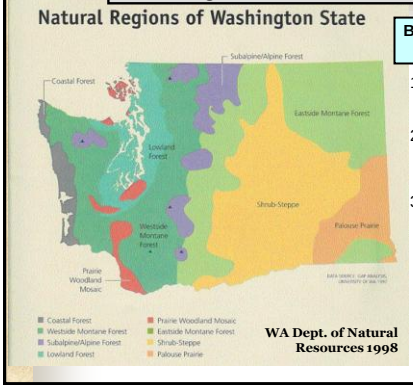
Beyond the Treeline: Prairies, Alpine & Drylands

Washington State Natural Regions



Beyond the Forested Ecosystems:

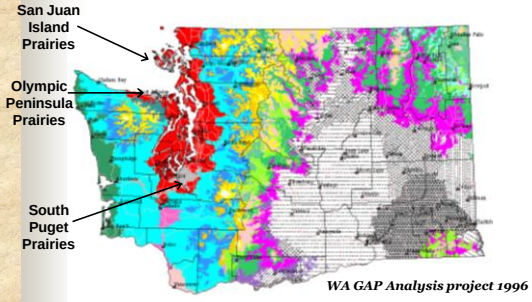
1. West-side prairies & woodlands
2. East-side prairies, shrublands & woodlands
3. Alpine ecosystems

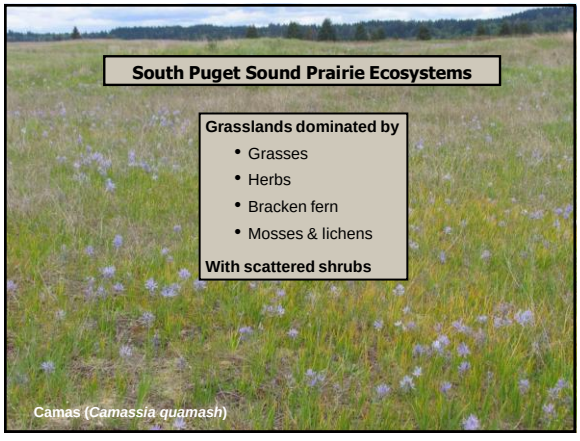
West-side Prairies & Woodlands

1. South Puget Sound prairies & oak woodlands
2. Island / Peninsula coastal prairies & woodlands
3. Rocky balds

Oak Woodland & Prairie Ecosystems

West-side Oak Woodland & Prairie Ecosystems in Grey





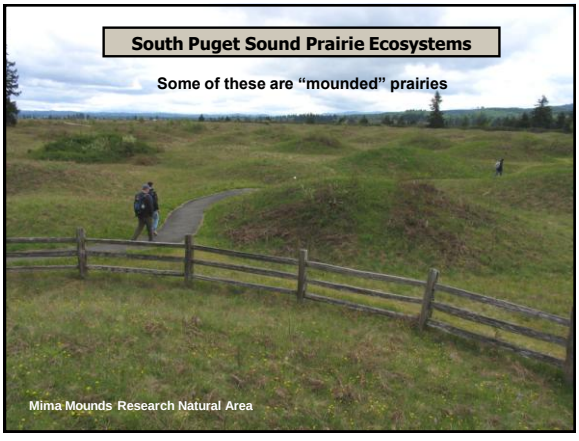
South Puget Sound Prairie Ecosystems

Grasslands dominated by

- Grasses
- Herbs
- Bracken fern
- Mosses & lichens

With scattered shrubs

Camas (*Camassia quamash*)

