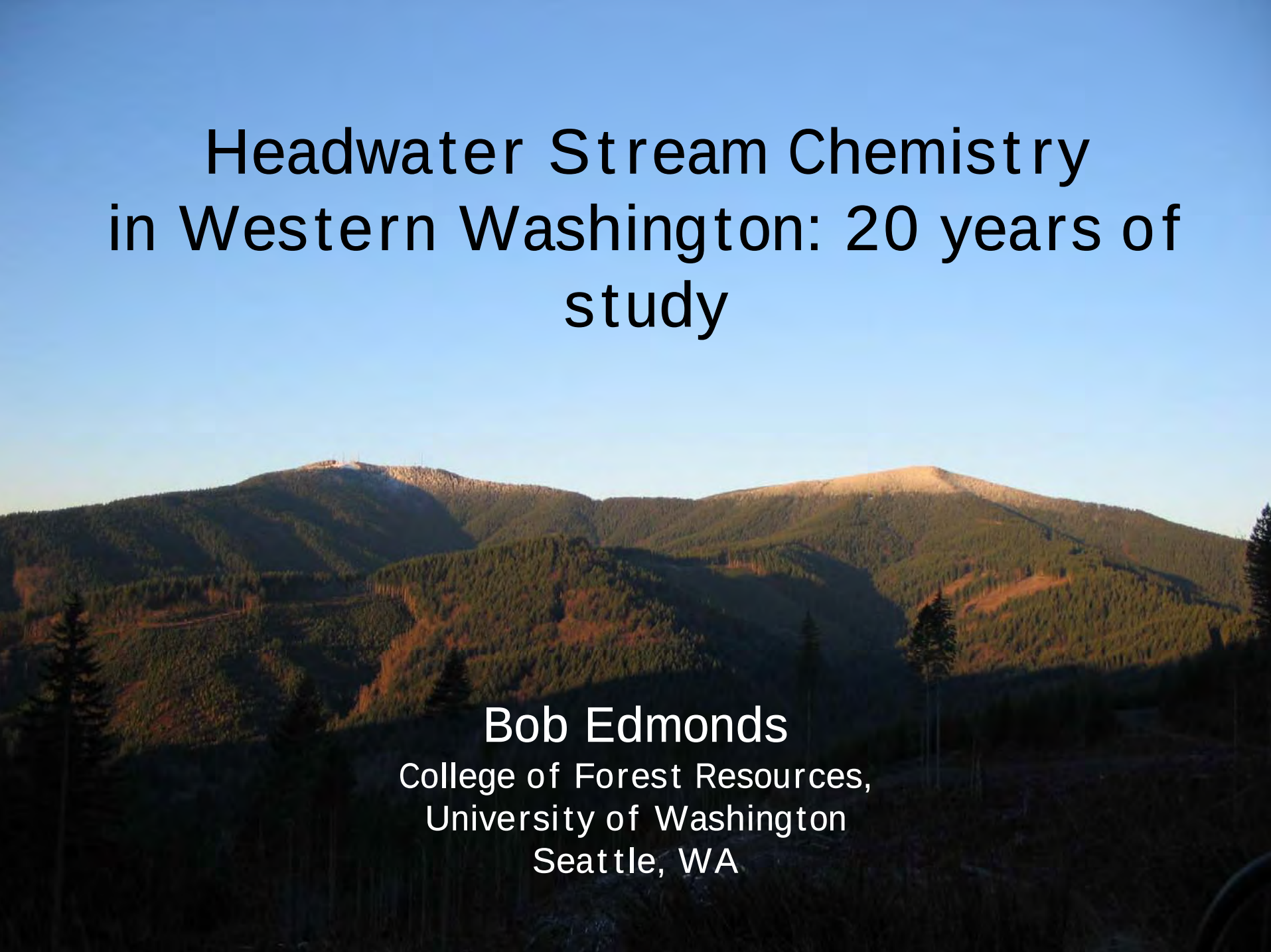
Headwater Stream Chemistry in Western Washington: 20 years of study



Bob Edmonds
College of Forest Resources,
University of Washington
Seattle, WA

Headwater streams

Small in size, large in coverage (50% of stream mileage)

Headwater Streams 101

- Transition Zone Between Terrestrial and Aquatic Systems
- Large reactive surface
- Source of Organic and Inorganic Nutrients to Drainage Network
- Sharp Gradients - Physical and Chemical
- Regulate Physical Conditions - Temperature and Coarse Wood Inputs
- Diverse Biotic Assemblages and High Species Richness

Many stream chemistry studies have focused on nitrogen (N) because it is a limiting nutrient and in excess it is a pollutant.

Studying N cycling gives an understanding of natural ecosystems functioning and the influence of management practices such as clearcut harvesting

Stream N forms
DIN – Dissolved inorganic N (NO_3 and NH_4)
DON – Dissolved organic N
Particulate N

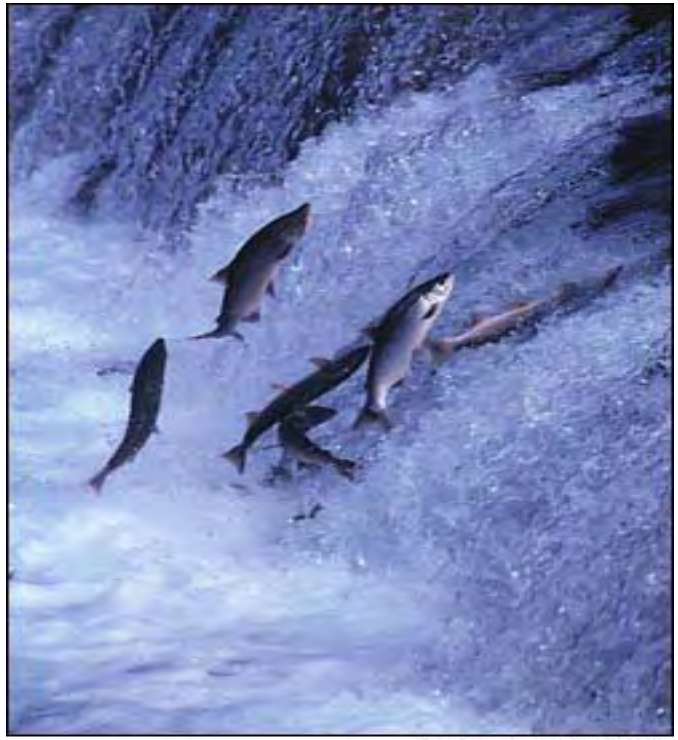
Effects of excess N inputs (Fenn et al. 2003)

AQUATIC

Elevated stream NO3-N, lowered pH, increased algal growth, eutrophication, negative effects on fish and salamanders

TERRESTRIAL

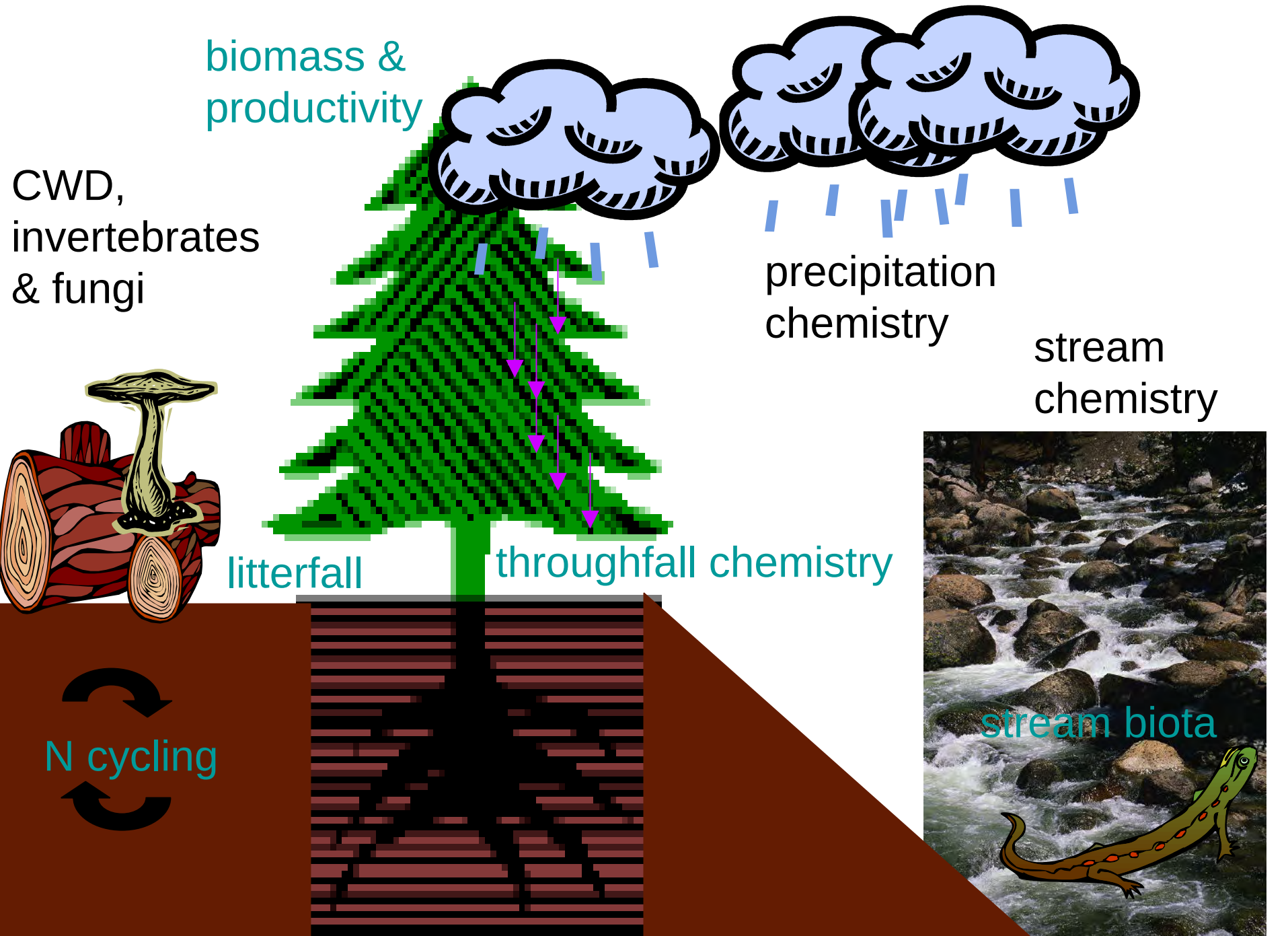
N fertilization of plants, altered C cycle, increased denitrification, decreased mycorrhizae, enhanced invasives growth, lichen changes,effects on threatened and endangered species



