Freshwater Ecosystems

I. Freshwater Ecosystem Types
1. Definition & classification

II. Freshwater Wetland Ecology
1. Wetland productivity
2. Wetland environments
3. Ecological functions

III. Freshwater Wetlands of the Puget Sound Region
1. Wetland Organisms
2. Wetland Communities

IV. Stream Ecology: Riverine and Riparian Wetlands

V. Lakes & Ponds

What are WETLANDS?

Wetlands definitions from a LEGAL standpoint

Those areas that are saturated or inundated by surface or groundwater at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, & similar areas. (US Army Corps of Engineers 1987)

"Wetlands" or "wetland areas" means areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas. Wetlands do not include those artificial wetlands intentionally created from non-wetland sites, including, but not limited to, irrigation and drainage ditches, grass-lined swales, canals, detention facilities, wastewater treatment facilities, farm ponds, and landscape amenities, or those wetlands created after July 1, 1990, that were unintentionally created as a result of the construction of a road, street, or highway. Wetlands may include those artificial wetlands intentionally created from nonwetland areas to mitigate the conversion of wetlands. (Washington Administrative Code 173-22-030.)

What are WETLANDS?

Wetlands are distinguished by:

1. WETLAND HYDROLOGY

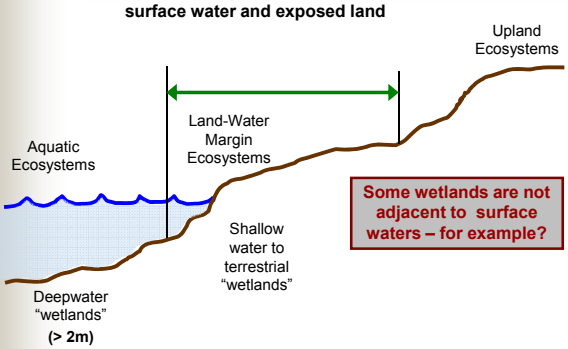
2. WETLAND VEGETATION

3. WETLAND SOILS

"Gleyed" soils

Wetlands: land-water margin ecosystems

Definition - Many (but not all) wetlands are located at the margins of surface water and exposed land



Simple wetland classification schemes

I. Water chemistry (salinity)

-
-
-

II. Water depth & source

1. Surface water wetlands

A. Shallow water – margins
B. Deepwater wetlands (> 2 meters in depth)

2. Groundwater wetlands

Soil saturation / inundation maintained by subsurface water flow

Scientific wetland classification schemes

1. Cowardin classification (1979)

Classifying wetlands hierarchically based upon

- **Hydrology & Geomorphology (Wetland System & Subsystem)**

  Riparian, riverine, lakeshore, marine

  - Vegetation Physiognomy (**Wetland class**)

    Forested, shrubland, grassland

    - Biological Characteristics (**Wetland subclass**)

      Dominant species

Alder-hemlock forested riparian wetland

Scientific wetland classification schemes

1. Cowardin classification (1979)

Cowardin Wetland Systems

1. **Marine**
   - Open ocean habitats over continental shelf
   - High energy shoreline (e.g., outer coast)
2. **Estuarine**
   - Nearshore, protected habitats
   - Mixture of fresh & salt water
3. **Riverine**
   - River channel habitats (low salinity)
4. **Lacustrine**
   - Lakes (deepwater) or lakeshore wetlands with <30% veg cover
   - Lake must be at least 8 ha (20 acres) & 2 m deep – or it is "palustrine"
5. **Palustrine**
   - Water-land margins: nontidal, low salinity (from ocean) wetlands

"Freshwater wetlands" for class purposes

Scientific wetland classification schemes

2. British classification system (Rieley & Page)

Major initial wetland categories based upon

- Dominant form of water source
- Hydrodynamics
- Nutrient status

Minerotrophic Wetlands	**Ombrotrophic Wetlands**
Water source: surface or groundwater	Water source: precipitation
Hydrodynamics: strong - moderate	Hydrodynamics: weak
Nutrient Status: high - moderate	Nutrient Status: poor
Riparian & lakeshore wetlands	Bogs & fens

Scientific wetland classification schemes

3. Hydrogeomorphic (HGM) classification

Major wetland categories based upon

- Hydrological characteristics of the wetland
- Landscape position ("geomorphology")

Used increasingly commonly in wetland regulatory applications

Not covered in this course – see wetland ecology course

Freshwater Wetland Classification for Class

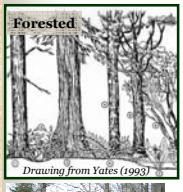
Wetland Types & Classification Categories

Physiognomy

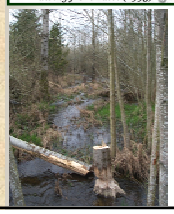
1.
2.
3.
4.

Freshwater Wetland Classification for Class

Physiognomic classification



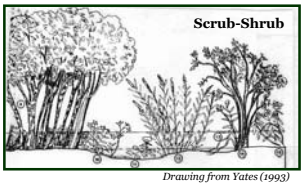
Forested wetlands: woody vegetation at least 6 m tall on at least 30% of the site



Freshwater Wetland Classification for Class

1. Physiognomic classification

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

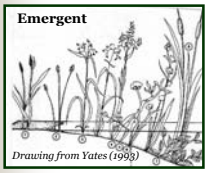


Drawing from Yates (1993)

Freshwater Wetland Classification for Class

Physiognomic classification

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

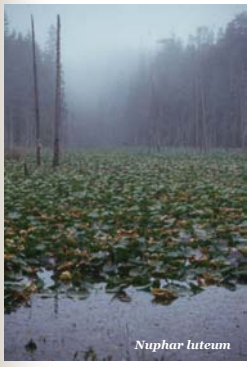


Drawing from Yates (1993)

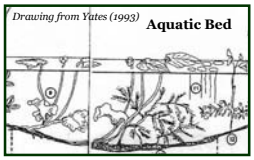
Freshwater Wetland Classification for Class

