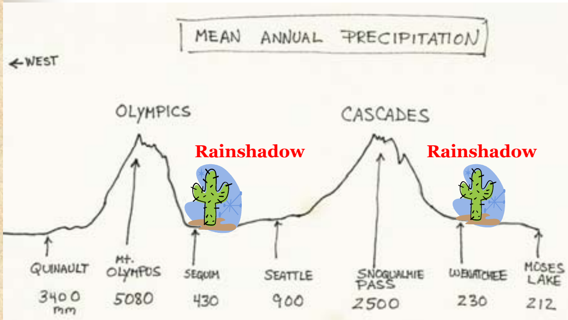


Inches of annual precipitation

Kruckeberg (1991)

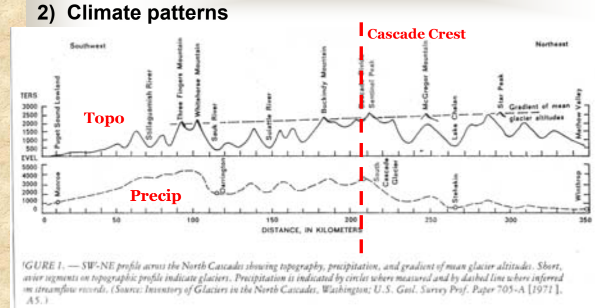
Washington Climate

2) Climate patterns



Washington Climate

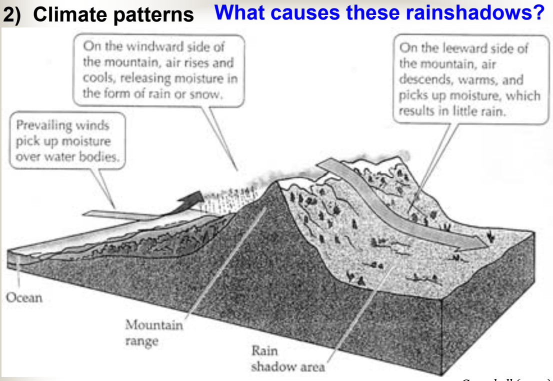
2) Climate patterns



Precipitation Patterns are actually highly complex across mountains

Washington Climate

2) Climate patterns **What causes these rainshadows?**

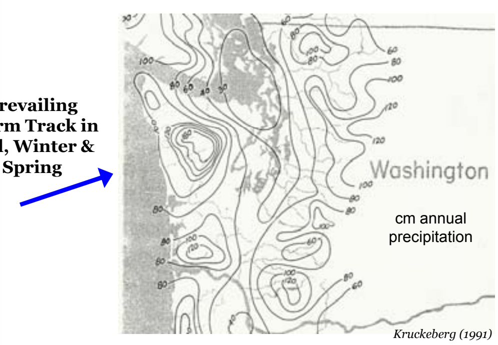


Campbell (2001)

Washington Climate

3) Local variations in climate patterns

Prevailing Storm Track in Fall, Winter & Spring



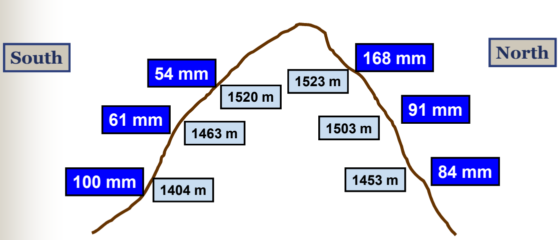
Kruckeberg (1991)

Washington Climate

3) Local variations in climate patterns

Olympic Mountain Study – Andrea Woodward

Summer precipitation at 6 meteorological stations (1993)



Bottom Line: beware of using general weather station for specific sites, especially in mountainous terrain

The Ecology of Washington

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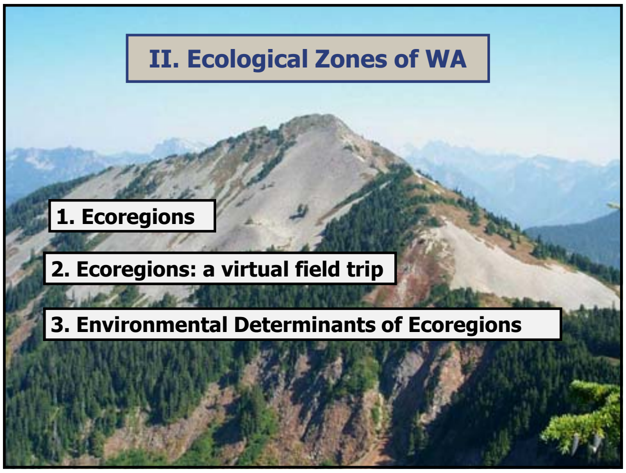
II. Ecological Zones of WA