Courtesy American Rivers

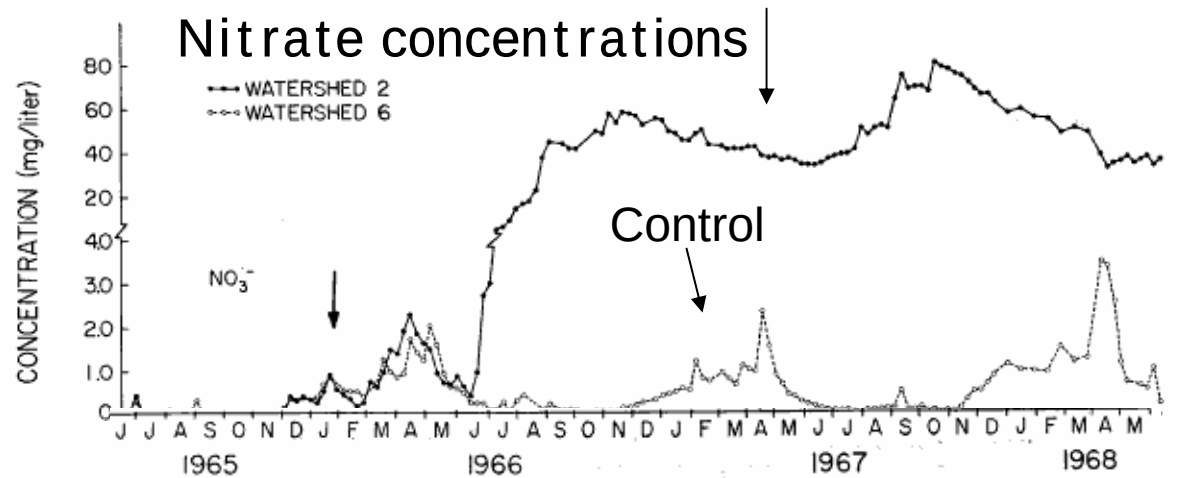
Salamanders - Sensitive to nitrate–N concs of 1 mg/L

Drinking water standard – 10 mg/L


biomass &
productivity
CWD,
invertebrates
& fungi
precipitation
chemistry
stream
chemistry
litterfall
throughfall chemistry
N cycling
stream biota

Watershed 2 –harvested 1966

Harvested and herbicided



Small watershed studies at Hubbard Brook New Hampshire

Four studies - 20 years

Hoh River

1. Long-term studies in old-growth temperate rain forest

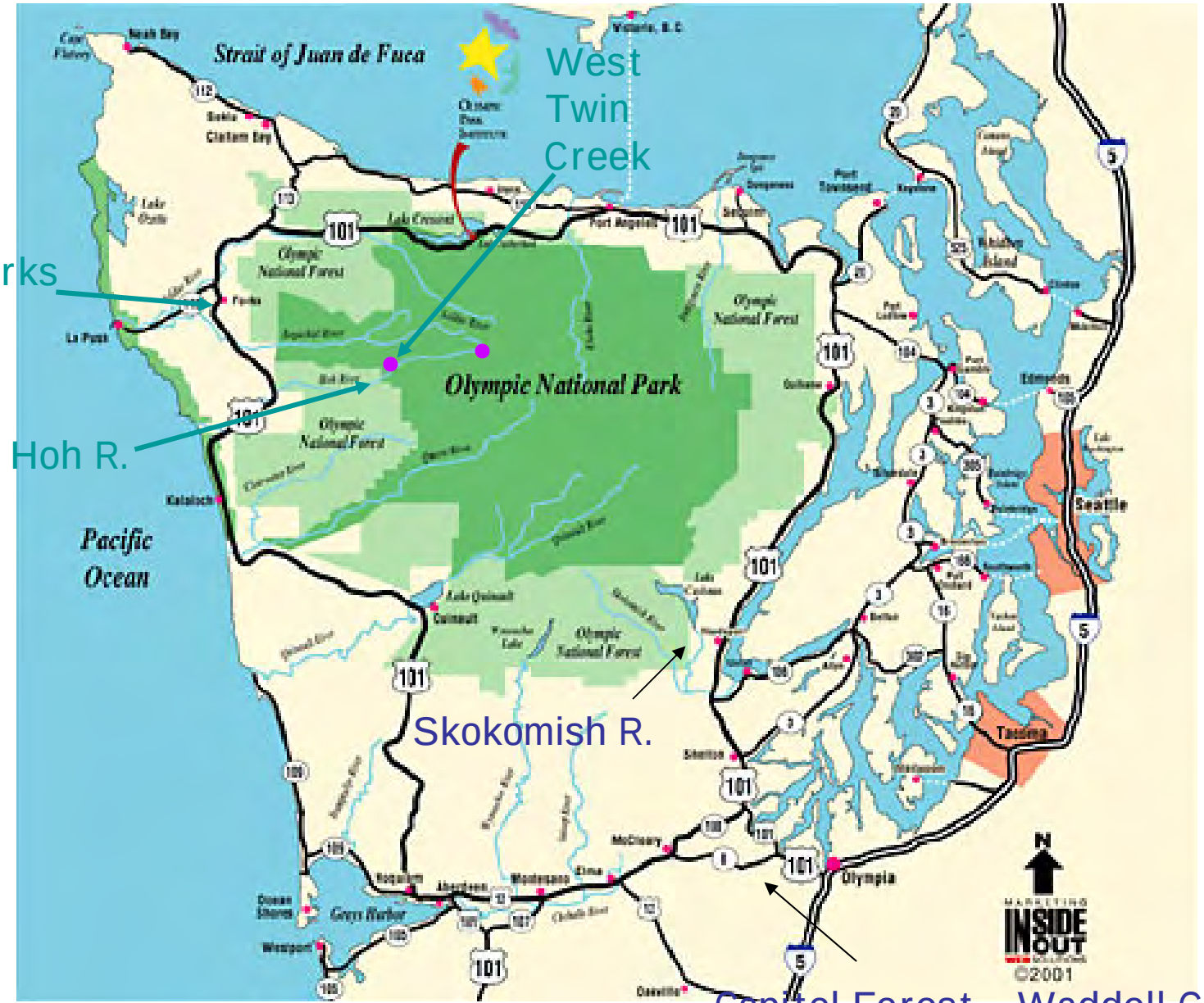
2. Influence of riparian vegetation – red alder

Skokomish

3. Effects of salmon carcass placement in riparian areas

Capitol Forest

4.Recovery from clearcut harvesting and influence of riparian buffers on harvested headwater streams



Map from Olympic Park Institute: http://www.yni.org/opi/location.html

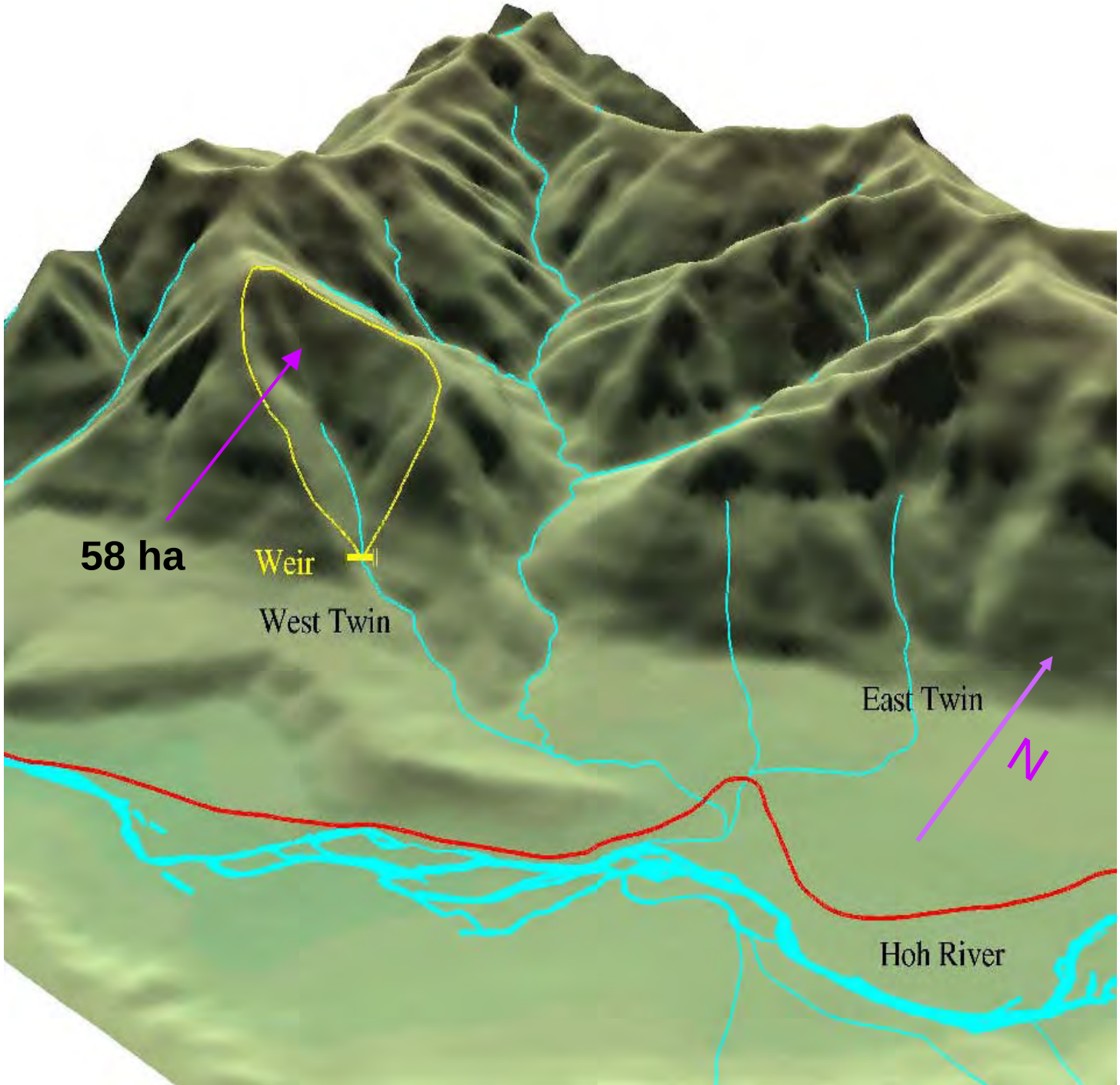
Study 1

Long-term monitoring of stream chemistry in pristine old-growth forests in the Hoh River Valley