Physiognomic classification

Aquatic bed wetlands: dominated by floating or submerged vegetation

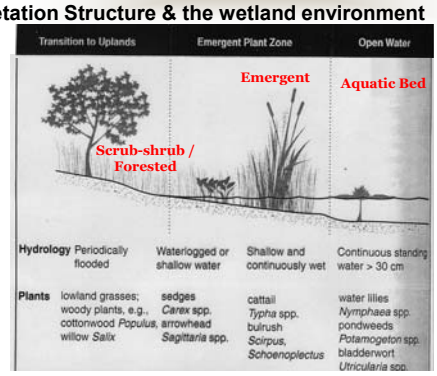


Drawing from Yates (1993)



Freshwater Wetland Classification for Class

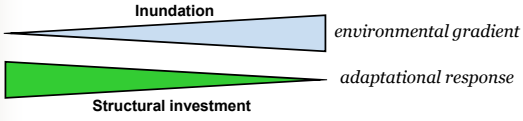
Vegetation Structure & the wetland environment



Mitsch & Gosselink (2001)

Freshwater Wetland Classification for Class

Vegetation Structure & the wetland environment



What is responsible for this pattern of adaptation?

1.

2.

Mitsch & Gosselink (2001)

Freshwater Wetland Classification for Class

Wetland Types & Classification Categories

Physiognomy	Location	Hydrology
1. Forested	1.	1.
2. Scrub-shrub	2.	2.
3. Emergent	3.	3.
4. Aquatic bed	4.	4.

Freshwater Wetland Classification for Class

Wetlands characterized by hydrology

Marsh — Wet meadow — Fen — Bog

Freshwater Wetland Ecology

1. Wetland Types & Classification

Physiognomy	Location	Hydrology
1. Forested	1. Riparian	1. Marsh / Swamp
2. Scrub-shrub	2. Lakeshore	2. Wet meadow
3. Emergent	3. Pothole	3. Fen
4. Aquatic bed	4. Hillslope	4. Bog

We will use various combinations: e.g.,

- Forested riparian bog
- Emergent hillslope wetland

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

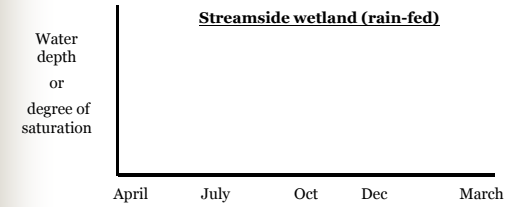
Freshwater Wetland Environments

A) Water – the defining feature of wetlands

1) Abundant supply (exceptions?)

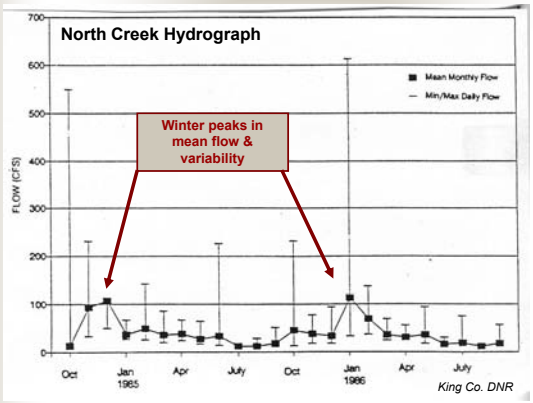
2) Variation in water availability
(depth of inundation / degree of saturation: the "hydroperiod")

a) Hydrographs show the hydroperiod



A streamside wetland that is both rain-fed and snowmelt-fed will have a similar pattern but offset timing

Freshwater Wetland Environments



Freshwater Wetland Environments

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(depth of inundation / degree of saturation: the "hydroperiod")

a) Hydrographs show the hydroperiod

b) Hydroperiod Classification (Cowardin et al. 1979)

Characterizing (categorize) environments with different hydroperiods

Freshwater Wetland Environments

Hydroperiod Classification (Cowardin et al. 1979)

Hydroperiod Class	Description
Permanently flooded	Inundated throughout year
Intermittently exposed	Permanently flooded, except in years of extreme drought
Semi-permanently flooded	Flooded during growing season (GS) in most years
Seasonally flooded	Flooded for extended periods during GS (but no standing water at end)
Saturated	No standing water but saturated soils for extended periods during GS
Temporarily flooded	Flooded for brief periods during GS but otherwise water table well below surface
Intermittently flooded	Surface water present unpredictably (without seasonal pattern)

Freshwater Wetland Environments

A) Water – the defining feature of wetlands

1) Abundant supply (exceptions?)

2) Variation in water availability
(depth of inundation / degree of saturation: the "hydroperiod")

a) Hydrographs show the hydroperiod

b) Hydroperiod Classification

What effects do these water level fluctuations have on ecological systems?

Ability of individuals to grow, survive & reproduce

Community & ecosystem properties

an example

3) Water Level Fluctuations & Biodiversity

Freshwater Wetland Environments

Water Level Fluctuations & Plant Biodiversity

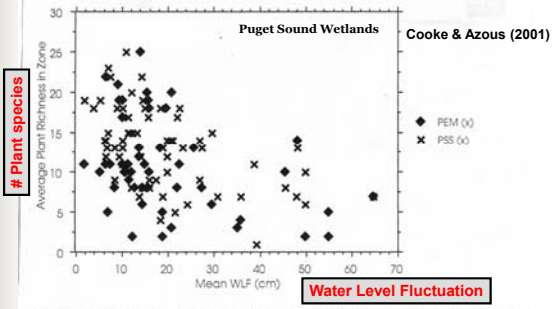


Figure 3-5. Plant richness in the emergent and scrub-shrub communities related to mean annual WLF.

Freshwater Wetland Environments

Water Level Fluctuations & Plant Biodiversity (Cooke & Azous 2001)

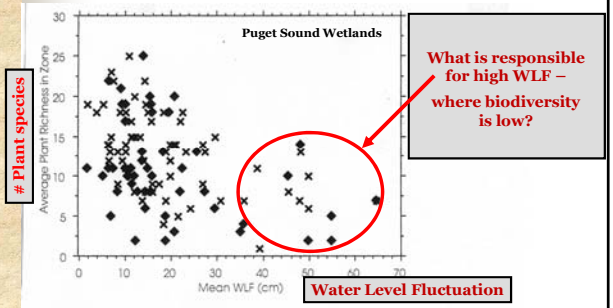


Figure 3-5. Plant richness in the emergent and scrub-shrub communities related to mean annual WLF.

