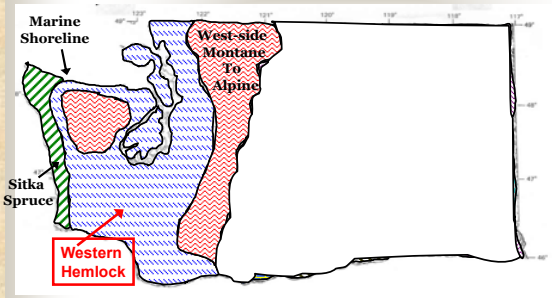
Washington State Ecoregions: West-side



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

Ecosystems of the Western Hemlock Ecoregion

Forest Ecosystems
- Hemlock – Cedar – Douglas-fir Forests
- Forested Wetlands
- Alder Forests
- Oak Woodlands

Non-Forested Ecosystems
- Prairies
- Non-Forested Wetlands
- Streams
- Lakes

Environment of the Western Hemlock Ecoregion

Coastal environment: wet & fairly 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**

Mature Forests of the Western Hemlock Ecroregion

- Low elevation forests
- Forests originally dominated by large, old evergreen trees
- Western hemlock, western red cedar, Douglas-fir

Lowland Evergreen Conifers

Douglas-fir
(*Pseudotsuga mensezeii*)

Among the 3 largest PNW trees
- Up to 300 ft tall
- 8 – 15 ft diameter

Rapid growth: 170 ft in 72 years

Life span ~ 800 – 1000 years

Comes in early after disturbance; shade intolerant

Lowland Evergreen Conifers

Western red cedar
(*Thuja plicata*)

Among the 3 largest PNW trees
- Up to 200 ft tall
- 8 – 10 ft diameter

Life span ~ 800 – 1000 years

Common later in forest development; shade tolerant

Wet sites (>30 in rain/yr or along streams)

Important ethobotanical species

Lowland Evergreen Conifers

Western hemlock
(*Tsuga heterophylla*)

"Moderate" size

- Up to 200 ft tall
- 4 – 5 ft diameter

Life span up to 500 years

Common later in forest development; shade tolerant

Often on stumps & downed logs

Mature WH Forest Ecosystem Productivity

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

WA WH Forests are HIGHLY productive:

Lassoie et al. 1985

Mature Forests of the Western Hemlock Ecroregion

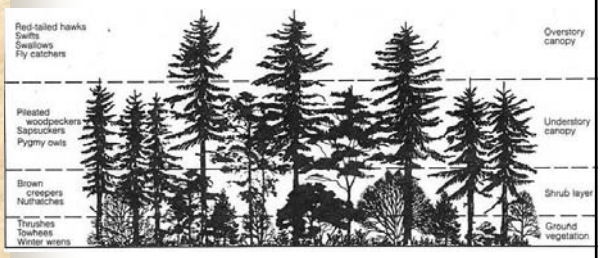
Conditions on the forest floor

- **Chronic shade**
- **Cool**
- **Moist / humid**
- **Little wind**

Some things are stressful

- **Chronic light shortage**
- **Acidic soils**
- **Low nutrients**
- **Dry summers**

Mature Forests of the Western Hemlock Ecroregion



Mature Forests of the Western Hemlock Ecroregion

Within overall forest structure there are four key structural elements

1.

2.

3.

4.

Mature Forests of the Western Hemlock Ecroregion

Pileated woodpeckers use snags & create further habitat (ecological engineers)

Holes used by:

- Owls
- Bats
- Martens
- Flying squirrels
- Vaux's swifts
  and other birds

Mature Forests of the Western Hemlock Ecroregion

Animal Species

Northern spotted owl

Nearly as diverse as coastal Sitka Spruce forests

~ 210 native vertebrates

Animals strongly tied to mature forest conditions – overall structure & habitat elements

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

Douglas squirrel (*Tamiasciurus douglasii*)

Other species similar to Sitka Spruce forests

High number of endemic amphibians

Photos from Mathews (1988)

Mature Forests of the Western Hemlock Ecroregion

Animal Species

Forests support very high animal diversity for nation

WA + OR

% US Conifer Forest Lands: _____

% US Breeding Birds: ____

% US Cavity Nesters: ____

% US Mammals: _____

% US Mammals (> 1 kg): _____

Mature Forests of the Western Hemlock Ecroregion

What is an "Old Growth Forest" ?