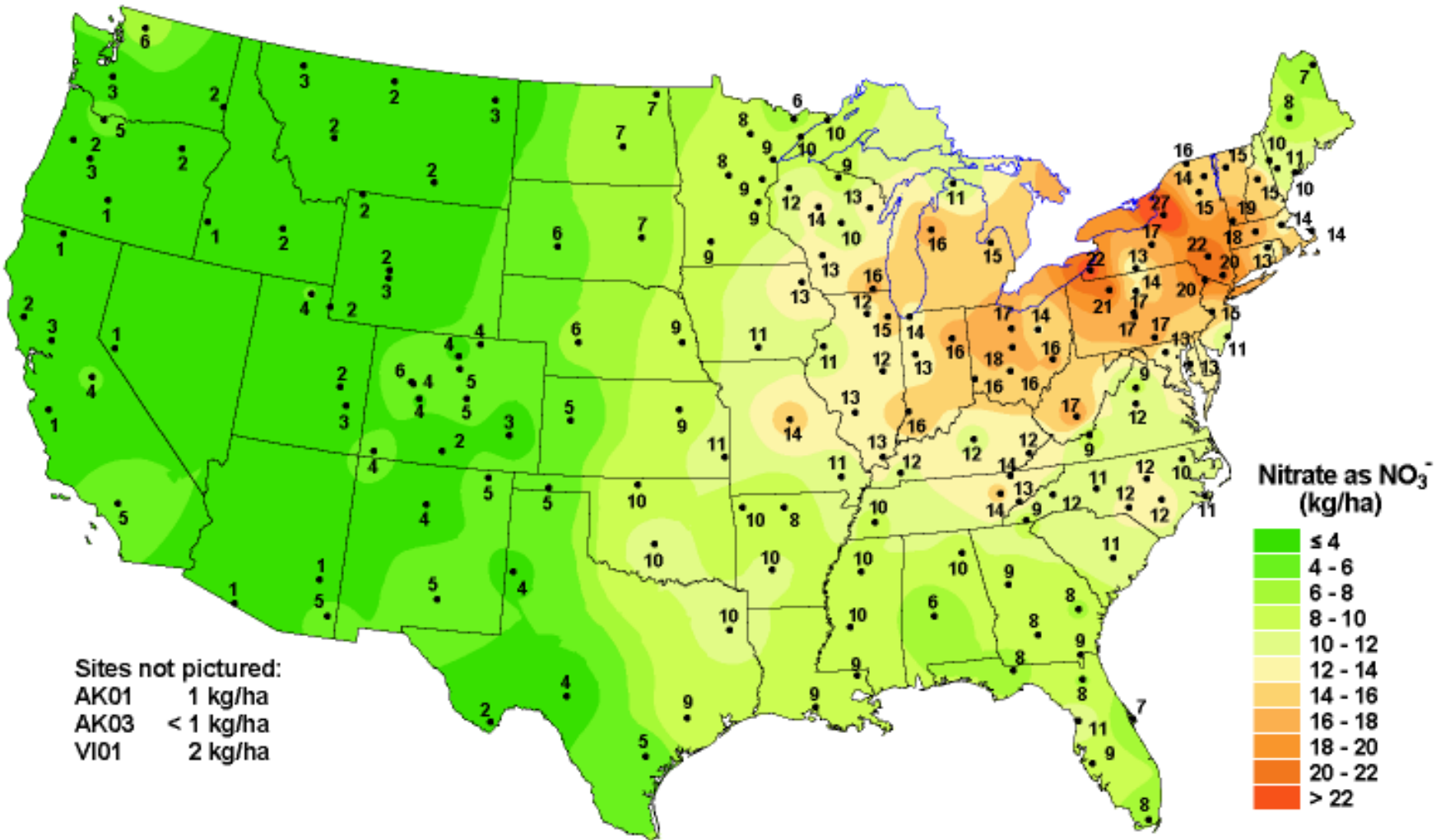
Effects of Air Pollution, Acid Rain and Excess Nitrogen

Ted Thomas, Roger Blew, Georgia Murray, Stephanie McAfee

Hoh River Valley


58 ha
Weir
West Twin
East Twin
N
Hoh River

Nitrate ion wet deposition, 2000



National Atmospheric Deposition Program/National Trends Network
http://nadp.sws.uiuc.edu