Freshwater Wetland Environments

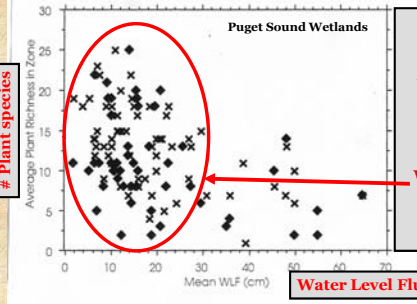
Water Level Fluctuation

What is responsible for high WLF – where biodiversity is low?

Impervious Surface Area

Freshwater Wetland Environments

Water Level Fluctuations & Plant Biodiversity (Cooke & Azous 2001)



Plant species

Impervious surfaces may be a driver for understanding low diversity in high WLF wetlands.

BUT

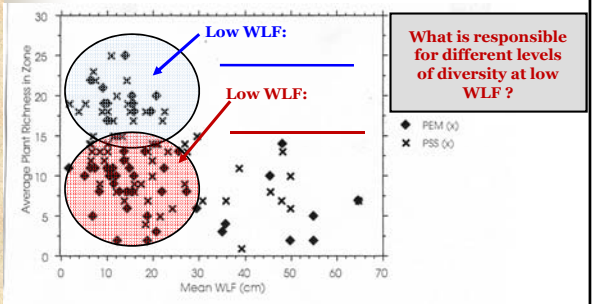
What is responsible for different levels of diversity at low WLF ?

Water Level Fluctuation

Figure 3-5. Plant richness in the emergent and scrub-shrub communities related to mean annual WLF.

Freshwater Wetland Environments

Water Level Fluctuations & Plant Biodiversity (Cooke & Azous 2001)



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Freshwater Wetland Environments

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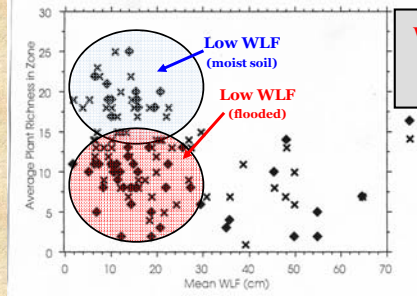


What is responsible for different levels of diversity at low WLF ?

Figure 3-5. Plant richness in the emergent and scrub-shrub communities related to mean annual WLF.

Freshwater Wetland Environments

A) Water

1) Abundant Supply

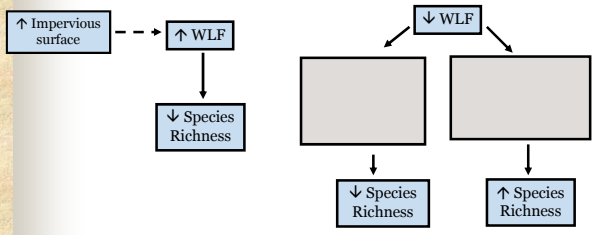
2) Hydroperiod

a) Typical Hydrographs

b) Hydroperiod Classification

3) Water Level Fluctuations & Biodiversity

The Bottom Line



Freshwater Wetland Ecology

2. Wetland Environments

A) Water

1) Abundant Supply (exceptions?)

2) Depth / Hydroperiod

a) Typical Hydrographs

b) Hydroperiod Classification (Cowardin et al. 1979)

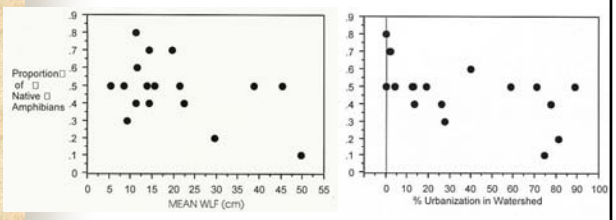
3) Water Level Fluctuations & Biodiversity

Fluctuating water levels also have effects on wetland **animals**

Example: amphibians

Freshwater Wetland Environments

Water Level Fluctuations & the success of native amphibians



Urbanized watersheds with high WLF tend to be more dominated by non-native amphibian species.

(Richter & Azous 2001)

Freshwater Wetland Environments

A) Water

1) Abundant Supply (exceptions?)

2) Depth / Hydroperiod

a) Typical Hydrographs

b) Hydroperiod Classification (Cowardin et al. 1979)

3) Water Level Fluctuations & Biodiversity

4) Water Source & hydrodynamics

Balance of water input sources is a strong ecological determinant
(precipitation, groundwater, stream flow, surface flow)

Speed of flow through is also a strong ecological determinant
(disturbance, chemistry)

Freshwater Wetland Environments

B) Temperatures

- Moderate & stable

C) Nutrients

- Large organic supply
- Inorganic availability variable (sometimes very limited)
  - Limited availability: Slow nutrient cycling slows replenishment
  - Limited availability: Reduced root function slows soil exploration

D) Acidity

- pH variable in space & time – can be quite low (e.g., acidic bogs)

E) Light

- Often high (varies) but considerable seasonal competition

F) Gases

- No aerial limitation on CO_2 or O_2
- Limited O_2 in soils can limit plant function & productivity

Freshwater Wetland Ecological Functions

(mostly from a human perspective)

III. Freshwater Wetlands of the Puget Sound Region

TWO References for Washington Wetland Science:

1. Freshwater Wetlands in Washington State
Volume 1: A Synthesis of the Science
Washington State Dept. of Ecology
Publication #03-06-016 (2003)

http://www.ecy.wa.gov/pubs/0306016.pdf

III. Freshwater Wetlands of the Puget Sound Region

TWO References for Washington Wetland Science:

2. Wetlands and Urbanization: Implications for the Future by A. Azous & R. Horner (CRC Press 2001)

UWB Library (on reserve): QH105.W2 W38 2001

Puget Sound Freshwater Wetlands

1. Wetland Organisms

A) King County Wetland Inventory Species List
(optional lists available as a handout)

- Appendix 1: Full species list
- Appendix 2: Priority species & habitats (part D below)

B) Wetland Plants
Using plants as wetland indicators

Puget Sound Freshwater Wetlands

1. Wetland Organisms

B) Wetland Plants

Table 3-1. Indicator status categories for wetland plant species.