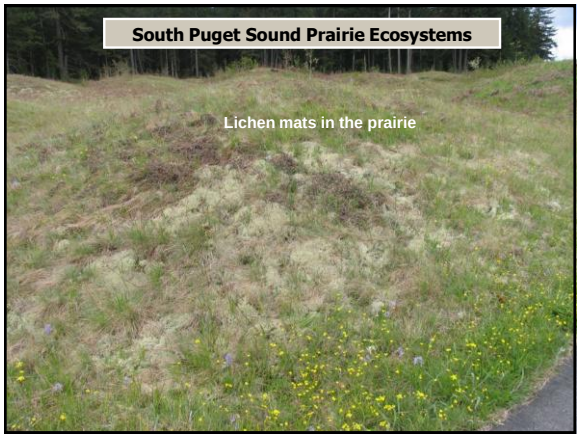


South Puget Sound Prairie Ecosystems

Some of these are "mounded" prairies

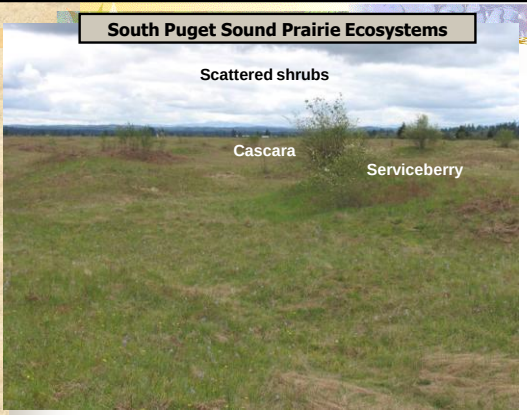
Mima Mounds Research Natural Area

South Puget Sound Prairie Ecosystems



Lichen mats in the prairie

South Puget Sound Prairie Ecosystems



Scattered shrubs

Cascara

Serviceberry

South Puget Sound Prairie Ecosystems

As unique ecosystems they provide habitat for unique plants

Camas
(*Camassia quamash*)

Golden paintbrush
(Castilleja levisecta)

South Puget Sound Prairie Ecosystems

As unique ecosystems they provide habitat for unique critters

Mazama Pocket Gopher

Many unique species of butterflies
(this is an Anise Swallowtail)

Photos from Dunn & Ewing (1997)

South Puget Sound Prairie Ecosystems

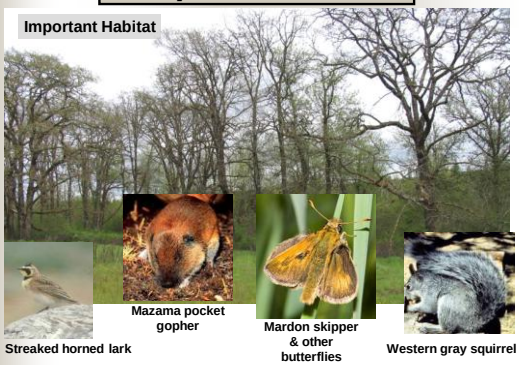
Fire is an important & natural part of ecosystems

Garry Oak Woodlands

Quercus garryana

Garry Oak Woodlands

Important Habitat



Streaked horned lark

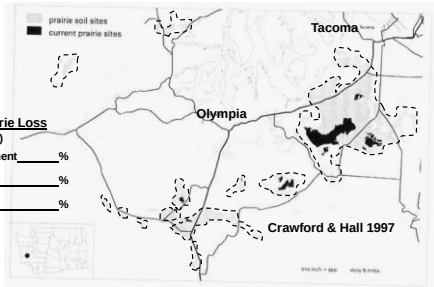
Mazama pocket gopher

Mardon skipper & other butterflies

Western gray squirrel

Oak Woodland & Prairie Ecosystems: Human Impacts

Current prairie cover is about _____ of its historical extent in South Puget Sound



Causes of Prairie Loss

Hall (1995)

Urban development_____%

Forest invasion_____%

Agriculture_____%

South Sound Oak Woodland & Prairie Ecosystems: Protected Areas

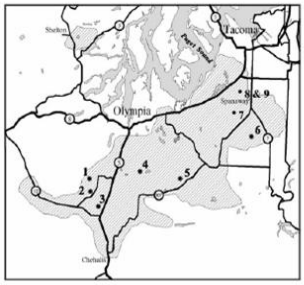


Figure 1. South Puget Sound prairie region, including major protected prairies.

