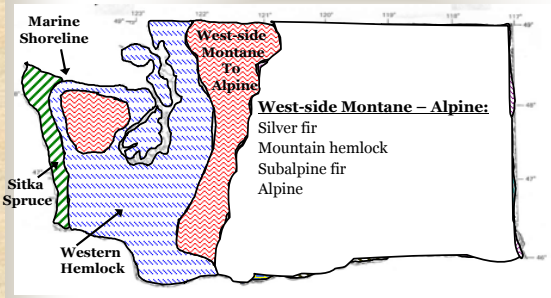
Future Washington

BIS 358 Fall 2006

West-side Ecosystems

October 4, 2006

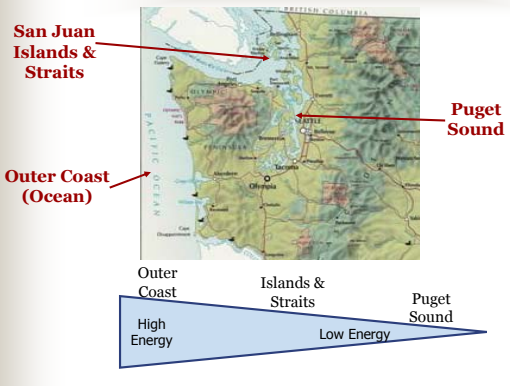
Washington State Ecoregions: West-side



Ecosystems of the Marine Shoreline Ecoregion

Marine Shoreline Ecosystems

I. Marine Shoreline Regions of WA



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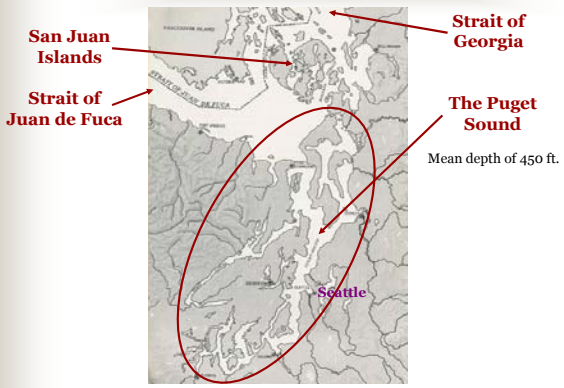
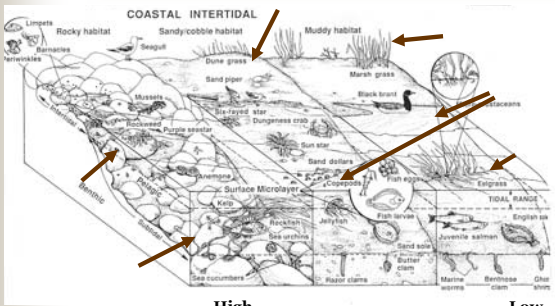


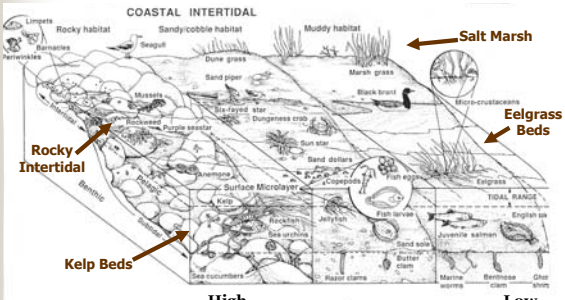
II. Marine Shoreline Ecosystems



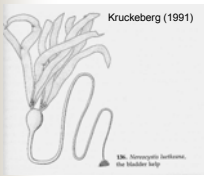
Kruckeberg 1991

II. Marine Shoreline Ecosystems

Ecosystems of focus



Kelp Beds (Kelp Forests)



Dominated by 3 large brown algal species (kelp):

Nereocystis luetkeana (bull kelp)
- Up to 20 m tall
- Annual
- Puget Sound, straits, protected outer coast

Macrocystis integrifolia (giant kelp)
- Up to 10 m tall; perennial
- Outer coast nearshore & western straits

Macrocystis pyrifera
- Up to 40 m tall; perennial
- Outer coast further away from shore
- In water up to 80 m deep

Kelp Beds: Other organisms

Primary Producers

Dominated by large brown algae – kelps (surprise ☺)

Other algae in kelp beds vary greatly with:
- dominant overstory species
- energetics of water at the site
- region (PS, straits, outer coast)
- season