II. Ecological Zones of WA

1. Ecoregions
2. Ecoregions: a virtual field trip
3. Environmental Determinants of Ecoregions

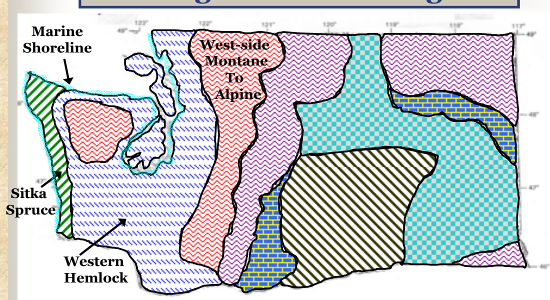
II. Ecosystems of WA

1. Ecoregions

11 Ecoregions of Washington State

1. Marine Shoreline
2. Sitka Spruce
3. Western Hemlock
4. Silver Fir
5. Mountain Hemlock
6. Subalpine Fir
7. Alpine
8. Douglas-fir / Grand Fir
9. Ponderosa Pine
10. Shrub Steppe
11. Palouse Prairie

Washington State Ecoregions



West-side Montane – Alpine: Silver fir; Mountain hemlock; Subalpine fir; Alpine

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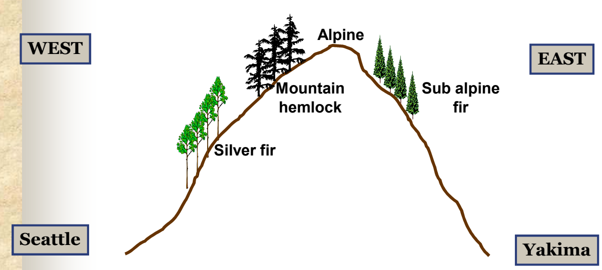
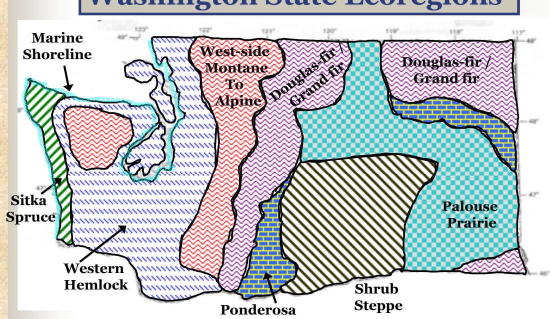
Washington State Ecoregions

Montane to Alpine Ecoregions



Washington State Ecoregions



West-side Montane – Alpine: Silver fir; Mountain hemlock; Subalpine fir; Alpine

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Washington State Natural Regions

Similar scheme to that we are using.

Note some prominent differences:

- Eastern WA prairie / shrub-steppe distribution
- Distinction of prairie woodland mosaic in western WA
- Discontinuity of high elevation forests/alpine

The Ecology of Washington

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II. Ecological Zones of WA

1. Ecoregions
2. **Ecoregions: a virtual field trip**

The Ecology of Washington

I. Physical & Chemical (Abiotic) Environment of WA

1. Where are we? : Global / Continental Position
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3. How are Landforms Created?
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II. Ecological Zones of WA

1. Ecoregions
2. Ecoregions: a virtual field trip
3. **Environmental Determinants of Ecoregions *(terrestrial)***

II. Ecosystems of WA

3. Environmental Determinants of Terrestrial Ecoregions

Bottom Line

Major determinants of ecoregion distribution:

I. Precipitation

- Amount
- Timing

II. Ecosystems of WA

3. Environmental Determinants of Terrestrial Ecoregions

Ecoregion	Elevation Range (ft.)	Avg. Annual Temp (°F)	Avg annual precip (cm)
(Seattle) *for reference*	0	53	86
Sitka Spruce	0 – 500	52	200 – 300
Western Hemlock	0 – 2500	47	70 – 300
Silver Fir	1900 – 4200	42	220 – 280
Mountain Hemlock	4200 – 5900	39	160 - 280
Subalpine Fir	4200 - 5800	*39*	*100 - 150*
Alpine	>5000 - >7000	*37.5**	*46**
Douglas-fir/Grand Fir	2000 – 5000	46	60 – 110
Ponderosa Pine	2000 – 4000	47	40 – 70
Shrub Steppe	150 – 2000	50	15 – 25
Palouse Prairie	< 3000	48	40 – 70

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II. Ecosystems of WA

3. Environmental Determinants of Terrestrial Ecoregions

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II. Ecosystems of WA

3. Environmental Determinants of Terrestrial Ecoregions

Bottom Line

Major determinants of ecoregion distribution:

I. Precipitation

- Amount
- Timing

II. Temperature

- Direct effects

BEWARE OF MEAN VALUES!

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III. Interactive Effects of Temperature & Moisture
- Moisture effects ability to cope with temperature

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- Moisture effects ability to cope with temperature
- Temperature effects moisture availability
  - ✓ ↑ temp → ↑ water use → ↓ water available
  - ✓ ↑ temp → ↑ evaporation from soil → ↓ water available

✓ ↓ temp → ↑ precip as snow → ↓ water available

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