Age – how old does it have to be?

1) Definitions vary

Variation often tied to:

- Basis for definition (species composition, structure)
- Political / social agenda

2) Class definition

Disturbance in Mature Western Hemlock Forest Ecosystems

Fires return interval of ~ 230 years is much more frequent than Sitka Spruce forests (1,146 years)

- Data possibly inflated by Native American burning

Fire consequences severe

- High fuel loads – stand destroying crown fires usual with fire
- Many species fire avoiders

Wind disturbance
significant but not nearly as often or intense as Sitka Spruce forests

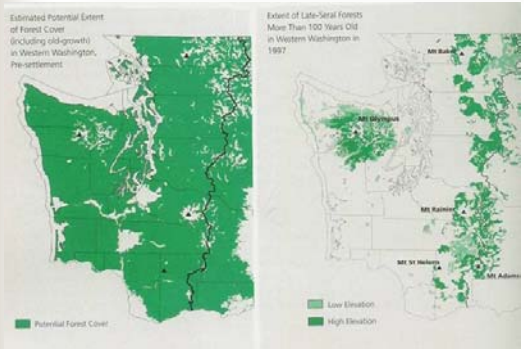
Western Hemlock Forests: Human Impacts & Management

Most of our lowland forests are heavily managed for production

Forest harvest Wishkah Valley

Western Hemlock Forests: Human Impacts & Management

Less than 10% of original forests remain at low elevations in western WA



WA DNR 1998

Western Hemlock Forests: Human Impacts & Management

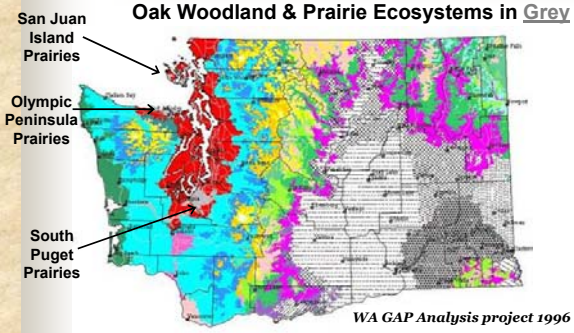
The landscape patterns of harvest are critical for understanding ecological impacts

Western Hemlock Forests: Human Impacts & Management

Plantation forests are not the same ecologically

Oak Woodland & Prairie Ecosystems in the Western Hemlock Ecoregion

Oak Woodland & Prairie Ecosystems in Grey



WA GAP Analysis project 1996

Oak Woodland & Prairie Ecosystems

Evergreen forests don't cover everything – why?

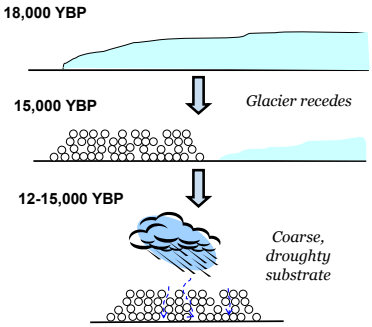
Prairies & oak woodlands of South Puget Sound

