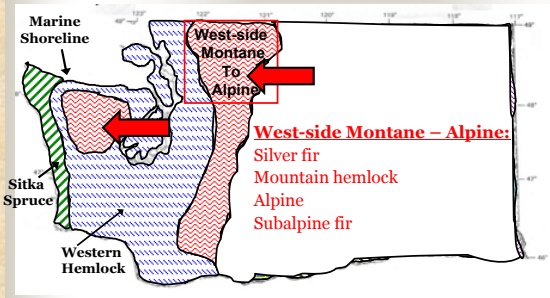
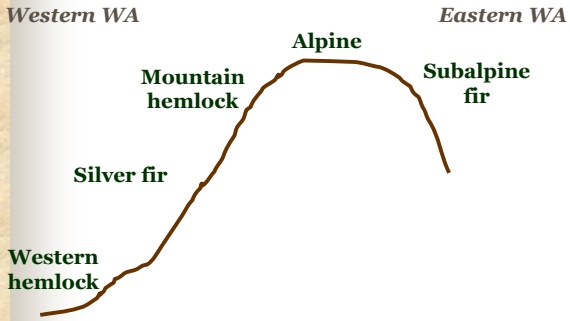
Washington State Ecoregions: West-side



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

West-side Montane to Alpine Ecoregions

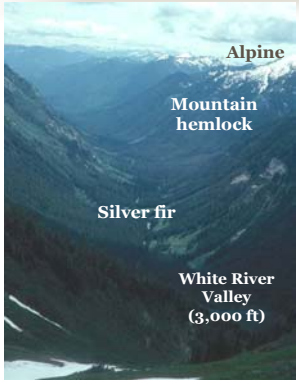


Environment of the west-side Mountain Ecoregions

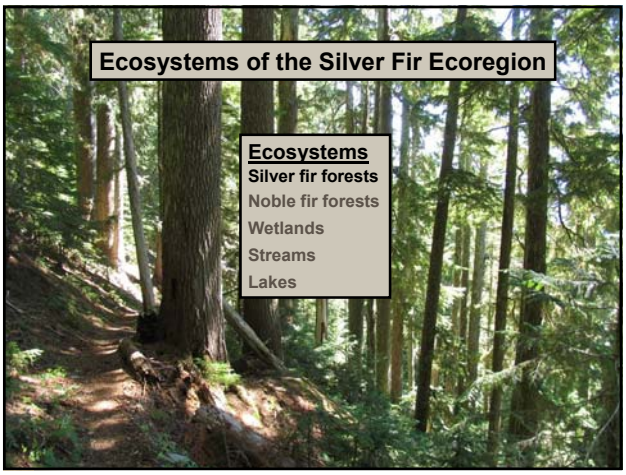
Changes in temperature & precipitation with elevation

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	150 – 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**

West-side Montane to Alpine Ecoregions



Ecosystems of the Silver Fir Ecoregion



Ecosystems
Silver fir forests
Noble fir forests
Wetlands
Streams
Lakes

Environment of the Silver Fir Ecoregion

Mountain environment: wet & cool

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	150 – 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**

Silver Fir Forests

Mountain valley bottoms from 2 – 4,000 feet

Silver Fir Forests

- Tree diameter:
- Woody debris:
- Fire return interval:

Silver Fir Forests

- Thin soils
- Cool temperatures
- Heavy snow accumulations: short growing seasons
- Mechanically-fragile Western hemlock seedlings do not tolerate snow as well as silver fir seedlings

On a coming slide not pictured here:

Lakes & streams provide important sites of ecosystem variation within a sea of evergreen forest

Silver Fir Forest Ecosystem Productivity

Silver Fir forests vary in productivity from low to high:

g C / m² /yr

Much less than Western Hemlock forests:

2,000 -3,200

g C / m² /yr

Lassoie et al. 1985

Annual Net Primary Productivity of Ecosystems

Ecosystem Type	Mean NPP g C / m² / yr	Range of NPP g C / m² / yr
Terrestrial Uplands		
Tropical rain forest	2,200	1,000 - 3,500
Temperate evergreen forest	1,320	600 - 2,500
Temperate deciduous forest	1,200	600 - 2,500
Boreal forest	800	400 - 2,000
Woodland & shrubland	700	250 - 1,200
Temperate grassland	600	200 - 1,500
Tundra and alpine	140	10 - 400
Desert & semidesert scrub	90	10 - 250
Freshwater Wetlands		
Swamp & marsh	2,000	800 - 6,000
Lake and stream	250	100 - 1,500
Marine		
Algal beds and reefs	2,500	500 - 4,000
Estuaries	1,800	500 - 4,000
Open Ocean	125	2 - 400