1 – Mima Mounds Natural Area Preserve

2 – Black River–Mima Prairie–Glacial Heritage Park

3 – Scatter Creek Wildlife Area

4 – Rocky Prairie Natural Area preserve

5 – Weir Prairie Research Natural Area

6 – Thirteenth Division Prairie Research Natural Area

7 – Bower Woods Ponderosa Pine Forest RNA

8 – Bensten Candidate RNA

9 – Talbot Candidate RNA

South Sound Oak Woodland & Prairie Ecosystems: Protected Areas

Table 1. Protected prairie areas in the South Puget Sound region.

Protected Area	Ownership	Size (Acres)
Mima Mounds NAP*	WA State - Dept. of Natural Resources	445
Rocky Prairie NAP	WA State - Dept. of Natural Resources	47
Black River-Mima Prairie-Glacial Heritage Preserve	Thurston County - Dept. of Parks and Recreation	1,020
Scatter Creek Wildlife Area	WA State – Dept. of Fish and Wildlife	1,200
13th Division Prairie RNA**	US Army - Ft. Lewis	234
Weir Prairie RNA	US Army - Ft. Lewis	1,096
Bower Woods Ponderosa Pine Forest RNA	US Army - Ft. Lewis	1,739
Bensten Candidate RNA	McChord Air Force Base	131
Talbot Candidate RNA	McChord Air Force Base	128

* Natural Area Preserve (NAP) ** Research Natural Area (RNA)

Fort Lewis & McChord Air Base: Protected Areas

> 75,000 acres of training grounds

Oak Woodland & Prairie Ecosystems: Human Impacts

Invasive Species are another threat

Scot's Broom (*Cytisus scoparius*) Fort Lewis

Control methods:

Oak Woodland & Prairie Ecosystems

These prairies & woodlands exist within the same climate as the surrounding sea of evergreen forest.

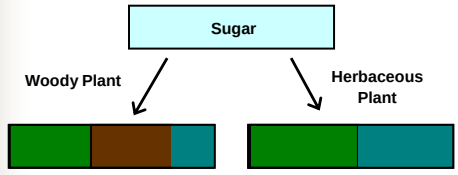
WHY?

A central question:

What prevents the forest from existing here?

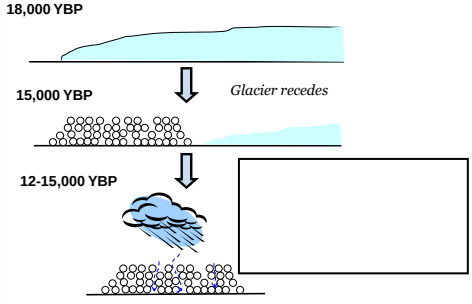
What Restricts Forest Cover?