Consumers

Invertebrates feeding on kelp: *urchins, snails, etc.*

Filter feeders using kelp as a place to live *(sponges, bryozoans, tunicates, marine worms, etc.)*

Invertebrates: *crabs, shrimp, etc.*

Pinnipeds: *sea otters*

Fish: *bass, lingcod, perch, sculpins, etc.*

There is a rich variety of consumers that vary through time & space – we cannot do them justice here

Ecosystem Net Primary Productivity

NPP =

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

Kelp Beds are highly productive ecosystems

Annual Net Primary Productivity of Ecosystems

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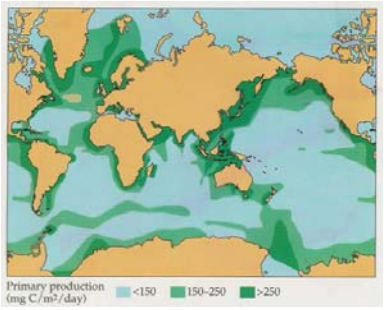
Kelp beds are as productive as tropical rainforests

Kelp Beds

Why are beds so highly productive ?

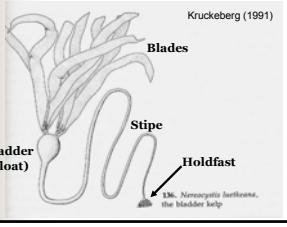
1.



Kelp Beds

Why are beds so highly productive ?

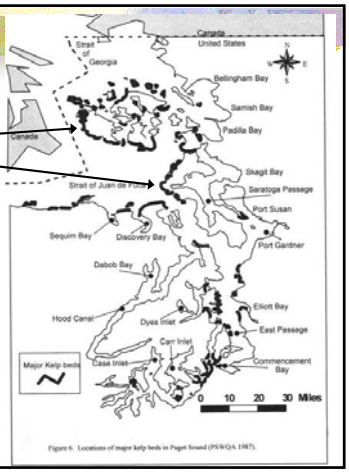
1.
2.
3.
4.



Bladder takes advantage of water's buoyancy to position blades in light

Kelp Bed Distribution in Puget Sound & San Juan Islands

Note the greater abundance on more exposed, high-energy shorelines



Kelp Beds (Kelp Forests)

Bottom Line

- Kelp beds are HIGHLY productive ecosystems
- Kelp beds associated with higher energy shorelines
- Kelp beds vary in species composition and seasonal dynamics

Bull kelp *Photo: Jim Ramaglia*

Kelp Beds: Human Impacts

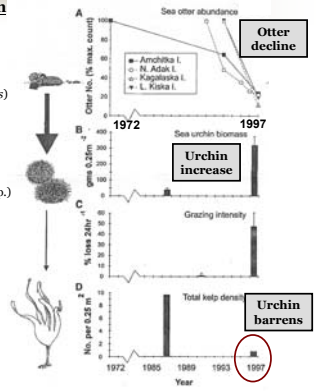
Cascading impacts in a food chain

Stellar sea lions decline (fishing? climate?) caused Killer Whales to consume lots of sea otters

Sea otters (*Enhydra lutris*)

Sea urchins (*Strongylocentrotus* sp.)

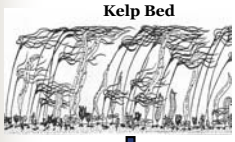
Bull Kelp (*N. leutkeana*)



Kelp Beds: Human Impacts

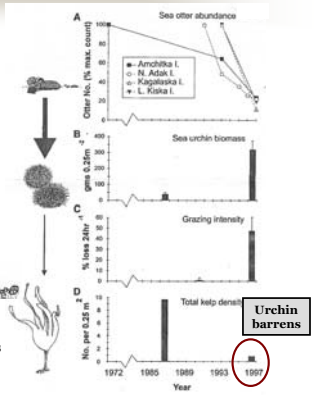
Converting a kelp bed to an urchin barren

Kelp Bed



Urchin Barrens

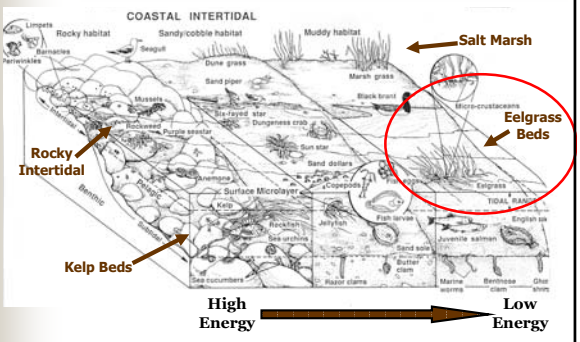
Similar changes through food chains can come with climate shifts