Ecosystems of the Mountain Hemlock Ecoregion

Ecosystems

Mountain Hemlock forests

Subalpine meadows

Wetlands

Streams

Lakes

Avalanche gullies

Environment of the Mountain Hemlock Ecoregion

Severe mountain environment: heavy snow & cold

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	150 – 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**

Snow accumulation appears critical to dynamics of tree & ecosystem function in mountain hemlock subalpine ecosystems

_____ limits growing season length

(climate change may alter this)

Mountain Hemlock Forests

Forest – meadow mosaics at high end

Closed canopy forests at lower end

Mountain Hemlock Forests

High elevation snowy subalpine forests

Subalpine meadows

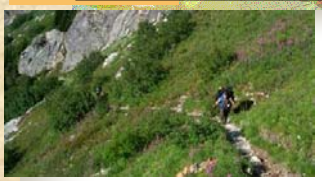
- Heathers
- Huckleberries
- Tall, lush forbs

Avg annual snowfall: _____

Mountain hemlock forests:

- Mountain hemlock
- Subalpine fir
- Alaska yellow cedar
- Silver fir

Mountain Hemlock Subalpine Meadows



Lush herb community

Highly variable meadow communities – depending upon: _____

_____

Rich soils of lush herb community

Red heather

Mountain blueberry

Mountain Hemlock Subalpine Meadows

These meadows change through time – trees can invade

Cascade subalpine meadow invasion rapid in past century (peaked in mid-1900s)

Climate change may have a big influence on:

Fires are infrequent (800 – 1,500 yr return interval) but severe in effect

Mountain Hemlock Avalanche Track Ecosystems

Snow avalanches create distinct community patterns

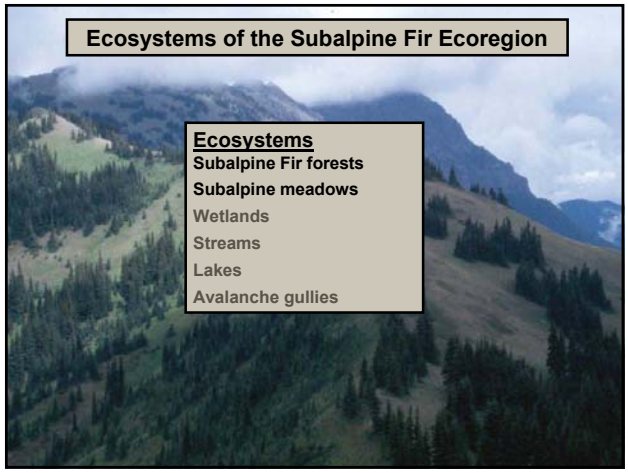
Mountain Hemlock Avalanche Track Ecosystems

Snow avalanches are an important ecological feature

Climate change effects on snow accumulation may influence:

_____

Ecosystems of the Subalpine Fir Ecoregion



Ecosystems

Subalpine Fir forests

Subalpine meadows

Wetlands

Streams

Lakes

Avalanche gullies

Environment of the Subalpine Fir Ecoregion

Severe mountain environment: moderate snow & very cold

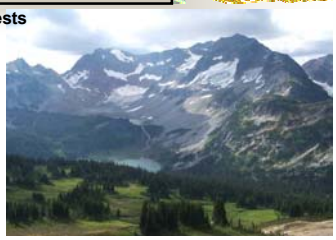
Ecoregion	Elevation Range (ft.)	Avg. Annual Temp (°F)	Avg annual precip (cm)
(Seattle) *for reference*	0	53	86
Sitka Spruce	0 – 500	52	200 – 300
Western Hemlock	0 – 2500	47	150 – 300
Silver Fir	1900 – 4200	42	220 – 280
Mountain Hemlock	4200 – 5900	39	160 - 280
Subalpine Fir	4200 - 5800	*39*	*100 - 150*
Alpine	>5000 - >7000	*37.5**	*46**

Snow accumulation appears critical to dynamics of tree & ecosystem function in subalpine fir ecosystems

Deep snow limits growing season length & moisture availability
(climate change may alter this)