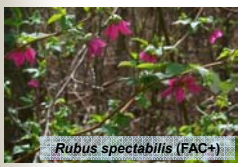
Code	Designation	Wetlands Probability 1
OBL	Obligate wetland	> 99
FACW	Facultative wetland	67 to 99
FAC	Facultative	34 to 66
FACU	Facultative upland	1 to 33
UPL	Obligate upland	< 1
NI	No indicator status	

1Percent occurrence of plant found in a wetland

Puget Sound Freshwater Wetlands


Lysichiton americanum (OBL)


Salix lucida (FACW+)


Rubus spectabilis (FAC+)


Acer circinatum (FACU)

Puget Sound Freshwater Wetlands

1. Wetland Organisms

A) King County Wetland Inventory Species List

- Appendix 1: Full species list
- Appendix 2: Priority species & habitats

B) Wetland Plants

1) Wetland Indicator Lists

Wetland plant guides

AVAILABLE IN THE LIBRARY
- Cooke, S. (ed.) 1997. A Field Guide to the Common Wetland Plants of Western Washington & Northwestern Oregon
- Guard, B.J. 1995. Wetland Plants of Oregon and Washington

US Fish & Wildlife Service Branch of Habitat Assessment
http://www.nwi.fws.gov/bha/

USDA "PLANTS" Database: http://plants.usda.gov/wetland.html

State and local government lists

Puget Sound Freshwater Wetlands

1. Wetland Organisms

A) King County Wetland Inventory Species List

- Appendix 1: Full species list
- Appendix 2: Priority species & habitats

B) Plants

1) Wetland Indicator Lists

2) Common Puget Lowland Wetland Plants

Field Guides mentioned previously

plus

Pojar, J & MacKinnon, A (1994)
Plants of the Pacific Northwest Coast

Puget Sound Freshwater Wetlands

1. Wetland Organisms

Common Puget Sound Lowland Wetland Plants

2 most common species:

Table 3-2. Species occurrence for different categori **Frequency** over dominance.

Cover Dominance Category **Cover**	High Occurrence (>80% wetlands)	Low Occurrence (<10% wetlands)
Usually dominant. Greater than 64% coverage in more than 19 percent of observations.	Phalaris arundinaceae Spirea douglasii	Juncus supiniformis Menyanthes trifoliata
Dominance in plots varies	Alnus rubra Athyrium filix-femina Kalmia microphylla Lonicera involucrata Polystichum munitum Pteridium aquilinum Ranunculus repens Rhamnus purshiana Rubus laciniatus Rubus spectabilis Rubus ursinus Salix pedicellaris Salix scouleriana Salix sitchensis Vaccinium parvifolium	Azola mexicana Brasenia schriberi Eriophorum chamissonis Hippurus vulgaris Hydrocotyl ranunculoides Hydrophyllum tenuipes Nymphaea odorata Polygonum amphibium Potentilla gramlneus Rhynchospora alba Sparganium eurycarpum Sagittaria latifolia Scirpus acutus Veronica americana
Always less than 1% coverage	no species	Mimulus guttatus Myosotis laxa Potamogeton diversifolius Ranunculus acris Rorippa curvisiliqua Rumex obtusifolius Trillium ovatum Vaccinium ovatum Vaccinium uliginosum Vicia sativa

Cooke & Azous (2001)

Puget Sound Freshwater Wetlands

Puget Sound Freshwater Wetland Plants

TREES

Red alder
Cascara
(Pacific willow)
(Oregon ash)
(Cottonwood)

SHRUBS

Hardhack
Twinberry
Salmonberry
Blackberries
Red huckleberry
Willows

HERBACEOUS

Reed Canarygrass
Lady, sword, bracken ferns
Creeping buttercup
(sedges & rushes)
(many herbs)

Table 3-2. Species occurrence for different categories of plant type and cover dominance.

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Cooke & Azous (2001)

Puget Sound Freshwater Wetlands

1. Wetland Organisms

C) Consumers

1) Herbivores

Invertebrates:

Insects (caddis flies, midges, beetles, etc.) *many omnivorous*

Crustaceans (crayfish, fairy shrimp) *often indiscriminate filter feeders*

Mollusks (freshwater snails & clams)

Vertebrates:

Birds

Mammals (rodents, beaver, muskrat)

Amphibians

Fish

2) Carnivores

Birds, mammals, fish, insects, amphibians, etc.

3) Detritivores

Insects, annelid worms, crustaceans, microbes, etc.

Puget Sound Freshwater Wetlands

1. Wetland Organisms

D) Protected / Declining Species

King County 1991 Wetland Inventory Priority Species & Habitats

Priority species: species of concern due to population status and/or sensitivity to habitat manipulation

*Includes federal & state listed species as well as species of special concern and **game species***

Birds

Plants

Fish

Insects

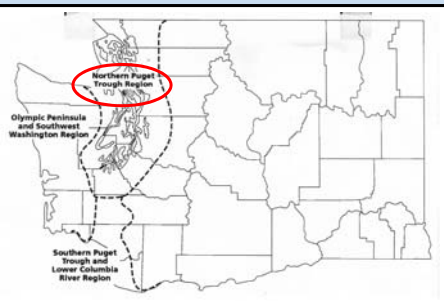
Amphibians

Reptiles

Puget Sound Freshwater Wetlands

2. Wetland Communities

Kunze, L.M. 1994. Preliminary classification of native, low-elevation freshwater wetland vegetation in western Washington. Washington State Dept. of Natural Resources