Eelgrass Beds

II. Marine Shoreline Ecosystems

Ecosystems of focus



Eelgrass Beds

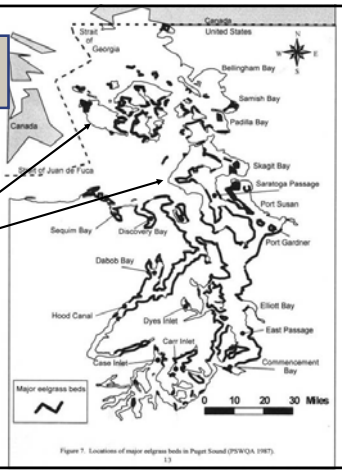
Eelgrass Beds

Environment

Eelgrass Bed Distribution in Puget Sound & San Juan Islands

Note the **lower** abundance on more exposed shorelines

Seagrass beds are in more protected, low-energy locations

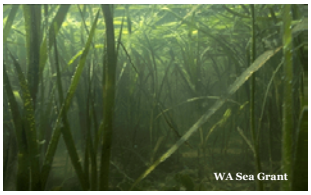


Eelgrass Beds

Eelgrass beds are also VERY Productive

A) Who does the productivity?

1. Eelgrass (*Zostera marina*)
   Flowering, vascular plant
   An ecological engineer
2.



Eelgrass Beds

Eelgrass beds are also VERY Productive

A) Who does the productivity?

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   An ecological engineer
2. _____

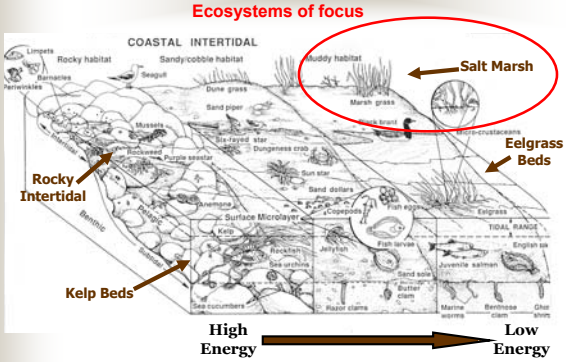
B) Why are eelgrass beds so productive?

1.
2.
3.
4.
5.

Salt Marsh

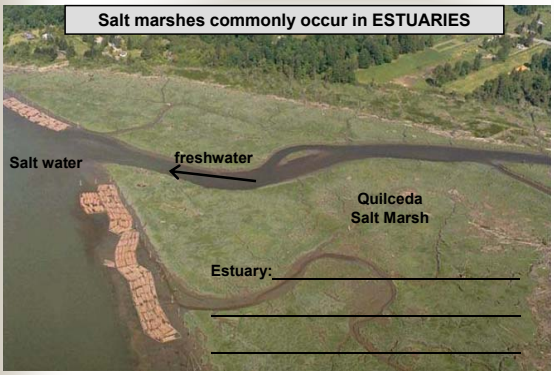
II. Marine Shoreline Ecosystems

Ecosystems of focus



Salt Marsh

Salt marshes commonly occur in ESTUARIES



Salt Marsh

Salt marshes are HIGHLY PRODUCTIVE ecosystems dominated by grass-like plants of simple structure

Salt Marsh Ecosystem Productivity

Salt Marshes are also highly productive

Annual Net Primary Productivity of Ecosystems

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Salt Marshes

Salt Marsh Ecosystems are tightly coupled to the health & function of surrounding ecosystems

Some Examples

1. Sediment brought down from inland ecosystems by rivers

- Nutrient input
- Determines tidal height

2. Detritus washed up by tides

- Organic matter / Nutrient input

3. Logs brought downstream

- Sites of ecosystem diversity

Salt Marshes

Salt marsh plants are unique and highly adapted to salty conditions – they are often not found outside of salt marshes