Mima Mounds Prairie Natural Area Preserve

Garry Oak woodland Glacial Heritage Park

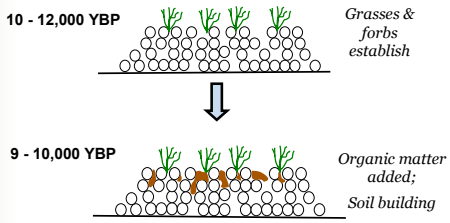
Oak Woodland & Prairie Ecosystems

Development of Puget Prairies



Oak Woodland & Prairie Ecosystems

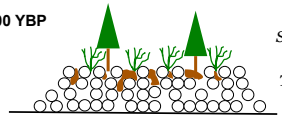
Development of Puget Prairies



Oak Woodland & Prairie Ecosystems

Development of Puget Prairies

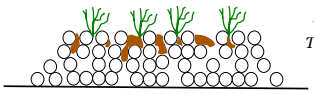
10,000 YBP



Soil holds more water & nutrients

Trees & shrubs begin to establish

7 - 10,000 YBP



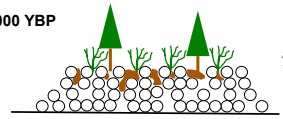
Climate shift: HYPSITHERMAL

Too warm & dry for trees; prairies remain

Oak Woodland & Prairie Ecosystems

Development of Puget Prairies

5 - 7,000 YBP

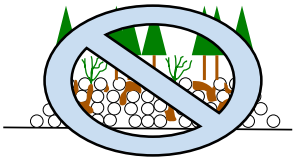


Climate cools & becomes more wet

Trees & shrubs begin to establish again

Humans arrive

200 - 7,000 YBP



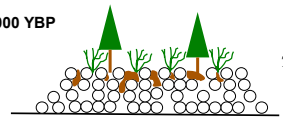
Soil OM builds rapidly

Forest establishes

Oak Woodland & Prairie Ecosystems

Development of Puget Prairies

5 - 7,000 YBP



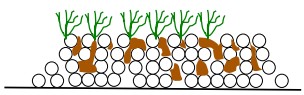
Climate cools & becomes more wet

Trees & shrubs begin to establish again

Humans arrive

200 - 7,000 YBP

FIRE



Native Americans use fire to keep trees & shrubs out – maintaining prairie

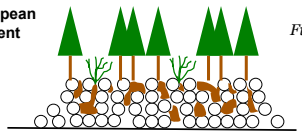
"EDAPHIC" Prairies – there due to soil conditions

Maintained by humans

Oak Woodland & Prairie Ecosystems

Development of Puget Prairies

Post European settlement



Fire suppression allows forest succession to proceed

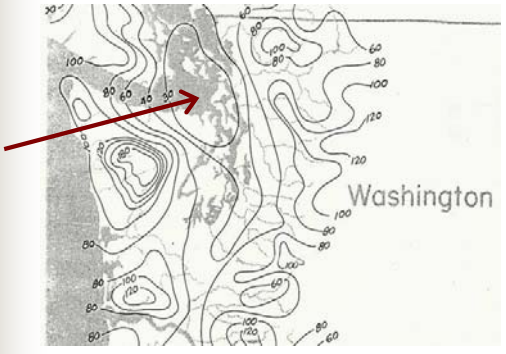
Oak Woodland & Prairie Ecosystems

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



Oak Woodland & Prairie Ecosystems

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

Just a little different

Oak Woodland & Prairie Ecosystems

As unique ecosystems they provide habitat for unique plants

Camas
(*Camassia quamash*)

Golden paintbrush
(Castilleja levisecta)

Oak Woodland & 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)

Oak Woodland & Prairie Ecosystems

Fire is an important & natural part of ecosystems

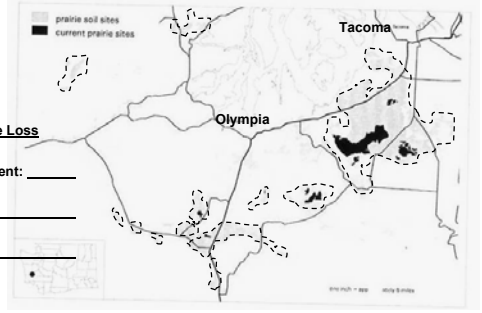
Native Americans increased fire frequency

Fires are usually now suppressed

Photo from Dunn & Ewing 1997

Oak Woodland & Prairie Ecosystems: Human Impacts

Prairie covers about 8% of historical extent in South Puget Sound



Causes of Prairie Loss
Hall (1995)

Urban development: _____

Forest invasion: _____

Agriculture: _____

Crawford & Hall 1997

Oak Woodland & Prairie Ecosystems: Human Impacts

Invasive Species are another threat

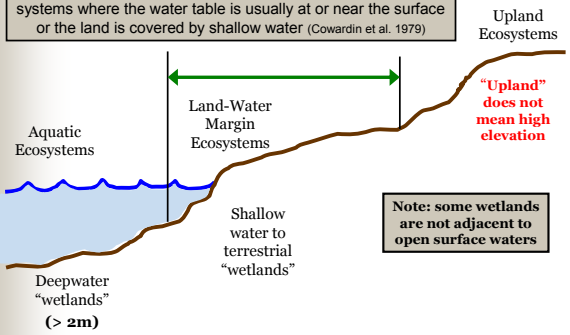
Such as Scotch Broom
(*Cytisus scoparius*)

Wetlands & Streams in the Western Hemlock Ecoregion

Freshwater Wetland Ecosystems

What are WETLANDS?

Wetlands are lands transitional between aquatic and terrestrial systems where the water table is usually at or near the surface or the land is covered by shallow water (Cowardin et al. 1979)



Freshwater Wetland Ecosystems

What are WETLANDS?