Puget Sound Freshwater Wetlands

2. Wetland Communities

Generalized Wetland Plant Community Types of the Puget Trough Lowlands

I. Low Elevation Sphagnum Bogs

A. Herb Dominated
1. Sedge / *Sphagnum* spp. communities

B. Shrub Dominated
1. Western Bog Laurel – Labrador Tea / *Sphagnum* spp. community
2. Hardhack / *Sphagnum* spp. community

C. Tree Dominated
1. Pine or Western Hemlock (+ Labrador Tea) / Sphagnum spp. communities

II. Low Elevation Minerotrophic Wetlands

A. Permanently Flooded
1. Floating-leaved aquatics communities
2. Marc's-Tail community
3. Rush community
4. Bulrush communities
5. Cattail community

B. Saturated Soils or Seasonally Flooded
1. Herb Dominated
   a. Sedge communities
2. Shrub Dominated
   a. Mountain alder community
   b. Redosier dogwood – willow - hardhack community
   c. Sweet gale community
   d. Willow community
   e. Hardhack community
3. Tree Dominated
   a. Skunk Cabbage communities (with red alder, western red cedar or western hemlock)
   b. Red alder / salmonberry community
   c. Oregon ash communities (with sedge or snowberry)
   e. Pacific crab apple community

Optional handout available

Summarized from

Kunze's 37 Plant Community Types of the Puget Trough Lowland

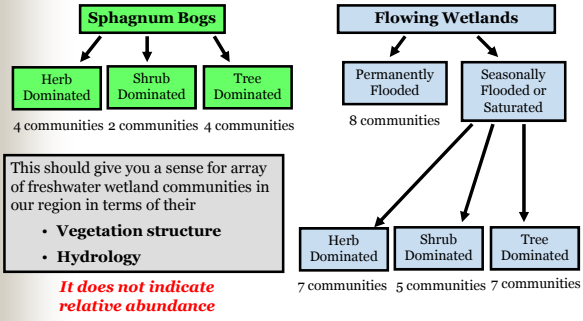
(Kunze 1994)

It is not necessary to "know" these specific communities.

Puget Sound Freshwater Wetlands

2. Wetland Communities

What I would like you to "know" is this distilled version:



This should give you a sense for array of freshwater wetland communities in our region in terms of their

- **Vegetation structure**
- **Hydrology**

It does not indicate relative abundance

This scheme was created from the 37 communities in Kunze (1994).

Puget Sound Freshwater Wetlands

2. Wetland Communities

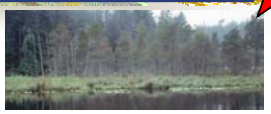
A) Sphagnum Bogs

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

Puget Sound Freshwater Wetlands

2. Wetland Communities

A) Sphagnum Bogs



1) Locations

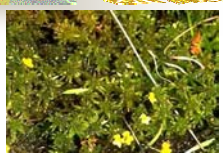
- **Depressions** (glacial scours, isolated oxbows, old lake beds)
- **Tops of drainages** (little inflow, usually a slow outflow)
- **Backwater pockets within flowing wetlands**

2) Environmental Characteristics

Puget Sound Freshwater Wetlands

2. Wetland Communities

A) Sphagnum Bogs



3) Plants

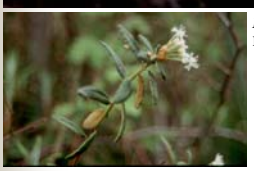
Characterized by

- **Predominance of *Sphagnum* moss**
- **stress tolerant species** (with inherently slow growth) **adapted to low nutrient conditions**
  - **Lodgepole & western white pines** (also in dry, nutrient-poor sites)
  - **Evergreen-leaved shrubs: an important strategy for nutrient conservation**
  - **Carnivorous plants (sundew, pitcher plant): nutrient acquisition**

Puget Sound Freshwater Wetlands

2. Wetland Communities **A) Sphagnum Bogs**

Evergreen shrubs: evergreen leaves an important strategy for nutrient conservation



Ledum groenlandicum
Labrador tea

Kalmia polifolia
Bog laurel

Puget Sound Freshwater Wetlands

2. Wetland Communities

A) Sphagnum Bogs

Carnivorous plants (e.g., sundew): nutrient acquisition

Drosera rotundifolia

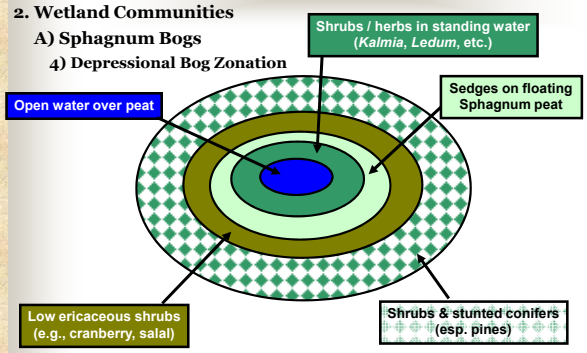
Drosera intermedia

Puget Sound Freshwater Wetlands

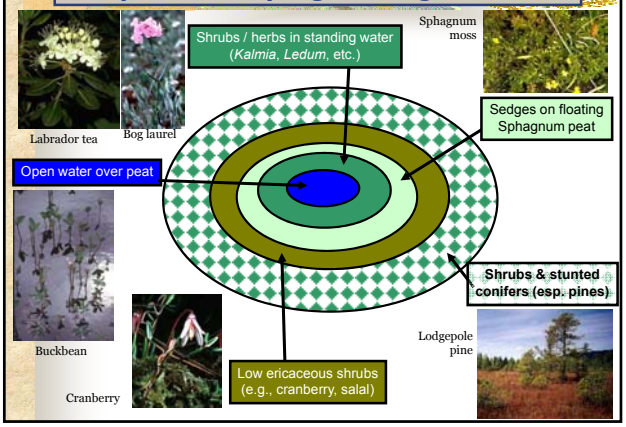
2. Wetland Communities

A) Sphagnum Bogs

4) Depressional Bog Zonation



Depressional Sphagnum Bog Zonation



Puget Sound Freshwater Wetlands

2. Wetland Communities

B) Flowing (Minerotrophic) Wetlands

1) Locations

Surface Water impounded by topography or beavers
Varies from highly impounded sites (fens) to strongly flowing river systems