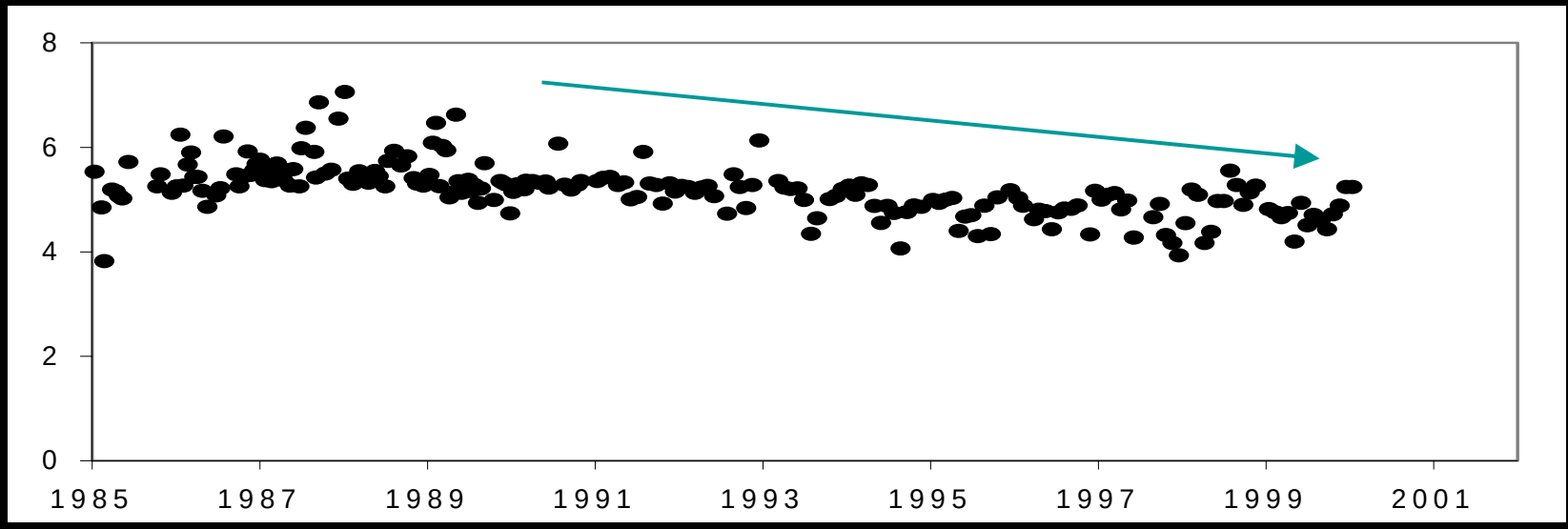
Bulk precipitation collectors

Hoh Ranger Station
NADP site

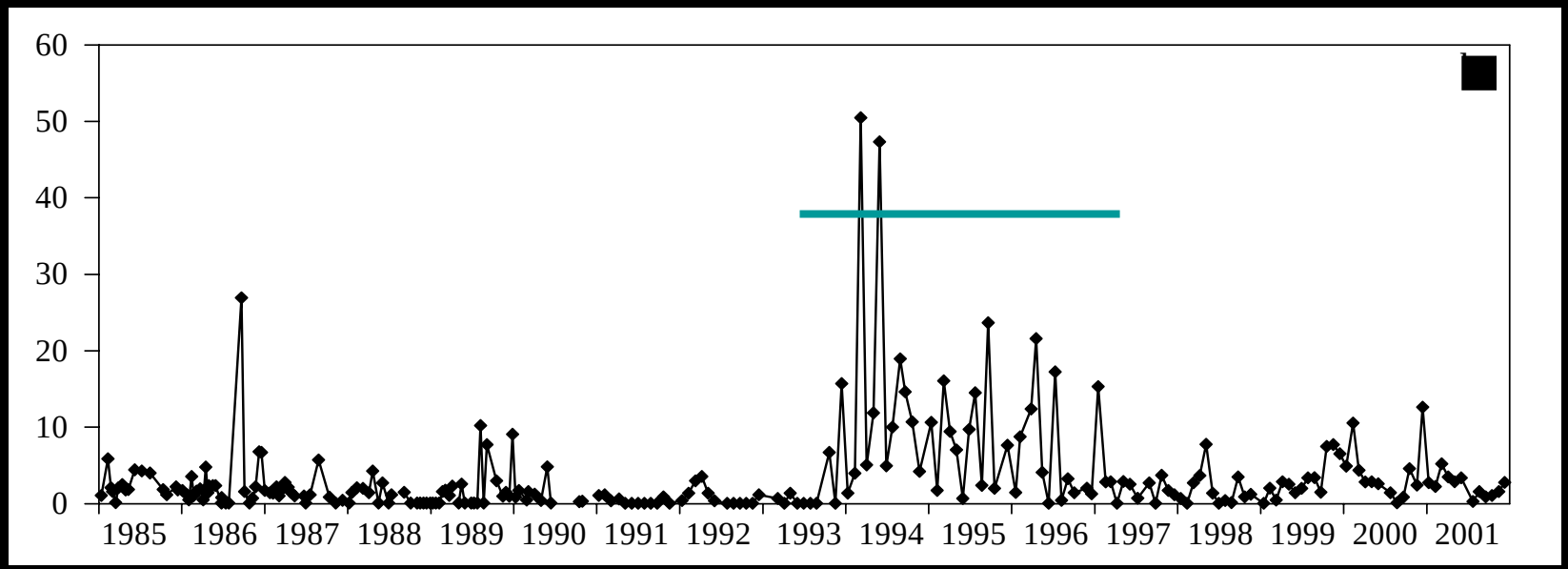
Wet-only precipitation collector

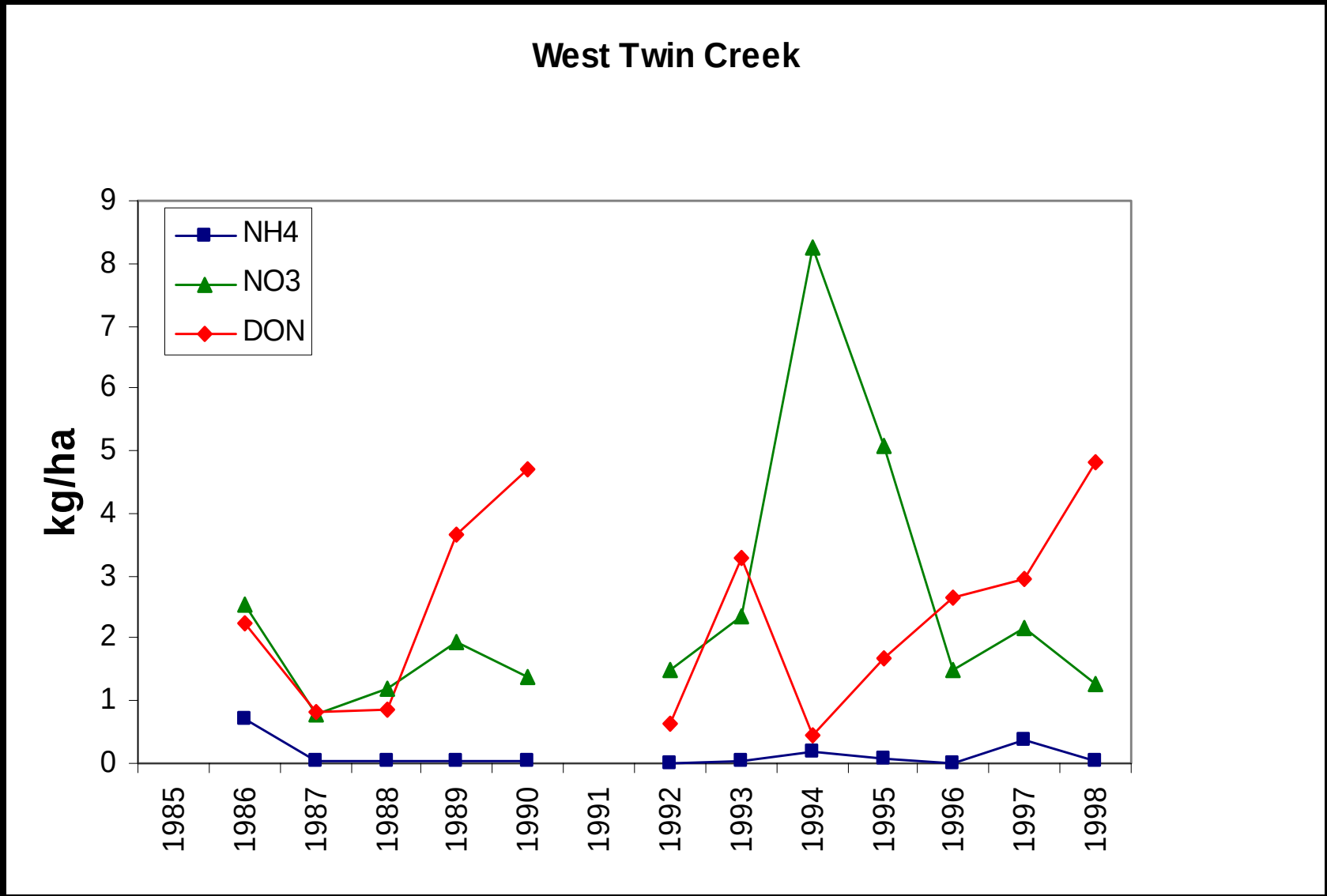
Bulk Precipitation

pH

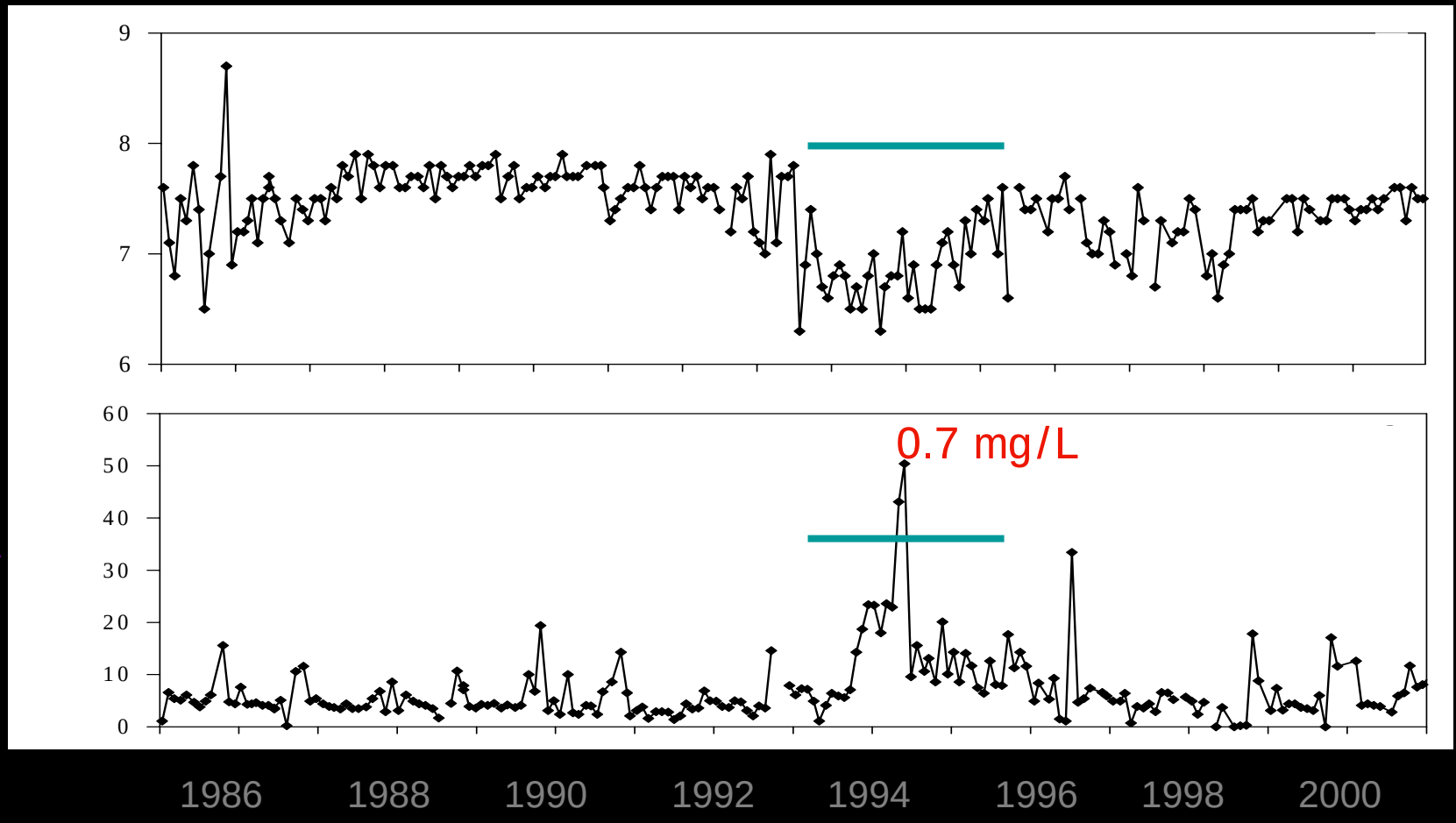


NO_3
$\mu eq\ L^{-1}$



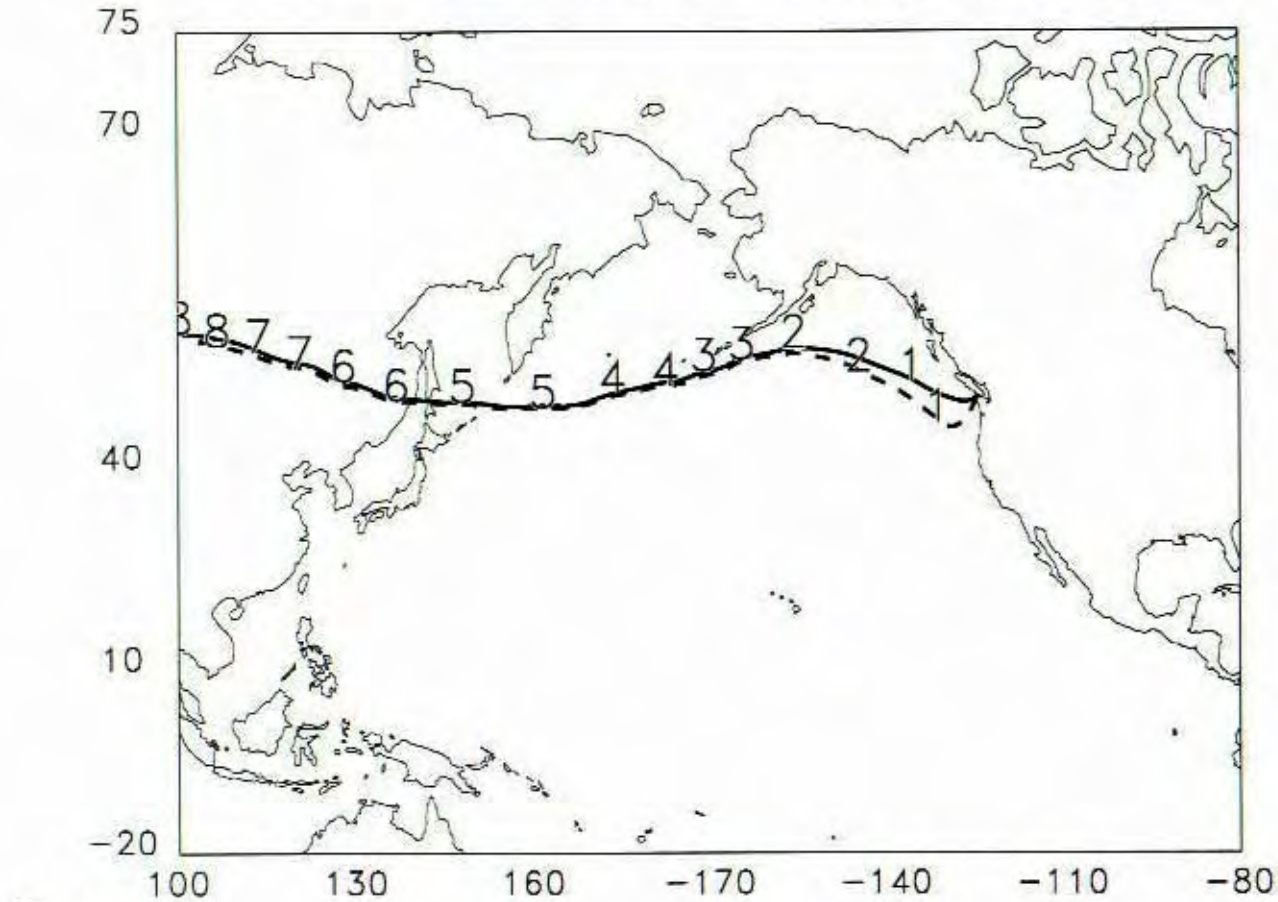

West Twin Creek
kg/ha
NH4
NO3
DON
0
1
2
3
4
5
6
7
8
9
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998

West Twin Creek water samples



POSSIBLE SOURCES/REASONS FOR INCREASED INPUTS IN 1993-95

1. Trans-Pacific -Asia/ Europe