Wetlands are distinguished by:

1.

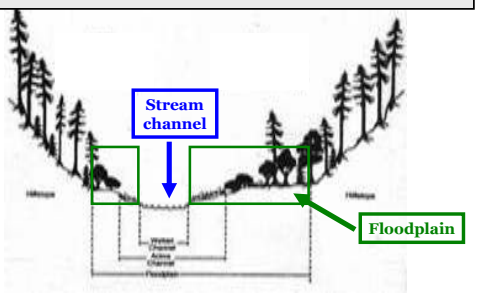
2.

3.

Freshwater Wetland Ecosystems

Streams have distinctive wetlands

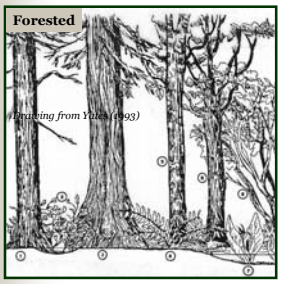
Stream Wetland Ecosystems: the Riparian Zone



Freshwater Wetland Ecosystems

1. Wetland Types based upon dominant plant form

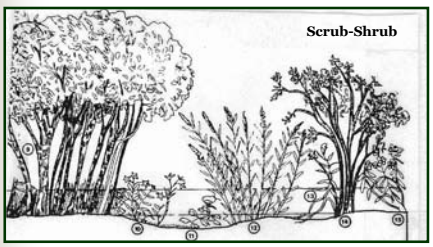
Forested wetlands: woody vegetation at least 6 m tall on at least 30% of the site



Freshwater Wetland Ecosystems

1. Wetland Types based upon dominant plant form

Scrub-Shrub wetlands: woody vegetation < 6 m tall on at least 30% of site

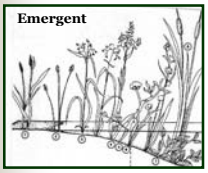


Drawing from Yates (1993)

Freshwater Wetland Ecosystems

1. Wetland Types based upon dominant plant form

Emergent wetlands: dominated by herbaceous vegetation (growing up & out of the water)



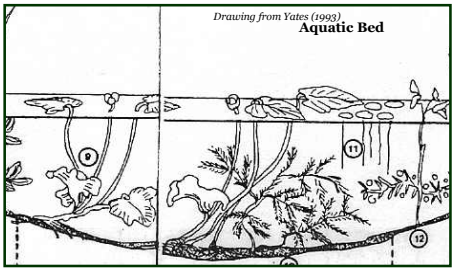
Drawing from Yates (1993)

Freshwater Wetland Ecosystems

1. Wetland Types based upon dominant plant form

Aquatic bed wetlands: dominated by floating or submerged vegetation

Drawing from Yates (1993)



Freshwater Wetland Ecosystems

2. Unique Wetland Types: Bogs

Bogs: wetlands with limited surface inflow or outflow; often acidic, low oxygen, dominated by unique vegetation

Freshwater Wetland Productivity

Freshwater wetlands are among the most productive ecosystems

Even higher than old growth forests per unit area

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

Freshwater Wetland Ecosystems

Why are freshwater wetlands so highly productive ?

1.

2.

3.

4.