All parts of drainages (both inflow & outflow)

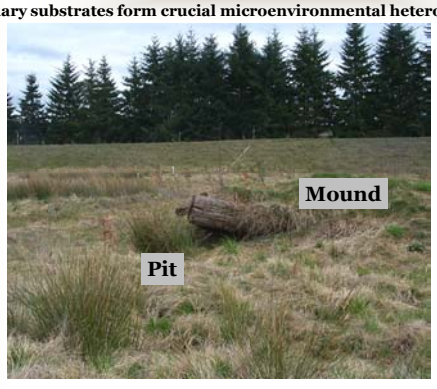
Degree of water-flow-through highly variable across types
Results in varying soils from peat to muck to mineral soil

2) Environmental Characteristics

Mosaics of varying environmental gradients
(often resulting in many communities within one wetland site)

Secondary substrates form crucial microenvironmental heterogeneity (e.g., wind throw depressions, root wads & other woody debris, standing snags, etc.)

Secondary substrates form crucial microenvironmental heterogeneity



Puget Sound Freshwater Wetlands

2. Wetland Communities **B) Flowing Wetlands**

1) Locations

Impounded by topography or beavers
All parts of drainages (both inflow & outflow)

Degree of water flow through highly variable across types

2) Environmental Characteristics

Mosaics of varying environmental gradients

Secondary substrates form crucial microenvironmental heterogeneity

Water input dominated by both precipitation and inflow

Natural disturbances from physical (flooding) **and biological** (beavers) **environments have important influences *(diversity)***

Puget Sound Freshwater Wetlands

2. Wetland Communities B) Flowing Wetlands

3) Plants

- **Vegetation correlated with:**
  - Water depth
  - Hydroperiod / fluctuation
  - Soil type & chemistry
  - Flow energy
- **Riverside wetlands: dynamic vegetation with high diversity**

Red alder floodplain forest

Black cottonwood floodplain forest

Flowing Wetlands

AQUATIC HERBS (Aquatic bed vegetation)

Pond Lily

Nuphar polysepalum

Pond Weed

Potomageton natans

Smart Weed

Polygonum hydropiperoides

Lemna minor

Duck Weed

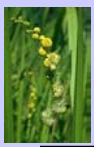
Flowing Wetlands

HERBS

Veronica americana

Oenanthe sarmentosa

Equisetum arvense



Sparganium emersum

Lysichiton americanum

Flowing Wetlands

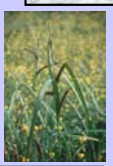
GRASSES, SEDGES & RUSHES

Carex obnupta

Typha latifolia

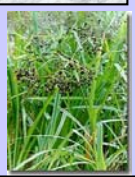
Juncus effusus

Carex comosa



Carex utriculata

Alopecurus pratensis



Scirpus microcarpus

Flowing Wetlands

SHRUBS

Spirea douglasii

Cornus sericea

Rubus spectabilis

Lonicera involucrata

Salix species

Some Evil Doers: exotic species

Creeping buttercup

Purple loosestrife

Reed canarygrass

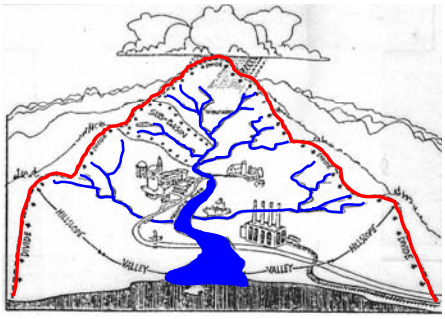
IV. Stream Ecology: Riverine and Riparian Wetlands

1) Streams in a Landscape
2) Structure of Stream Habitats
3) Salmon & Streams
4) Stream Environments
5) Stream Organisms

Streams in a Landscape

Streams in a Landscape: Streams exist within a watershed

A) Watersheds as Landscape Units



Murdoch & Cheo (1999)

Streams in a Landscape

Streams in a Landscape

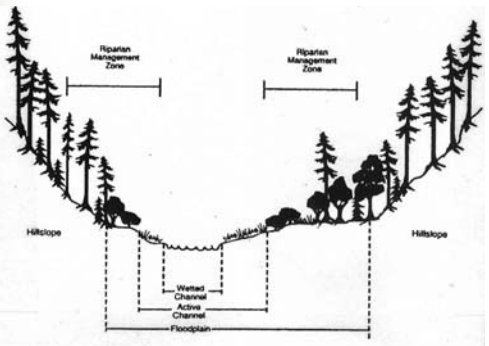
B) Streams as Ecological Corridors

1) Conduits of movement
2) Sites of ecological complexity

- Rapid lateral habitat transitions
- Atypical habitat attributes
  - ✓ High light
  - ✓ Summer water availability

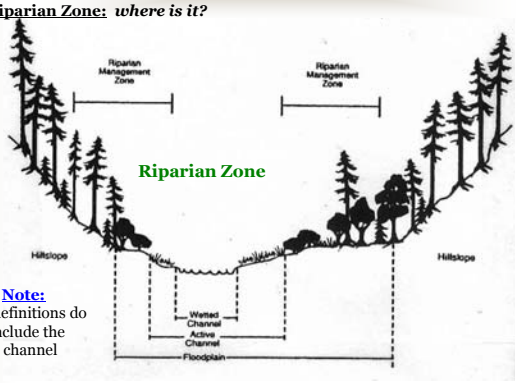
Structure of Stream Habitats

The Riparian Zone: ***what is it?***



Structure of Stream Habitats

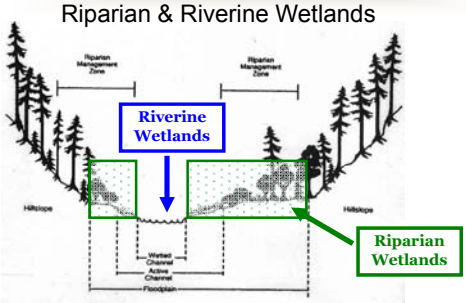
The Riparian Zone: ***where is it?***



Note:
some definitions do NOT include the stream channel

Structure of Stream Habitats

Riparian & Riverine Wetlands



Salmon & Streams

Salmon & Streams

Five species of salmon in our region

Chinook (King)