Jaumea carnosa

Scirpus acutus

Salicornia virginica

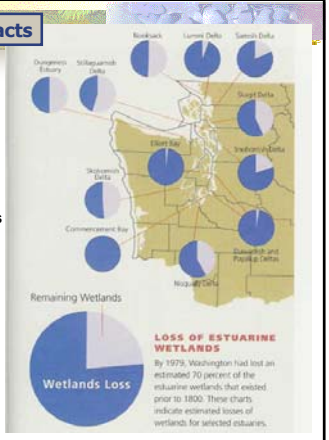
Carex lyngbyei

Salt Marshes: Human Impacts

Severe decline in salt marsh habitat area with Euro-American colonization

1800 – 1979: 70% loss in area

Particularly high in urban locations



WA Dept of Natural Resources (1998)

Salt Marshes: Human Impacts

Historical loss of salt marshes through agricultural conversion

Draining & diking

Pristine Salt Marsh in Puget Sound

Pre European Settlement:

2000:

Salt Marshes: Human Impacts

More recent loss of salt marshes through urbanization

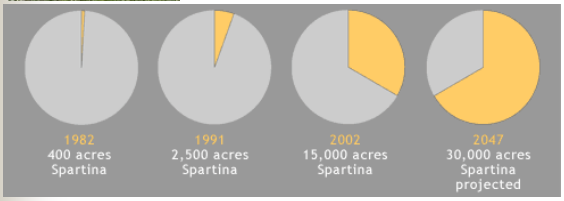
Ocean Shores, Grays Harbor County

WA DNR 1998

Salt Marshes: Human Impacts

The specter of invasive species: Cordgrass as an example

Spartina alterniflora invasion of Willapa Bay

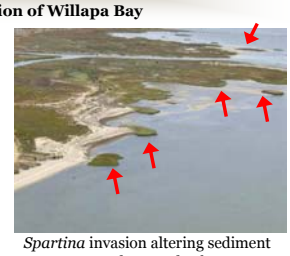


Photos & graphics: WA Dept. of Ecology

Salt Marshes: Human Impacts

***Spartina* invasion of Willapa Bay**

Spartina invasion colonizing tidal mudflats in Willapa Bay

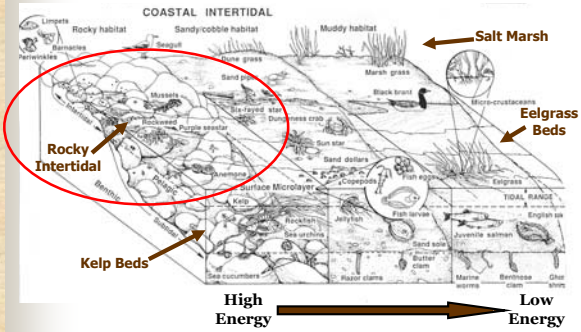


Spartina invasion altering sediment transport at the mouth of a stream

Photos: WA Dept. of Ecology

II. Marine Shoreline Ecosystems

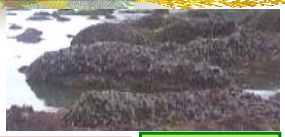
Ecosystems of focus



Rocky Intertidal

Primary Productivity by a great diversity of Algae

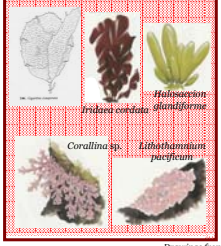
Some Examples



Brown Algae

Fucus distichus

Red Algae



Green Algae

Drawings from Kozloff (1993) and Sheldon (1998)

Rocky Intertidal

Algae (and other material) eaten by a variety of marine invertebrates

Strongylocentrotus purpuratus

Notoacmea scutum

Balanus glandula

Halichondria sp. (sponge)

Anisodoris nobilis

Katharina tunicata

Mytilus californicus

Piugettia producta

Polychaete worm tubes

Drawings from Sheldon (1998)

Rocky Intertidal

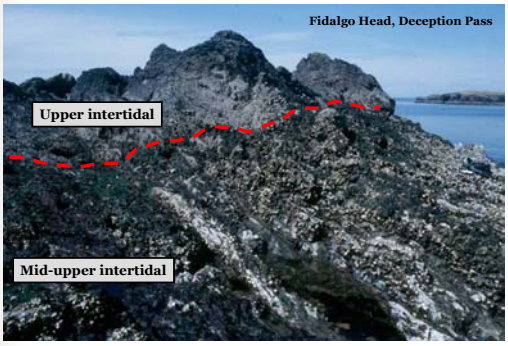
A variety of carnivores consume the herbivores