2. Local
3. Seattle, Vancouver, Victoria
4. El ninos/ PDO
5. Oceanic sources

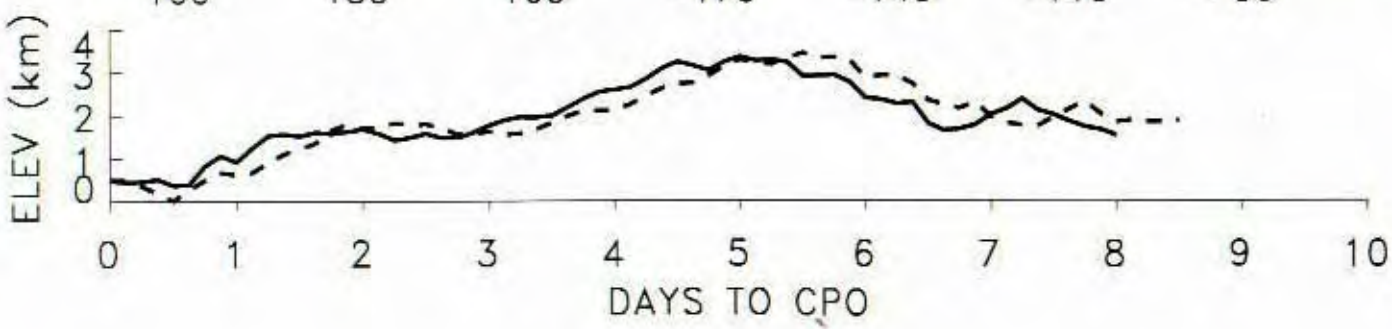


00UT

Day	km	hPa	C
0	0.5	968	3
1	0.9	914	−1
2	1.7	826	−9
3	1.8	817	−10
4	2.6	724	−19
5	3.4	638	−28
6	2.4	736	−17
7	2.0	782	−13
8	1.5	836	−8

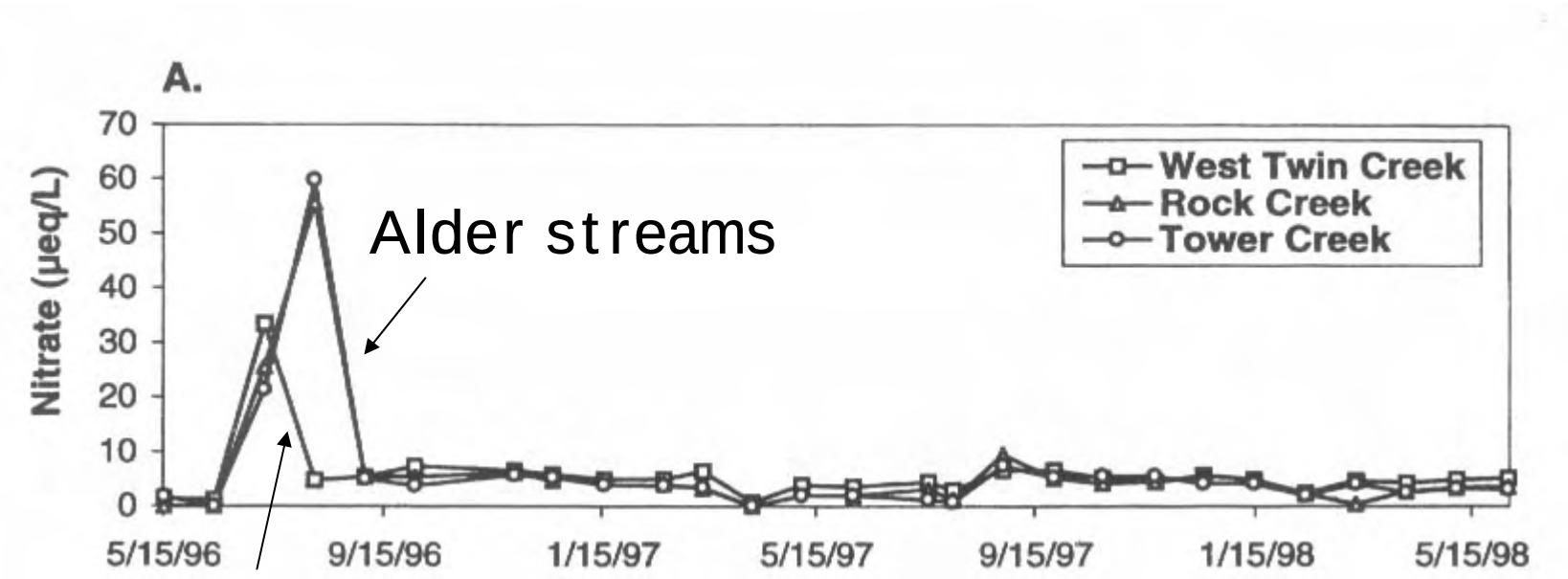
12UT

Day	km	hPa	C
0	0.5	928	0
1	0.6	954	3
2	1.7	828	−8
3	1.6	832	−8
4	2.1	779	−13
5	3.3	650	−26
6	2.9	689	−22
7	2.0	785	−12
8	1.9	804	−10



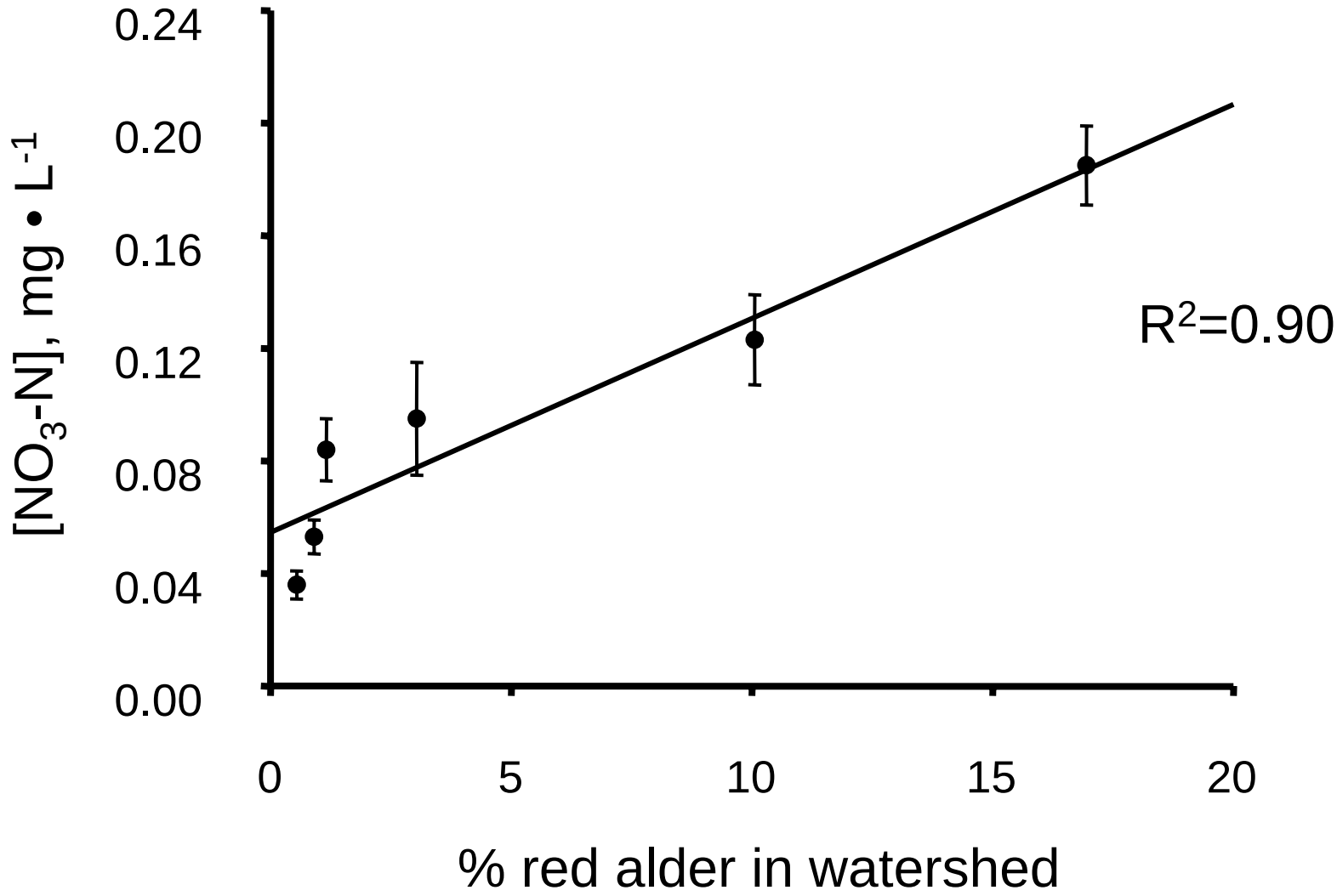
Study 2
Influence of red alder in riparian zones in the Hoh River Valley
Conifer vs alder - Carol Volk