See your readings for a rich, required discussion of salmon

Chum

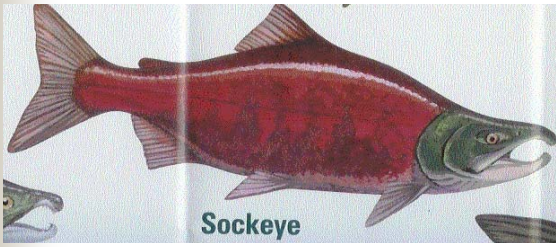
Plus (not pictured):
Steelhead (freshwater only)
Sea-run cutthroat trout

Illustrations from USFWS brochure 1998

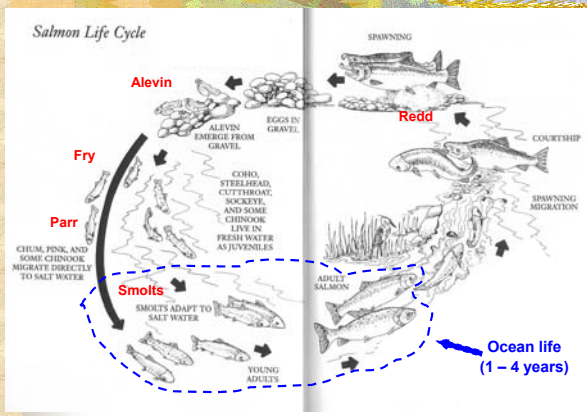
Salmon & Streams

Salmon are ANADROMOUS fish

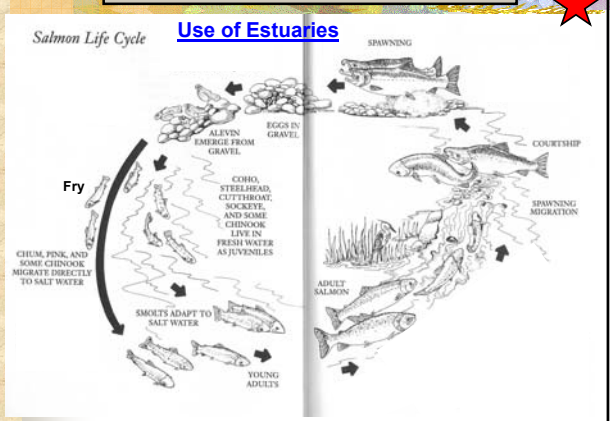
This means they use both FRESH & SALT water during their life cycle



Salmon & Streams

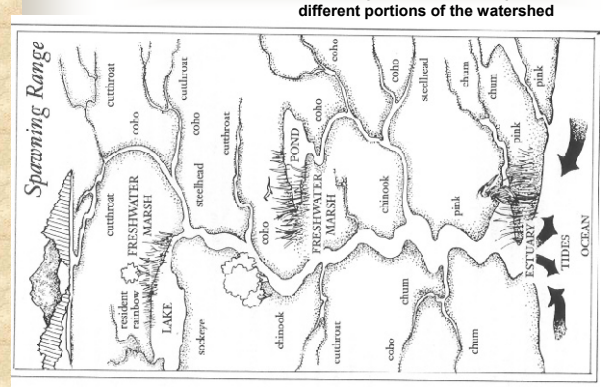


Salmon & Streams



Salmon & Streams

Different species of salmon spawn in different portions of the watershed



Salmon : current status

Endangered Species Act Status of West Coast Salmon & Steelhead

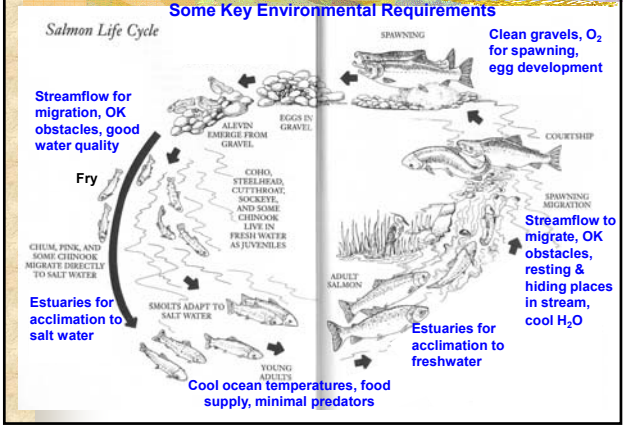
Species[1]			Current Endangered Species Act Listing Status[2]	ESA Listing Actions Under Review
Sockeye Salmon (*Oncorhynchus nerka*)	1	Snake River	Endangered	
	2	Ozette Lake	Threatened	
	3	Baker River	Not Warranted	
	4	Okanogan River	Not Warranted	
	5	Lake Wenatchee	Not Warranted	
	6	Quinault Lake	Not 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	Centra Valley Spring-run	Threatened	
	16	California Coastal	Threatened	
	17	Centra 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[3]	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

Some Key Environmental Requirements



Clean gravels, O_2 for spawning, egg development

Streamflow for migration, OK obstacles, good water quality

Fry

Streamflow to migrate, OK obstacles, resting & hiding places in stream, cool H_2O

Estuaries for acclimation to salt water

Estuaries for acclimation to freshwater

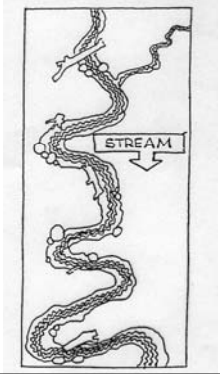
Cool ocean temperatures, food supply, minimal predators

Stream Environments

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

Stream Environments

What does a stream channel look like?