Freshwater Wetland Ecosystems

Ecological Functions ***(mostly from a human perspective)***

Freshwater Wetland Ecosystems

Streams & Salmon: a primer

Salmon & Streams: a primer

Five species of salmon in our region

Plus (not pictured):
Steelhead (freshwater only)
Sea-run cutthroat trout

Illustrations from USFWS brochure 1998

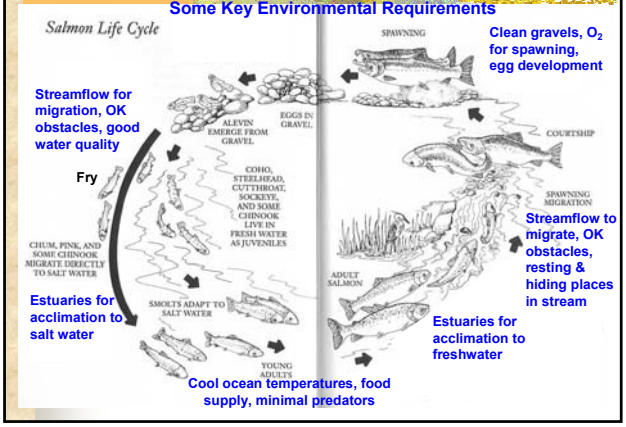
Salmon & Streams: a primer

Salmon are ANADROMOUS fish

This means they use both FRESH & SALT water during their life cycle

Salmon & Streams: a primer

Some Key Environmental Requirements



Salmon & Streams: a primer

RESEARCH NEWS

MARINE SCIENCE

Temperature Rise Could Squeeze Salmon

Modest rises in sea surface temperatures, in line with predictions of global warming over the next half-century, could make salmon disappear from much of the North Pacific Ocean. That possibility is suggested by a new review of a 40-year database that examines how fluctuating water temperatures affect the distribution of this commercially important fish. "This is a major

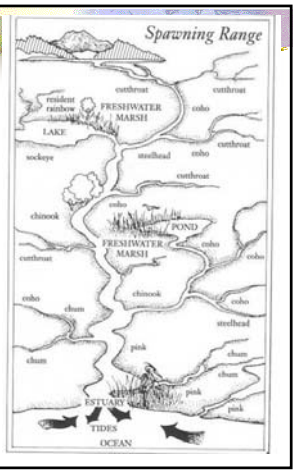
The importance of ocean temperatures beyond thermal limits to survival:

Feeding & metabolism

Welch et al. 1998

Salmon & Streams: a primer

Different species of salmon spawn in different portions of the watershed



Salmon : current status

Endangered Species Act Status of West Coast Salmon & Steelhead

(Updated June 8, 2006)

Species[1]			Current Endangered Species Act Listing Status[2]	ESA Listing Actions Under Review
Sockeye Salmon (*Oncorhynchus nerka*)	1	Snake River	Endangered	
	2	Ozette Lake	Threatened	
	3	Baker River	Not Warranted	
	4	Okanogan River	Not Warranted	
	5	Lake Wenatchee	Not Warranted	
	6	Quinault Lake	Not Warranted	
	7	Lake Pleasant	Not Warranted	
Chinook Salmon (*O. tshawytscha*)	8	Sacramento River Winter-run	Endangered	National Marine Fisheries Service, NOAA; 2006
	9	Upper Columbia River Spring-run	Endangered	
	10	Snake River Spring/Summer-run	Threatened	
	11	Snake River Fall-run	Threatened	
	12	Puget Sound	Threatened	
	13	Lower Columbia River	Threatened	
	14	Upper Willamette River	Threatened	
	15	Central Valley Spring-run	Threatened	
	16	California Coastal	Threatened	
	17	Central Valley Fall and Late Fall-run	Species of Concern	
	18	Upper Klamath-Trinity Rivers	Not Warranted	
	19	Oregon Coast	Not Warranted	
	20	Washington Coast	Not Warranted	
	21	Middle Columbia River spring-run	Not Warranted	
	22	Upper Columbia River summer/fall run	Not Warranted	
	23	Southern Oregon and Northern California Coast	Not Warranted	
	24	Deschutes River summer/fall-run	Not Warranted	

Salmon : current status

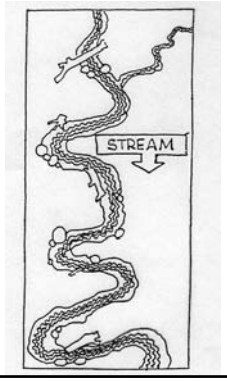
Coho Salmon (*O. kisutch*)	25	Central California Coast	Endangered	
	26	Southern Oregon/Northern California	Threatened	
	27	Lower Columbia River	Threatened	• Critical habitat
	28	Oregon Coast	Not Warranted	
	29	Southwest Washington	Undetermined	
	30	Puget Sound/Strait of Georgia	Species of Concern	
	31	Olympic Peninsula	Not Warranted	
Chum Salmon (*O. keta*)	32	Hood Canal Summer-run	Threatened	
	33	Columbia River	Threatened	
	34	Puget Sound/Strait of Georgia	Not Warranted	
	35	Pacific Coast	Not Warranted	
Steelhead (*O. mykiss*)	36	Southern California	Endangered	
	37	Upper Columbia River	Threatened	
	38	Central California Coast	Threatened	
	39	South Central California Coast	Threatened	
	40	Snake River Basin	Threatened	
	41	Lower Columbia River	Threatened	
	42	California Central Valley	Threatened	
	43	Upper Willamette River	Threatened	
	44	Middle Columbia River	Threatened	
	45	Northern California	Threatened	
	46	Oregon Coast	Species of Concern	
	47	Southwest Washington	Not Warranted	
	48	Olympic Peninsula	Not Warranted	
	49	Puget Sound[2]	Proposed Threatened	• Critical habitat • Protective Regulations
	50	Klamath Mountains Province	Not Warranted	
Pink Salmon (*O. gorbuscha*)	51	Even-year	Not Warranted	
	52	Odd-year	Not Warranted	