Hoh River Valley



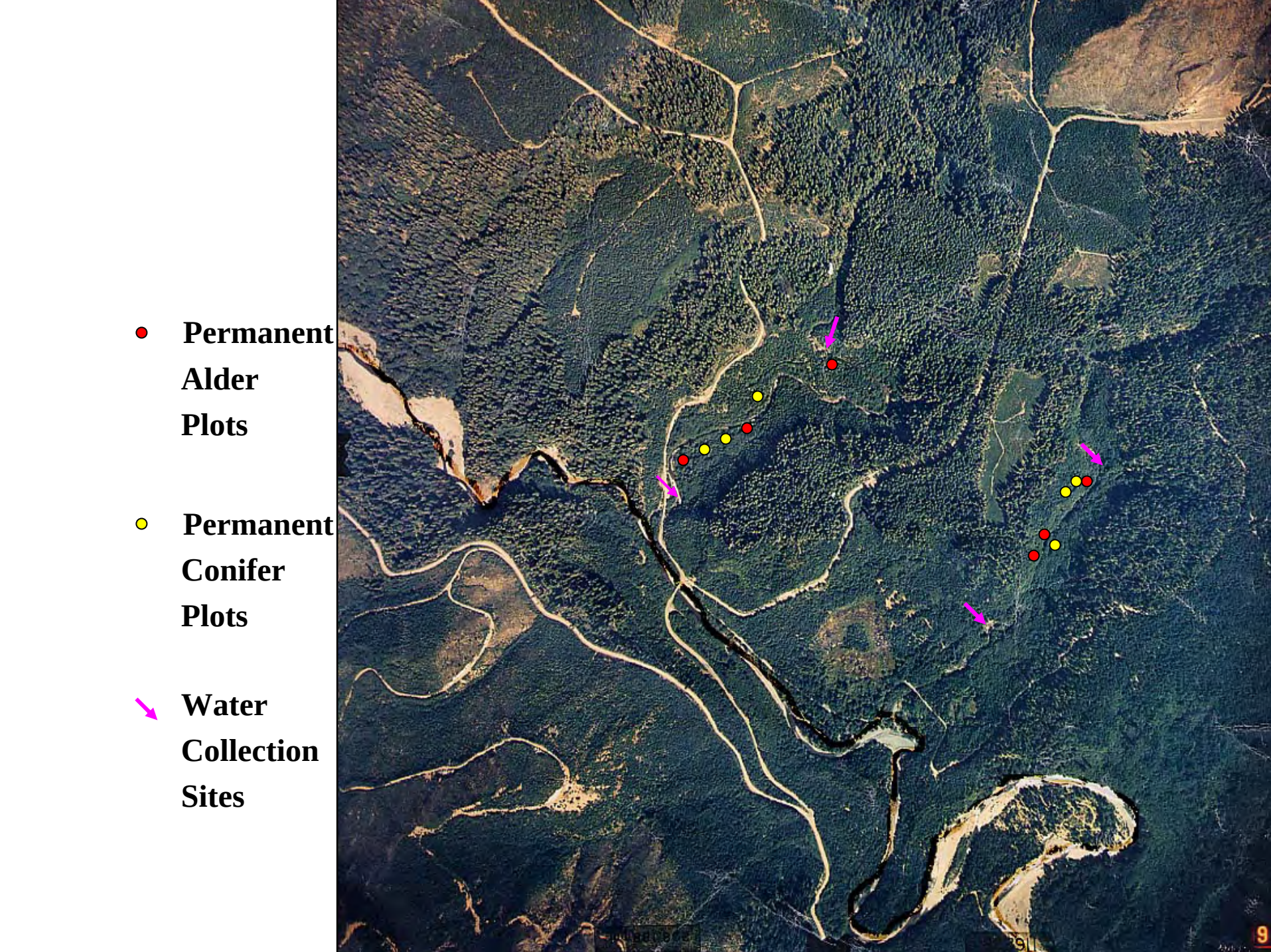
Conifer stream

NO_3-N in alder and conifer streams
Carol Volk

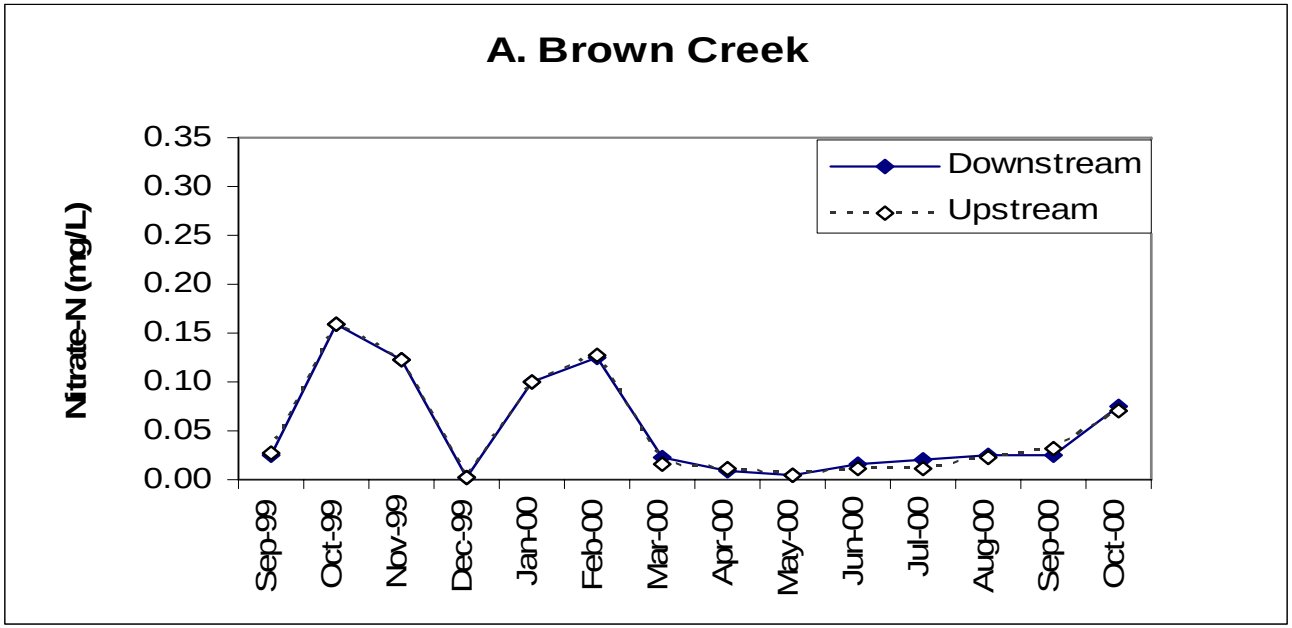


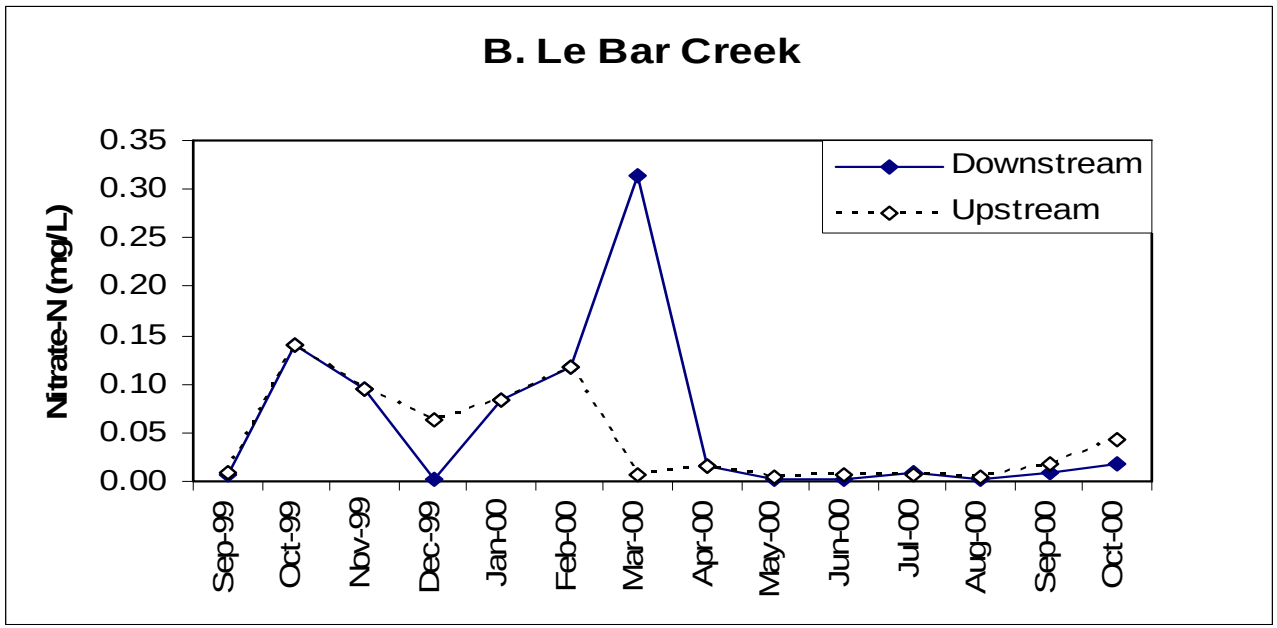
Study 3 -
Influence of salmon carcass placement in riparian areas (Brown and LeBar Creeks Skokomish River drainage)

Kerri Mikkelsen


Permanent Alder Plots
Permanent Conifer Plots
Water Collection Sites

Chum salmon from hatcheries – up to 60 kg N/ha added in riparian areas


A. Brown Creek
Nitrate-N (mg/L)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Downstream
Upstream
Sep-99
Oct-99
Nov-99
Dec-99
Jan-00
Feb-00
Mar-00
Apr-00
May-00
Jun-00
Jul-00
Aug-00
Sep-00
Oct-00