PLANT INVESTMENTS



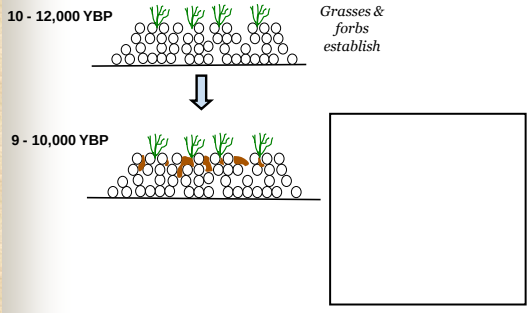
Oak Woodland & Prairie Ecosystems

Development of Puget Prairies



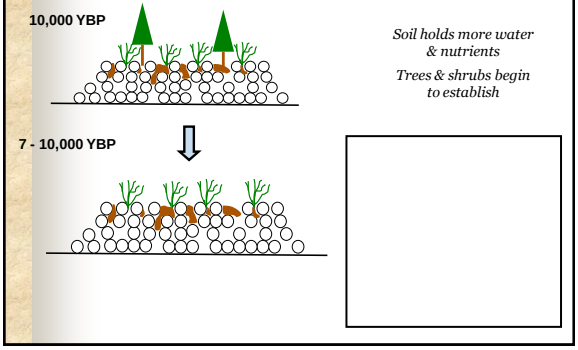
Oak Woodland & Prairie Ecosystems

Development of Puget Prairies



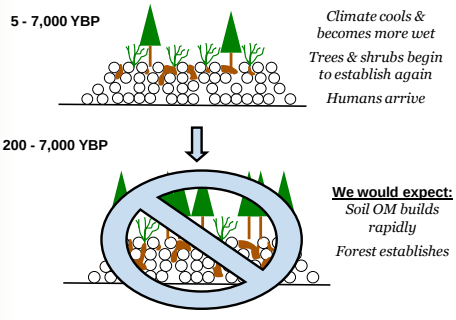
Oak Woodland & Prairie Ecosystems

Development of Puget Prairies



Oak Woodland & Prairie Ecosystems

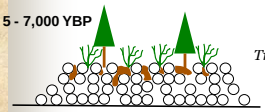
Development of Puget Prairies



Oak Woodland & Prairie Ecosystems

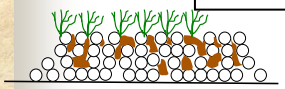
Development of Puget Prairies

5 - 7,000 YBP



Climate cools & becomes more wet
Trees & shrubs begin to establish again
Humans arrive

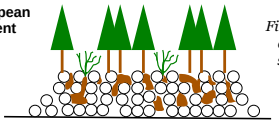
200 - 7,000 YBP



Oak Woodland & Prairie Ecosystems

Development of Puget Prairies

Post European settlement



Fire suppression allows forest succession to proceed

How do we maintain these unique ecosystems in the face of natural succession to forests?

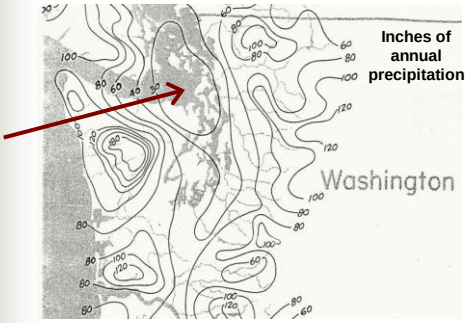
Island & Peninsula Woodland & Prairie Ecosystems

Prairies in San Juan Islands, NE Olympic Peninsula & Coastal Bluffs

Just a little different

Oak Woodland & Prairie Ecosystems

Rainshadow of the San Juans & NE Olympic Peninsula



Rocky Balds: another west-side ecosystem not dominated by trees

Windswept resistant bedrock outcrops

More common on San Juan Islands

Unique, rare species

Lord Hill, Snohomish County

West-side Prairies & Woodlands

South Puget Sound prairies & oak woodlands

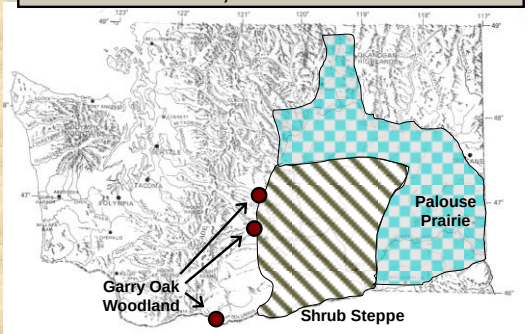
Rocky balds

Island / Peninsula coastal prairies & woodlands

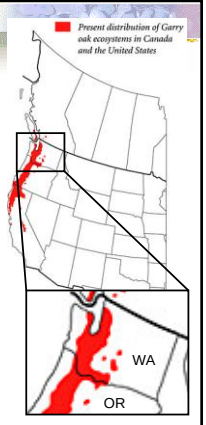
What is the common reason all of these ecosystems exist?

How is that different from the factors that tend to control ecosystem existence for our more extensive ecosystems?

East-side Prairies, Shrublands & Woodlands

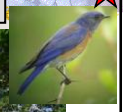


East-side Garry oak woodlands



East-side Garry oak woodland habitat


Western Kingbird




Western Grey Squirrel

Garry oak – important characteristics for wildlife habitat

1.

2.