Subalpine Fir Forests

Highly diverse subalpine forests



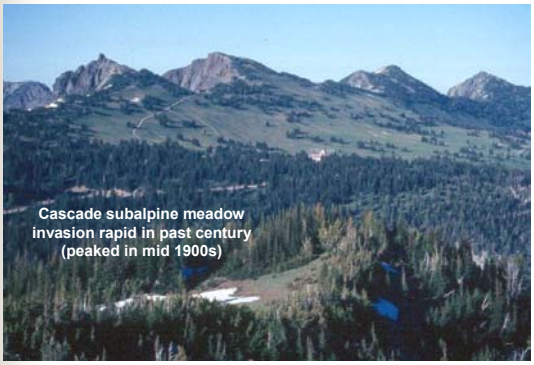
Subalpine Fir Meadow Ecosystems

Showy subalpine meadows

Fire may be important in the establishment of tree – meadow mosaics

Subalpine Fir Forests

Subalpine parkland at Sunrise, Mount Rainier National Park



Cascade subalpine meadow invasion rapid in past century (peaked in mid 1900s)

Subalpine Fir Meadow Ecosystems

Some unique critters to subalpine / alpine ecosystems

Pikas depend upon specific vegetation

Subalpine Fir Meadow Ecosystems

High elevation critters on the decline

Olympic Marmots – on the decline

Cascade mountain goats – on the decline

Alpine Ecoregion: LAND ABOVE THE TREES

Environment of the Alpine Ecoregion

Severe mountain environment: low snow & very cold

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	150 – 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**

Snow accumulation & topography are critical to dynamics of ecosystem function (climate change may alter this)

Alpine Ecosystem Productivity

Alpine ecosystems generally low in productivity :

10 – 400

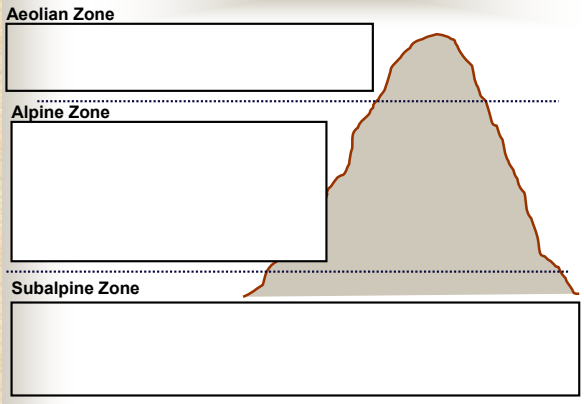
g C / m^2 /yr

Variation due to different types of ecosystems

Annual Net Primary Productivity of Ecosystems

Ecosystem Type	Mean NPP g C / m^2 / yr	Range of NPP g C / m^2 / yr
Terrestrial Uplands		
Tropical rain forest	2,200	1,000 - 3,500
Temperate evergreen forest	1,320	600 - 2,500
Temperate deciduous forest	1,200	600 - 2,500
Boreal forest	800	400 - 2,000
Woodland & shrubland	700	250 - 1,200
Temperate grassland	600	200 - 1,500
Tundra and alpine	140	10 - 400
Desert & semidesert scrub	90	10 - 250
Freshwater Wetlands		
Swamp & marsh	2,000	800 - 6,000
Lake and stream	250	100 - 1,500
Marine		
Algal beds and reefs	2,500	500 - 4,000
Estuaries	1,800	500 - 4,000
Open Ocean	125	2 - 400

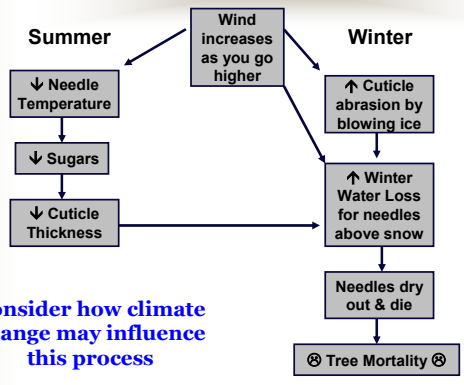
Boundaries of the Alpine Ecoregion



Boundaries of the Alpine Ecoregion

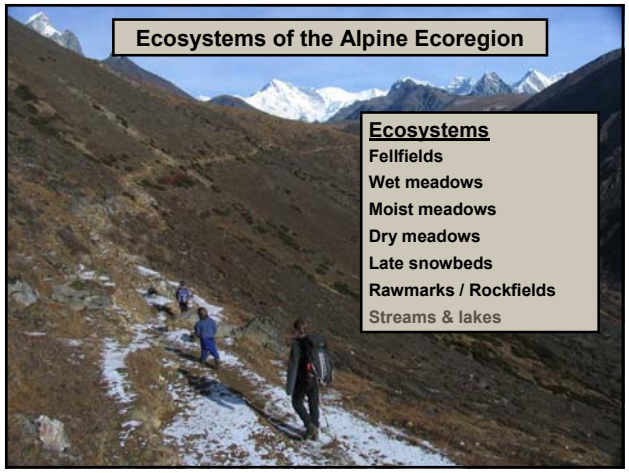
Why don't trees grow higher?