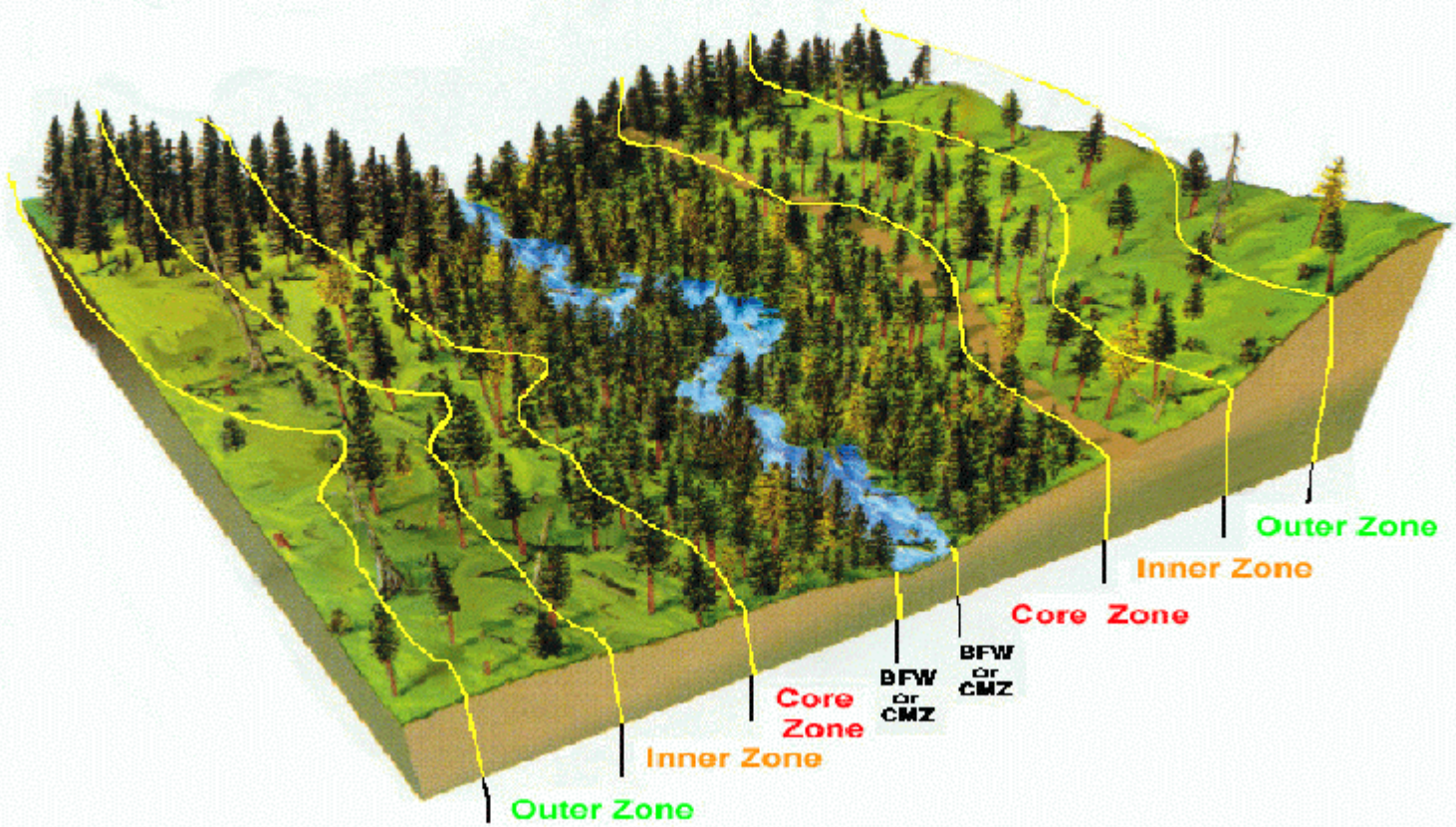

B. Le Bar Creek
Nitrate-N (mg/L)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Downstream
Upstream
Sep-99
Oct-99
Nov-99
Dec-99
Jan-00
Feb-00
Mar-00
Apr-00
May-00
Jun-00
Jul-00
Aug-00
Sep-00
Oct-00

Study 4 – Capitol Forest

Recovery from clearcut harvesting and effects of riparian buffers in harvested headwater streams

Garrett Liles, Dan Vogt, Jessie Taylor
Richard Bigley (DNR)

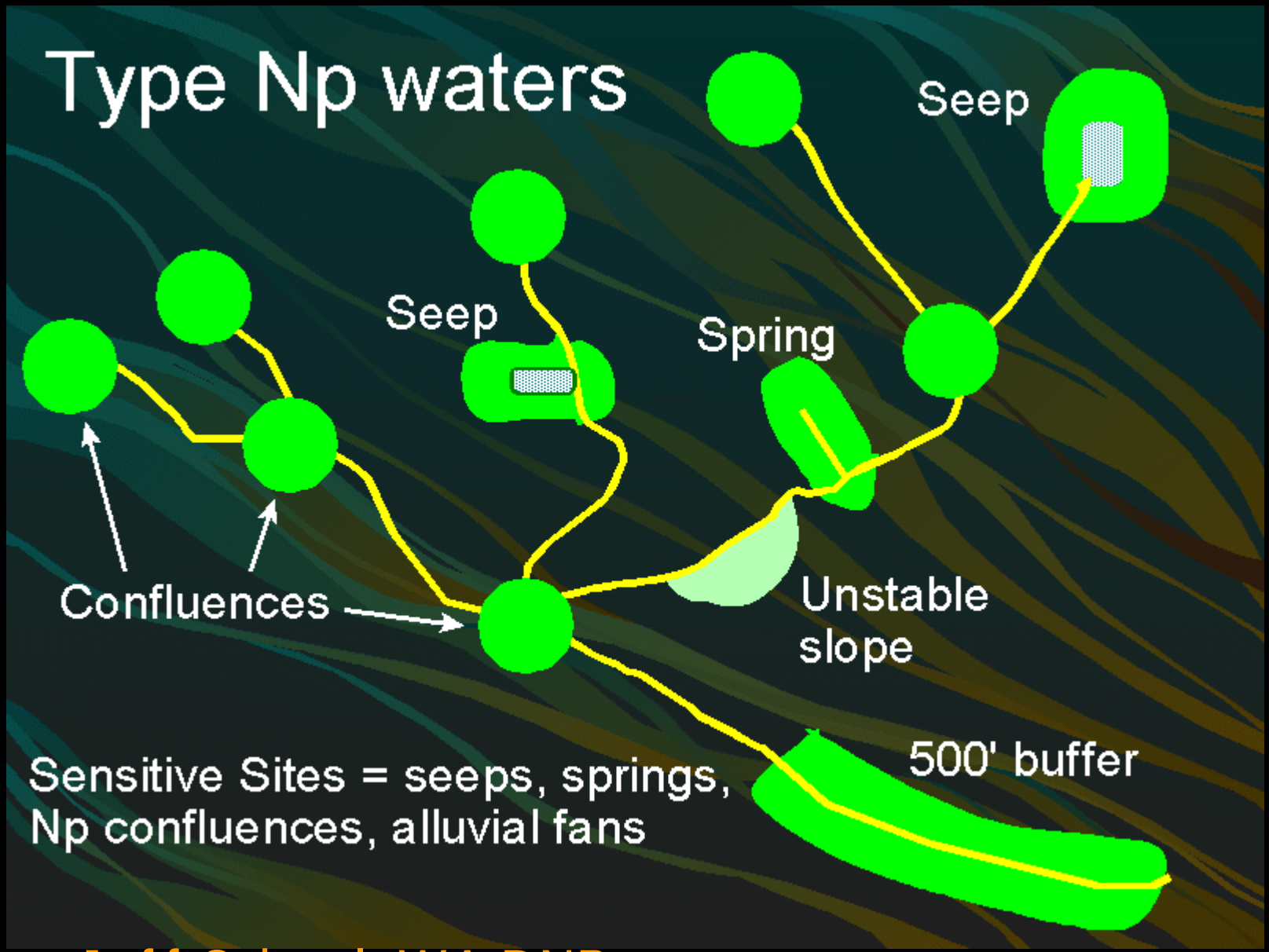
Graphic Representation of Riparian Zones