Mule deer

Shrub Steppe Ecoregion

Shrub Steppe Ecoregion: Climate

General Environment : HOT & VERY dry

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*
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

Shrub Steppe Ecoregion

Low elevation hot, arid shrub and grass dominated ecosystems:

1.

2.

3.

Shrub Steppe Ecoregion

Shrub Steppe Ecosystem: dominated by big sagebrush & other shrubs

Pothole wetlands

Bunchgrass steppe

Shrub Steppe Soil Crusts – "Cryptobiotic Crusts"

Living surface coating: fungi, lichens, mosses, algae, cyanobacteria

- Reduce erosion
- Increase water infiltration
-
-

Crust destruction

-
-
-
-

Shrub Steppe Ecosystem Productivity

Shrub Steppe productivity:

105 - 166

g C / m^2 /yr

Grassland Steppe productivity:

239 - 368

g C / m^2 /yr

Daubenmire 1988

_____ %

NPP of west-side 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

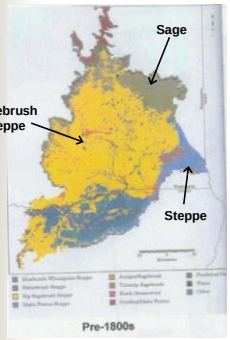
Shrub Steppe Ecoregion

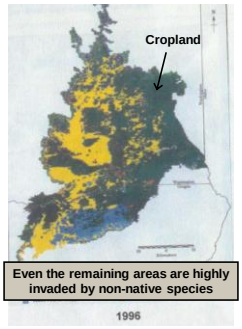
Fire is a frequent disturbance

Photos omitted to reduce file size

Disturbance in the Shrub Steppe Ecoregion: Land Use

Little Pristine Shrub Steppe Remains





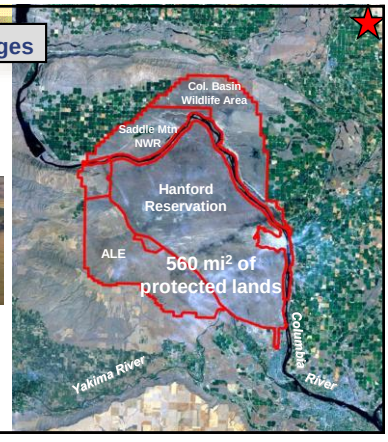
Even the remaining areas are highly invaded by non-native species

O'Connor & Wieda (2001)

Land Use Changes

_____ of WA shrub-steppe converted to agriculture
(Dobler et al. 1996)

Large part of remainder has been degraded by invasive species



Yakima Training Center: US Army

Another large reserve

510 mi² (326,000 acres)

Invasive Species in the Shrub Steppe Ecoregion: Impacts

-
-
-


Yellow star thistle


Dalmatian toadflax


Cheatgrass


Diffuse knapweed

Disturbance in the Shrub Steppe Ecoregion: Invasive Species

Non-native Species

20% WA Shrub Steppe plants are non-native

The horror of

Cheatgrass (*Bromus tectorum*)

Covers nearly 100 million acres of Columbia Basin

Outcompetes natives

Germinates in ALL seasons, taking advantage of transient moisture

Produces huge # of seeds

Cheatgrass (*Bromus tectorum*)

Cheatgrass alters many ecosystem properties

- ↓ Native vascular plant diversity (Norton et al. 2004, Whisenant 1990)
- ↓ Biological soil crust diversity (McIntosh 2003, Belnap & Phillips 2001)
- ▲ Soil physical properties (Norton et al. 2004)
- ▲ Soil nutrient distribution & cycling (Norton et al. 2004, Evans et al. 2001)
- Soil organic matter: Rate of cycling ↑ / amount ↓ (Norton et al. 2004, Knick & Rotenberry 1997)
- ↓ Soil faunal diversity (Kuske et al. 2002, Belnap & Phillips 2001)
- ↓ Water use & community productivity (Link et al. 1990, Cline et al. 1977)
- ↑ Fire frequency

Cheatgrass (*Bromus tectorum*)