Salmon & Streams: a primer

Understanding the features of stream channels important to salmon (and other critters!)

Salmon & Streams: a primer

What does a stream channel look like?



Murdoch & Cheo (1999)

Salmon & Streams: a primer

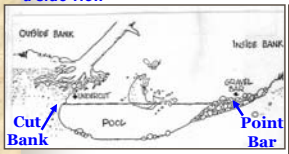
What happens with a meandering stream channel?

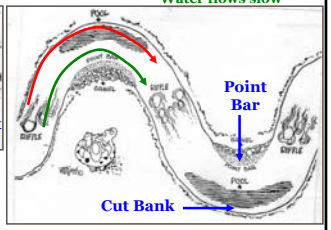
Cut Banks & Point Bars

Water flows fast

Water flows slow

a side view





Pools are created in cut banks

What good are pools?

Other important features

- Woody debris

Drawings from Murdoch & Cheo (1999)

Salmon & Streams: a primer

Wood in streams is very important – WHY?

Salmon & Streams: a primer

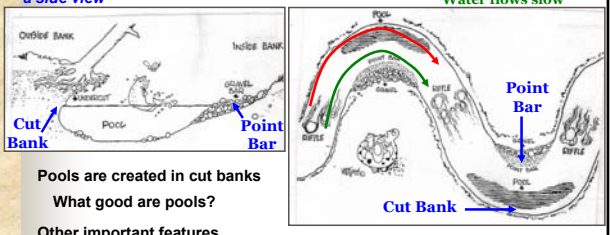
What happens with a meandering stream channel?

Cut Banks & Point Bars

Water flows fast

Water flows slow

a side view



Pools are created in cut banks

What good are pools?

Other important features

- Woody debris
- Succession

Drawings from Murdoch & Cheo (1999)

Salmon & Streams: a primer

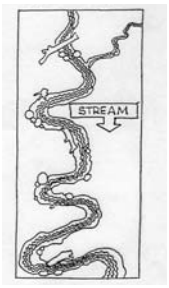
Point bar succession in action

Point bar colonization by black cottonwood on the Elwha River

Streams are DYNAMIC systems!

Salmon & Streams: a primer

What do we do to stream channels ?



What are the effects of removing meanders on habitat?

Murdoch & Cheo (1999)

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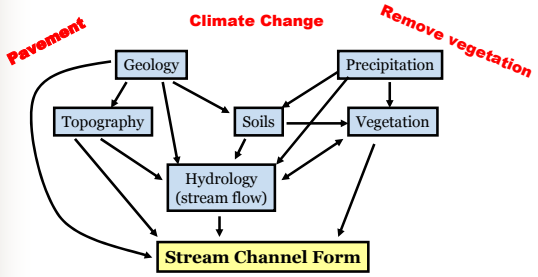
We can also alter how stream channels form and change without a backhoe



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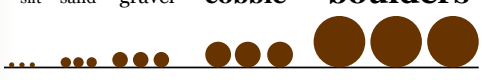
The Stream Bed is also important

silt sand gravel **cobble** **boulders**



Why is this important?

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Water Quality is Important

1)

2)

3)

4)

5)

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Streams FLOOD

Precipitation / snowmelt

Topography
Wetlands (rentention ponds) vs. slopes

Surface runoff
Pavement vs. plants

☹ **Flooding** ☺

Salmon & Streams: a primer

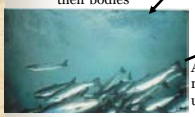
Marine-derived nutrients support forest ecosystems

Young salmon migrate out to ocean

Predators transport nutrients in salmon into forest ecosystem

After spawning the salmon die (if not taken by predators earlier)

Salmon feed in ocean, gathering nutrients from the marine environment and incorporating them into their bodies



After a few years they return to migrate upstream

Photos from Lewis (1994)