Timberline Winter Drought Theory



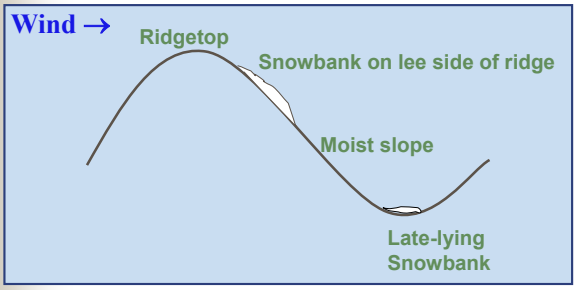
Consider how climate change may influence this process

Ecosystems of the Alpine Ecoregion



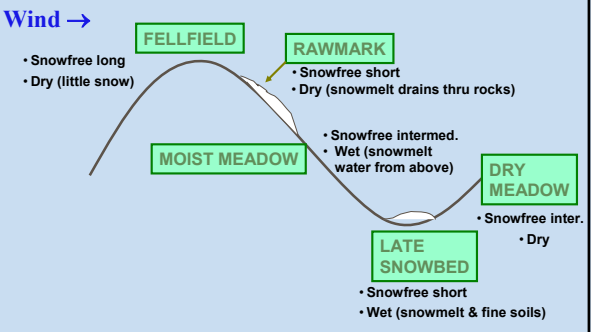
Ecosystems of the Alpine Ecoregion

Alpine ecosystems organized by topography & snow



Ecosystems of the Alpine Ecoregion

Alpine ecosystems organized by topography & snow



Ecosystems of the Alpine Ecoregion

Ridgetop fellfield ecosystems

Ecosystems of the Alpine Ecoregion

Late-lying snow ecosystems

Late snowbed
Carex nigricans
community

Ecosystems of the Alpine Ecoregion

Productive meadow ecosystems

Ecosystems of the Alpine Ecoregion

Many plants are uniquely adapted & restricted to the alpine


Juncus mertensiana


Oxyria digyna


Penstemon davidsonii


Eriogonum pyralifolium


Saxifraga caespitosa

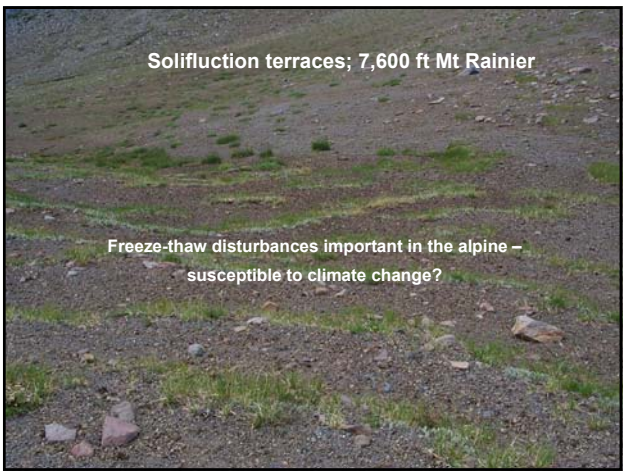

Douglasia laevigata


Claytonia megarhiza

Ecosystems of the Alpine Ecoregion

Abiotic Factors are generally harsh –
and thus they control primary production

- **Growing season:**
- **Temperatures:**
- **Summer moisture:**
- **Nutrients:**
- **Wind:**
- **Other soil attributes:**



Ecosystems of the Alpine Ecoregion

Alpine habitats as ecological islands in WA

Ecosystems of the Alpine Ecoregion

Soil Crusts of lichens & mosses

Crustose lichen dominated Crust

Crust of Loose Fruticose Lichens

Moss / Fungi Dominated Black Crust

Crust Effects

- **Nitrogen input; trap soil moisture**
- **Surface temperature modification**
- **Seed trapping**

They're fragile & response to climate change is unknown

Human Impacts in the Alpine Ecoregion

- Grazing
- Mining
- Recreation
- Research / Study
- Road building
- Introduced species
- Atmospheric pollution

Restoring heavily degraded alpine areas is a difficult process!