Cheatgrass Alters the Shrub Steppe Fire Cycle

- **Produces huge amount of flammable biomass (4x NPP of native sagebrush community)**
- **Fire frequency & extent increase**
- **Colonizes rapidly after fire – positive feedback cycle**

Disturbance in the Shrub Steppe Ecoregion: Fire

24-Command Fire at Arid Lands Ecology Reserve (July 2000)

164,000 acres in 6 days

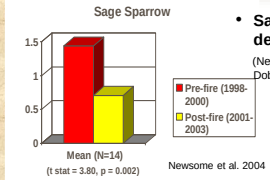
Effect on cheatgrass:

Year 1:

Year 2:

Year 3:

Other Impacts of Fire in the Shrub Steppe



- **Sagebrush obligate animal species decline**

(Newsome et al. 2004, Vander Haegen et al. 1999, Dobler 1994, Brandt & Rickard 1994)

- **Biological soil crusts scarce and species-poor in areas of recent severe fire**

(McIntosh 2003)

Shrub Steppe – Animal Species in Peril

Sage Grouse

Habitat Loss has reduced once abundant populations

- **Douglas county**
- **Yakima Firing Range**

Columbia Basin Pygmy Rabbit

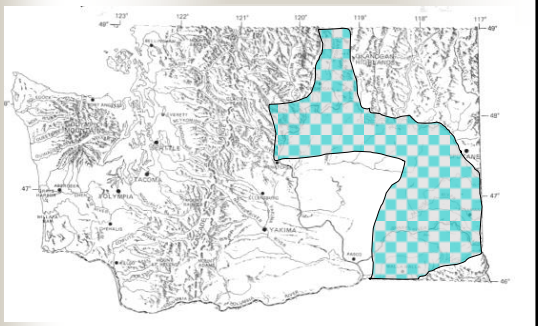
Endangered (State 1993; Federal 2003)

- **Dependent on sagebrush for winter forage**
- **Severe population decline with habitat loss & fire**
- **Captive breeding program**
- **Last purebred male died May 2006**
- **Crossbreeding program with ID pygmy rabbit**

Photo: USFWS

Photo: WDFW

Palouse Prairie Ecoregion



Palouse Prairie Ecoregion: Climate

General Environment : Hot & somewhat dry

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*
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

Palouse Prairie Ecoregion

Low elevation hot & semi-arid grass dominated ecosystems

- **Less extreme temperatures than shrub-steppe**
- **More summer precipitation than shrub steppe**
- **Forest pockets on north-facing slopes**
- **Fauna characterized by birds, burrowing rodents, reptiles**

Palouse Prairie

Fire is an important & natural part of this ecosystem

Invasive Species in the Palouse Prairie Ecoregion

Similar exotic species & effects to the Shrub Steppe

Palouse Prairie Ecoregion

Loess soil creates

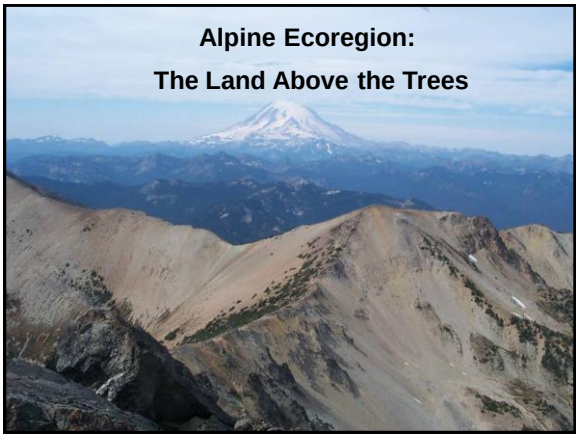
Palouse Prairie Ecoregion

Little remains of original Palouse Prairie: 1%

One of the most endangered ecosystems in North America

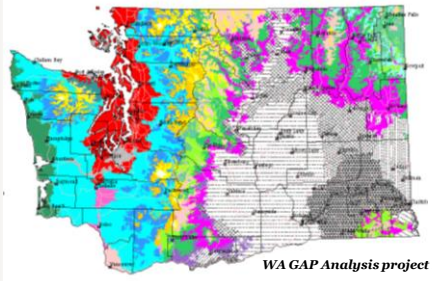
Alpine Ecoregion:

The Land Above the Trees



Northwest Alpine

Alpine areas indicated by YELLOW



WA GAP Analysis project 1996

Environment of the Alpine Ecoregion

Severe mountain environment: less 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

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
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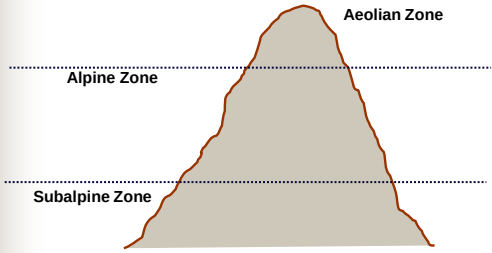
Freshwater Wetlands		
Swamp & marsh	2,000	800 - 6,000
Lake and stream	250	100 - 1,500
Marine		
Algal beds and reefs	2,500	500 - 4,000
Estuaries	1,800	500 - 4,000
Open Ocean	125	2 - 400

Boundaries of the Alpine Ecoregion



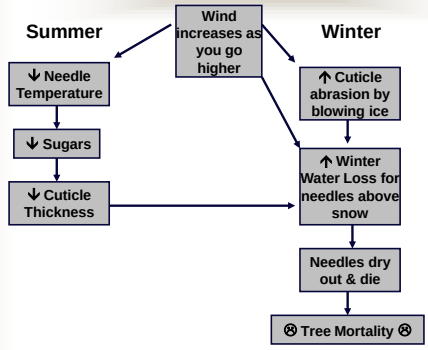
Boundaries of the Alpine Ecoregion

The lower limit of the alpine: Why don't trees grow higher?

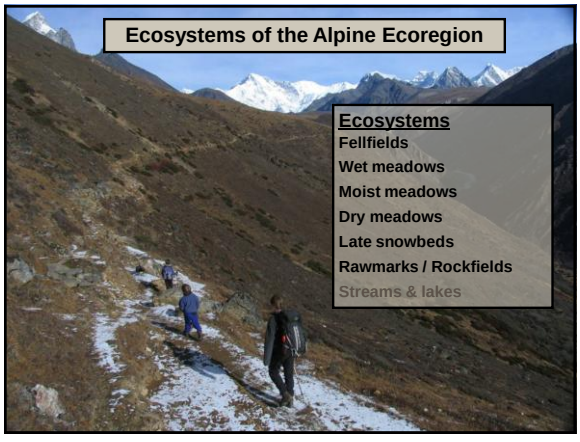
Timberline Winter Drought Theory

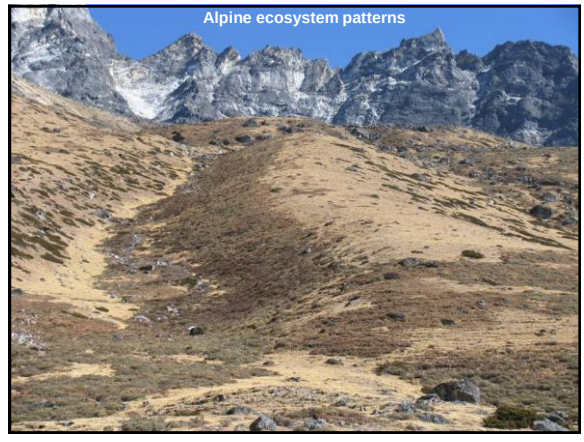
- Growing upright (as a tree) results in death at higher elevation
- Growing upright means leaves exposed above snow to drying wind
- Water loss from needles in winter cannot be replaced - soil frozen
- The higher you go, the more severe the effects of winter drought on trees