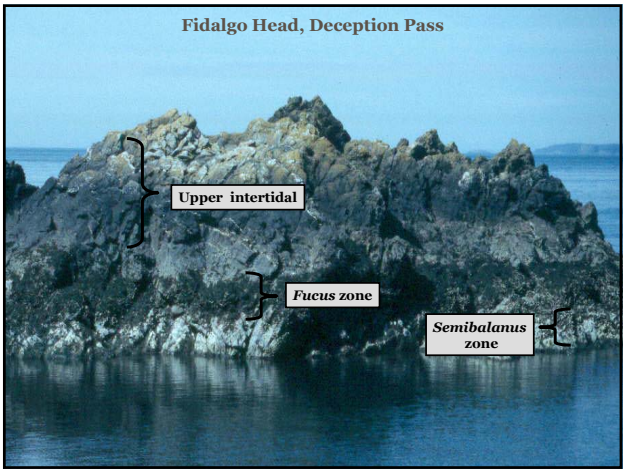
Anthopleura xanthogrammica

Pisaster ochraceus

Rocky Intertidal

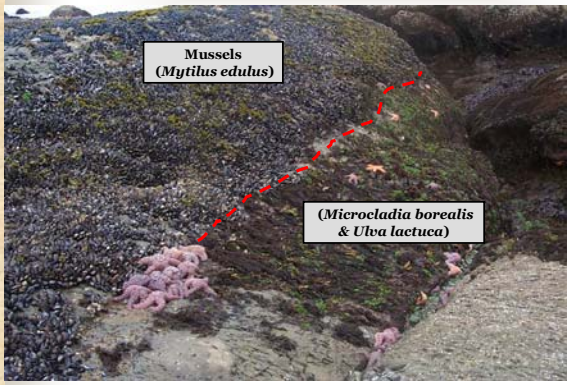
Rocky Intertidal communities are often highly organized





Rocky Intertidal

Rialto Beach



Rocky Intertidal

Environmental factors vary with height and control how ecosystems are organized

Light Temperature Desiccation Biological Interactions Wave shock

Upper Intertidal

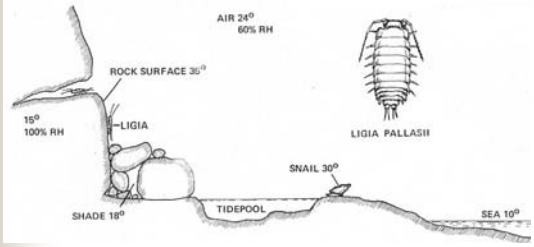
Lower Intertidal

Impacts on these environmental factors can cause significant disruption to rocky intertidal ecosystems (e.g., climate change)

Rocky Intertidal

Keys to Biological Diversity in the Rocky Intertidal

1)



Temperature & humidity vary – creating a variety of habitats

Tidepools create unique habitats

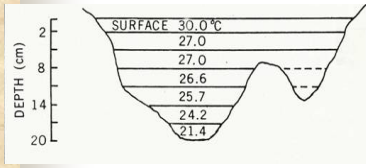
Rocky Intertidal

Keys to Biological Diversity in the Rocky Intertidal

1)

Tidepools create unique habitats

Habitats vary <u>within</u> tidepools



Rocky Intertidal

Keys to Biological Diversity in the Rocky Intertidal

1)

2)

Rocky Intertidal

Keys to Biological Diversity in the Rocky Intertidal

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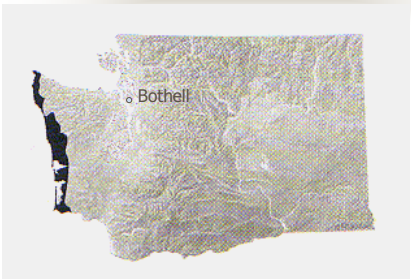
2)

3)

Ecosystems of the Sitka Spruce Ecoregion

Ecosystems of the Sitka Spruce Ecoregion



Coastal Bogs **Sitka Spruce Forests**

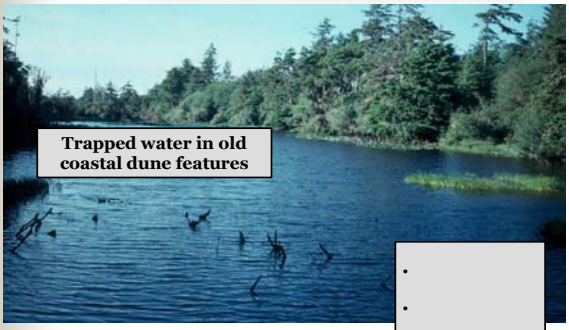
Streams & Riparian Wetlands
(covered in next ecoregion)