Murdoch & Cheo (1999)

Stream Environments

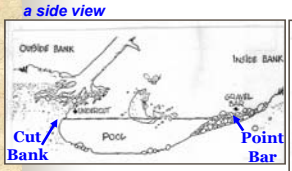
What happens with a meandering stream channel?

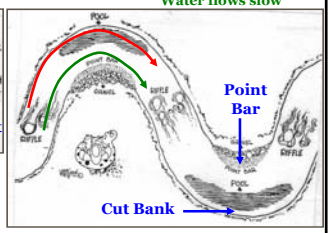
Cut Banks & Point Bars

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)

Stream Environments

Wood in streams is very important – WHY?

Stream Environments

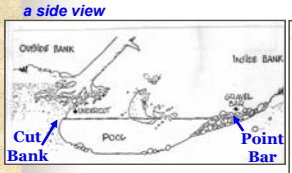
What happens with a meandering stream channel?

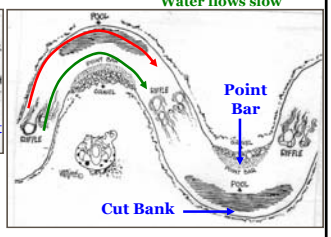
Cut Banks & Point Bars

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)

Campus Wetlands: point bar formation

Stream Environments

Point bar succession in action

Point bar colonization by black cottonwood on the Elwha River

Stream Environments

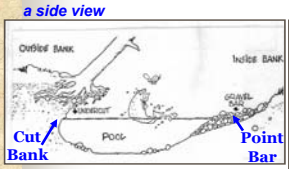
What happens with a meandering stream channel?

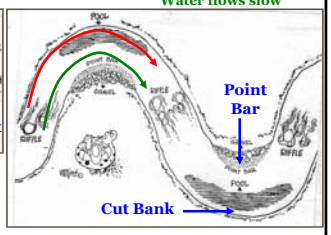
Cut Banks & Point Bars

Water flows fast

Water flows slow

a side view





Pools are created in cut banks

What good are pools?

Other important features

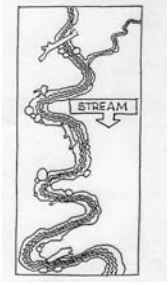
- Woody debris
- Succession

Streams are DYNAMIC systems!

Drawings from Murdoch & Cheo (1999)

Stream Environments

What do we do to stream channels ?

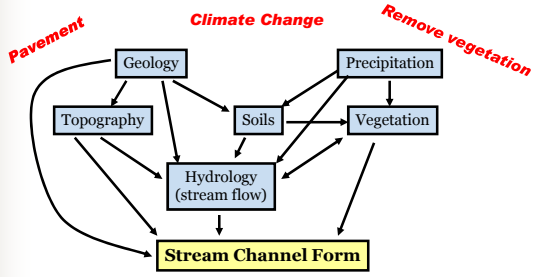


What are the effects of removing meanders on habitat?

Murdoch & Cheo (1999)

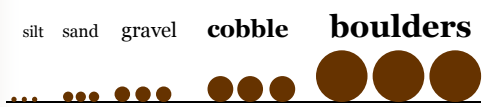
Stream Environments

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



Stream Environments

The Stream Bed is also important



Why is this important?

Stream Environments

Water Quality is Important

Stream Environments

Streams FLOOD

Precipitation / snowmelt

Topography
Wetlands (rentention ponds) vs. slopes

Surface runoff
Pavement vs. plants

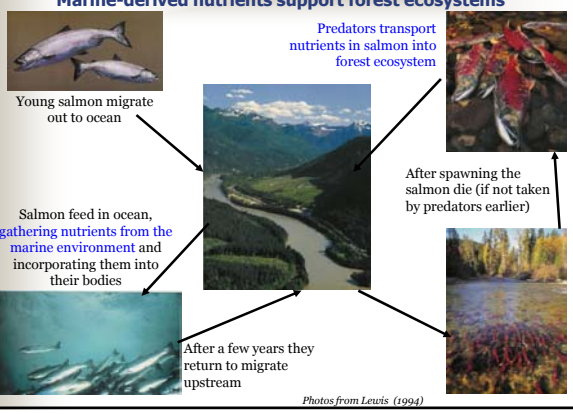
Flooding

☹ **Erosion** (can smother eggs or scour out streambed gravels)
Human losses

☺ **Soil building**
Nutrient exchange

Stream Environments

Marine-derived nutrients support forest ecosystems



Photos from Lewis (1994)

Stream Organisms

A) Primary Producers

- Algae
- Obligate wetland plants
- Facultative wetland plants
- Plants tolerant of saturated soils & flooding

Channel ⇩ Floodplain

B) Herbivores

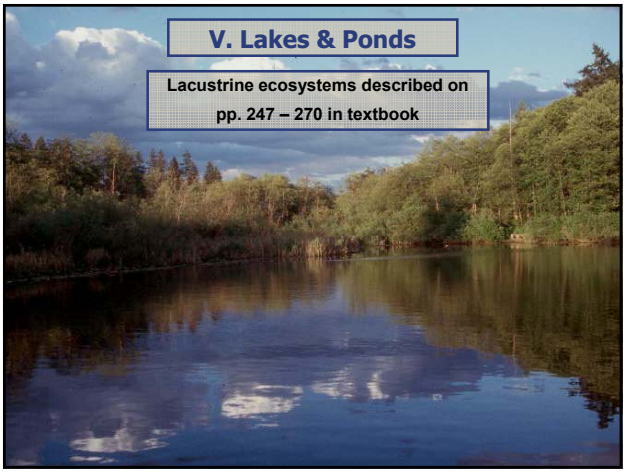
- Aquatic: Various invertebrates
- Terrestrial: Mammals (e.g., beavers)

C) Carnivores

- Aquatic: Various invertebrates; Fish (e.g., salmon)
- Terrestrial: Mammals (e.g., river otters)

D) Detritivores

- Aquatic insects
- Fungi
- Bacteria


V. Lakes & Ponds
Lacustrine ecosystems described on pp. 247 – 270 in textbook