Timberline Winter Drought Theory



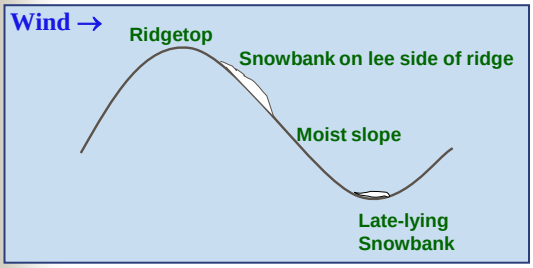
Ecosystems of the Alpine Ecoregion





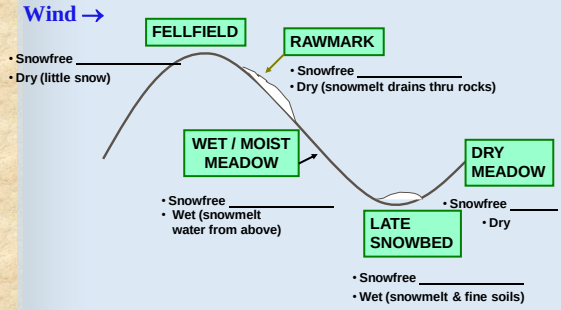
Ecosystems of the Alpine Ecoregion

Alpine ecosystems organized by topography & snow

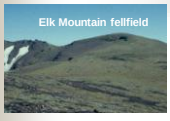


Ecosystems of the Alpine Ecoregion

Alpine ecosystems organized by topography & snow



Ecosystems of the Alpine Ecoregion



Late snowbed
Black Sedge ecosystem

There are other sources of ecological patterns in the alpine

Solifluction terraces; 7,600 ft Mt Rainier

Ecosystems of the Alpine Ecoregion

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

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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

Plant ecological adaptations to the Alpine


Ecological adaptation to high levels of UV radiation




Ecosystems of the Alpine Ecoregion

Alpine habitats occur as ecological islands in the Northwest

Lack of connectivity

-
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Northwest Alpine Animals

Who's There?

1. Mostly Herbivores & Detritivores

- Few carnivores – _____

2. Mammals

- Mountain goat
- Marmot
- Golden-mantled ground squirrel
- Pika

3. Birds

- Ptarmigan
- Pine siskin
- Chickadees
- Swallows

4. Insects

- Beetles, spiders, gryllablatids

PNW Alpine Animals

Characteristics

Adaptations to tolerate low temperatures & long cold seasons

- Thick fur (mammals)
- Large size (↓ surface area to volume)
- Constant grazing
- Food storage
- Fat Accumulation
- Hibernation / ↓ Body Temp.
- Seasonal migration

PNW Alpine Animals

Ecosystem Impacts of Animals – *a few examples*

- Burrowing rodents (marmots, ground squirrels, heather & meadow voles, pocket gophers)
  - bring subsoil to the surface
  - bury plant parts that decompose and help fertilization
  - distribute / consume seeds and aerate soil
  - consume plant material
  - add their own excreta (nutrient translocation) and organic remains when they die
- Insects
  - Pollination, herbivory, seed dispersal, etc.
- Birds, Large mammals *(no details now)*

PNW Alpine Food Webs

Food Chains are short in the Alpine

- Controlled by abiotic factors (climate, elevation, topography), rather than by keystone predators

"Bottom-up" control

Biotic interactions do have some effects on alpine plants:

- Lower limit of some alpine plants controlled by herbivory (e.g., alpine sky pilot & pikas)

Sky pilot
Polemonium elegans

Weasel or Hawk

Heather Vole

Alpine Plants

Nutrient Cycling

Available nutrients are limited

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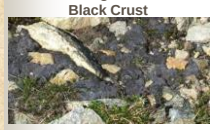
Ecosystems of the Alpine Ecoregion

Soil Cryptobiotic Crusts

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 & easily disturbed

Human Impacts in the Alpine Ecoregion

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

PNW Alpine Restoration

Some of the Challenges

- Stressful environment – slow recovery
- Rapid erosion following plant / cryptobiotic cover destruction (high winds, glacial loess soils)
- Little information on propagation of alpine plants
- Potentially high genetic variation
- Difficult sites to get people, plants, soil, and equipment to
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