Environment of the Sitka Spruce Ecoregion

Coastal environment: wet, foggy & mild temperatures

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**

Coastal Bog Ecosystems



Coastal Bog Ecosystems

Sphagnum moss Bogs

Lodgepole pine (*Pinus contorta*) growing on floating mat of *Sphagnum* moss

Coastal Bog Ecosystems

Specialized plant species found nowhere else in our region

Evergreen leaves conserve nutrients in nutrient-poor environment

Ledum groenlandicum
Labrador tea

Kalmia polifolia
Bog laurel

Coastal Bog Ecosystems

Specialized plant species found nowhere else in our region

Carnivorous plants acquire nutrients in nutrient-poor environment

Sundew

Drosera rotundifolia

Drosera intermedia

Coastal Bog Ecosystems: Human Impacts

Conversion to cranberry farms

Coastal Bogs: Human Impacts

In addition to salt marshes, coastal bogs are being lost to urbanization

Ocean Shores, Grays Harbor County

WA DNR 1998

Sitka Spruce Forest Ecosystems

"Coastal Temperate Rain Forest"

Sitka Spruce Forest Ecosystems

Sitka spruce (*Picea sitchensis*) Dominant coastal tree: Oregon to Alaska

Among the 3 largest trees in WA

- 175 – 200+ feet tall
- 8 – 16 feet in diameter

Rapid growth: 175 ft in 100 years

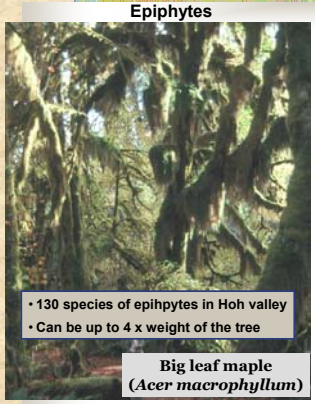
Life span ~ 700 + years

Sitka Spruce Forest Ecosystems

Washington's largest Sitka Spruce

Sitka Spruce Forest Ecosystems

Epiphytes



- 130 species of epihpytes in Hoh valley
- Can be up to 4 x weight of the tree

Big leaf maple (*Acer macrophyllum*)

Towering trees

Sitka Spruce Forest Ecosystems

Animal Species

Greatest vertebrate species diversity in the US except subtropical coastal areas (S California & Florida)

~ 225 native vertebrates

But only 11% restricted to coastal rain forest ("endemic")

- 2% bird species mostly endemic
- 14% mammals endemic
- 72% amphibians endemic

Canopy complexity → species diversity

Many vertebrate species are strongly tied to mature forest conditions (exploiting managed forests as remnant populations)

- 56 vertebrate species use cavities of large trees
- 42 vertebrate species use woody debris

Sitka Spruce Forest Ecosystems

Some Representative Animal Species

Northern flying squirrel

Northern spotted owl

Black-tailed deer

Roosevelt Elk

Marbeled Murrelet

Sitka Spruce Forest Ecosystems

Some Representative Animal Species

Marten

Kirk & Franklin (1992)

Fisher

Mathews (1988)

Vaux's swift

Mathews (1988)

Other mammals not pictured:

cougar, Douglas squirrel, raccoon, black bear, etc.

Other birds not pictured:

chestnut-backed chickadee, grey jay, dark-eyed junco, American dipper, etc.

Salamanders

Disturbance in Sitka Spruce Forest Ecosystems

Fires infrequent

Fire consequences severe

-
-

Disturbance in Sitka Spruce Forest Ecosystems

Hurricane-force winds hit WA coast about every 20 years (over last century)

Over last 100 years, major wind storms:

- **1921**
- 1955
- 1979
- 1923
- 1961
- **1981**
- **1934**
- **1962**
- **1995**

Columbus Day windstorm in 1962

- Peak winds > 100 mph
- 11 billion board feet timber blown down in WA & OR
- Enough to frame 845,000 homes

Long Island, WA 1962
Columbus Day Windstorm aftermath