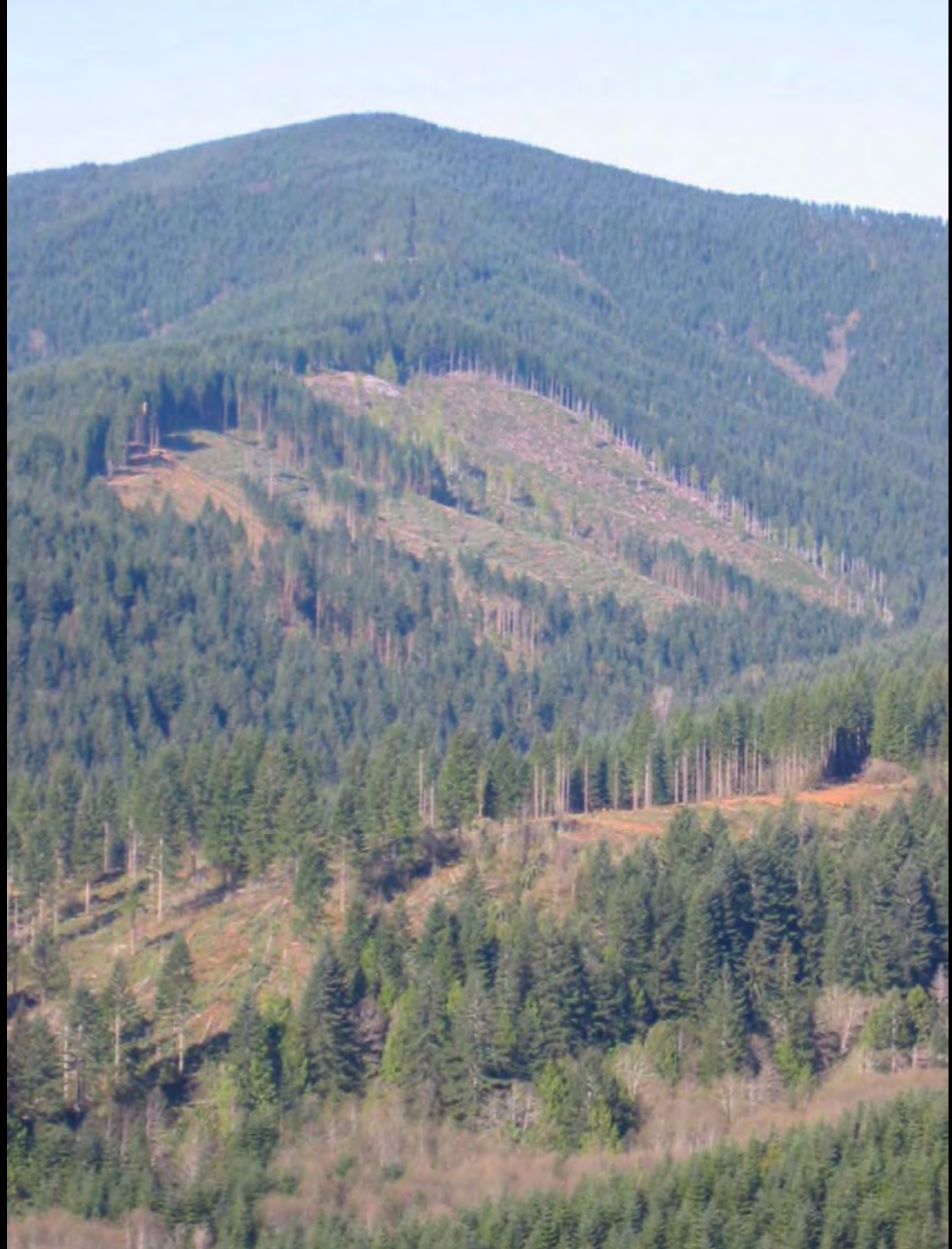
Jeff Grizzel, WA DNR

Washington Stream Classification and Buffer Regulation					
Type		Channel width (m)		Buffer	
				Yes/NO	Width (m)
S	1	> 23		Y	~ 20-50
F	2	< 23		Y	~ 20-50
F	3	> 1.5		Y	~ 20-50
NP	4	> 0.6		N	variable
NS	5	< 0.6		N	none

S-Shorelines of the State**, F**-Fish Habitat, **NP**-Non-Fish Perennial, **NS**-Non-Fish Seasonal



Jeff Grizzel, WA DNR



Considerable harvesting continues in lowland Douglas-fir forests in western Washington (0-3000 ft ASL) that contain headwater streams (types 4 – Np and 5 - Ns)

5-7 year Open Canopy Stands

15-18 Year Closed Canopy Stands

70-80 Year Maturing Stands

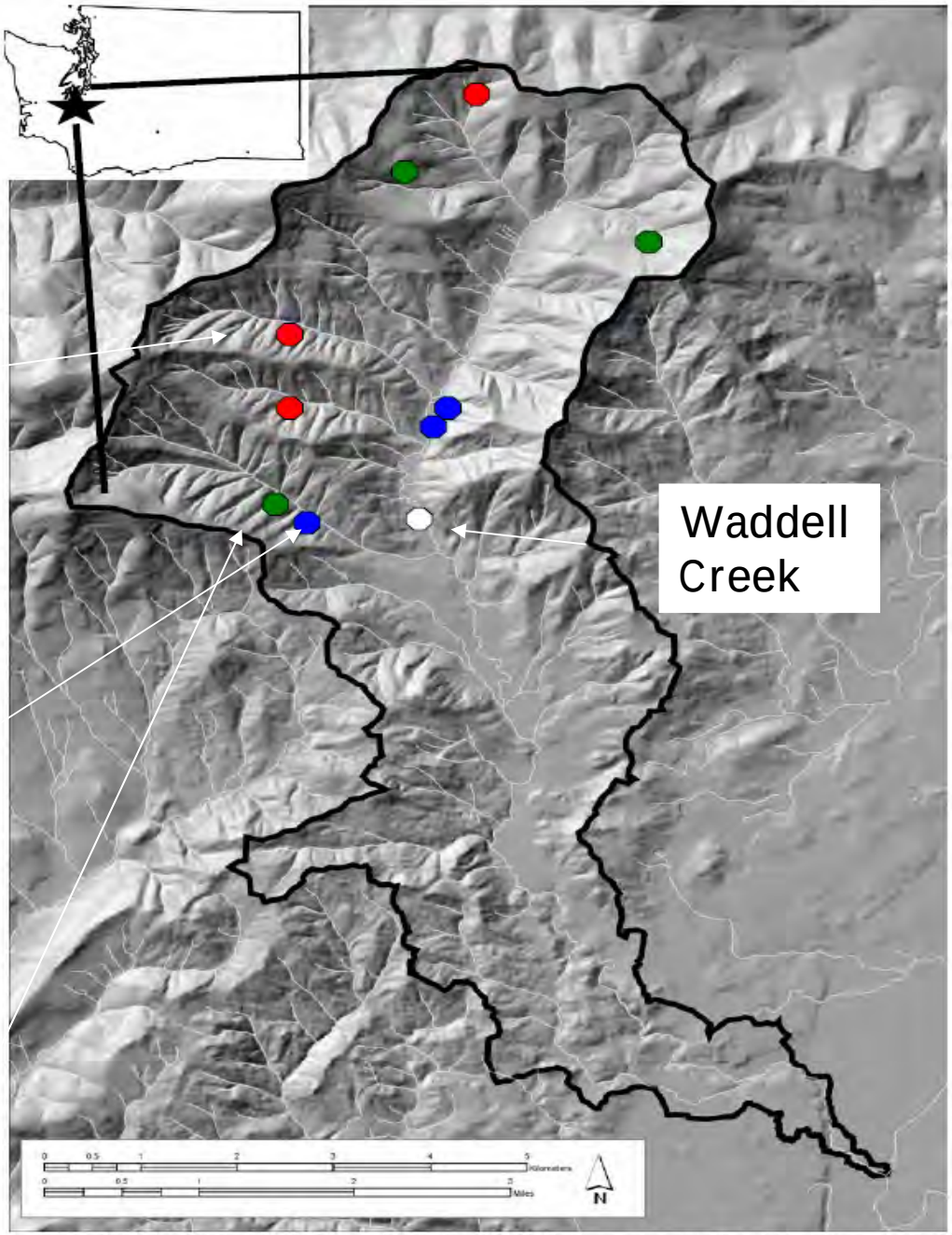
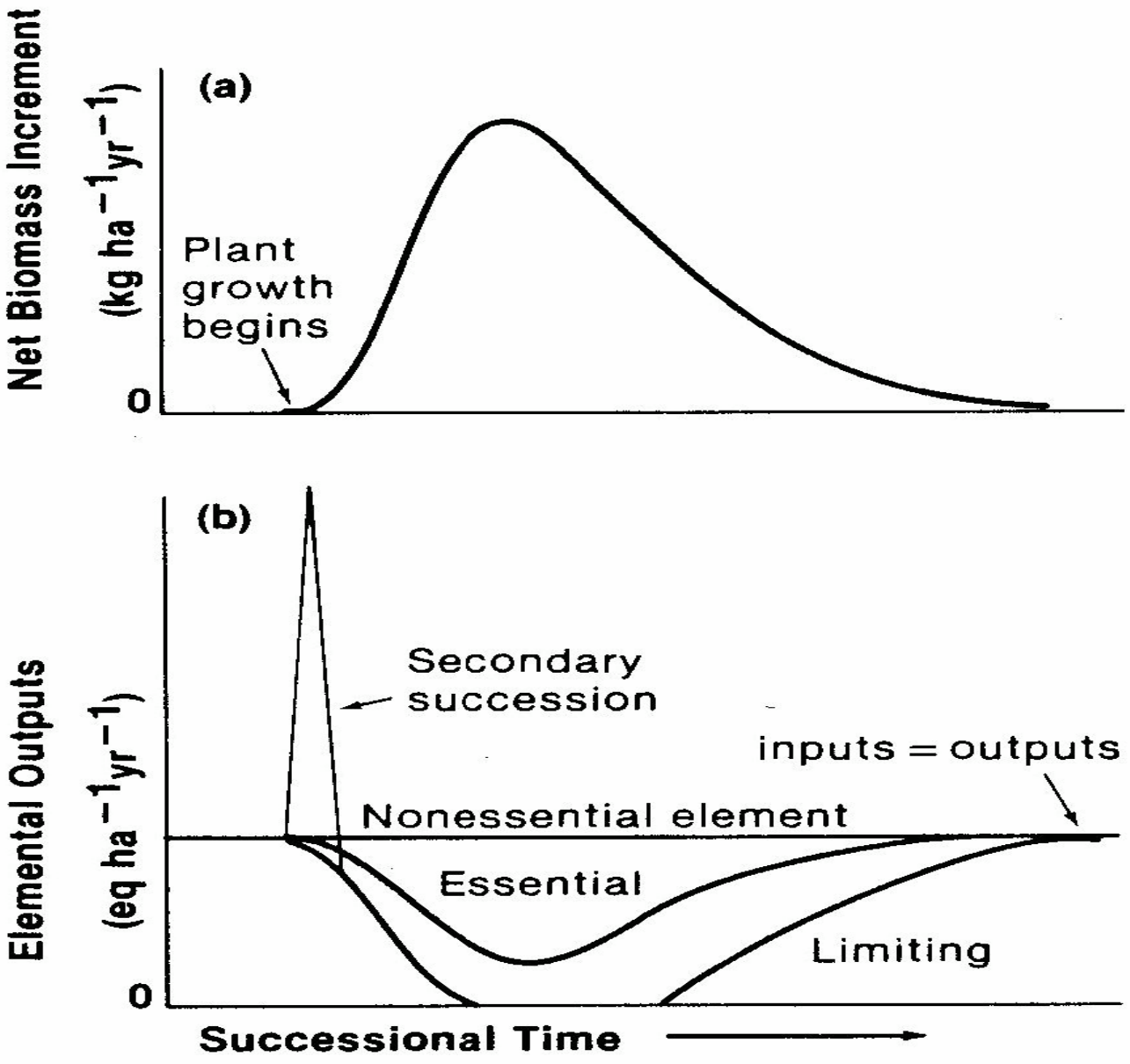
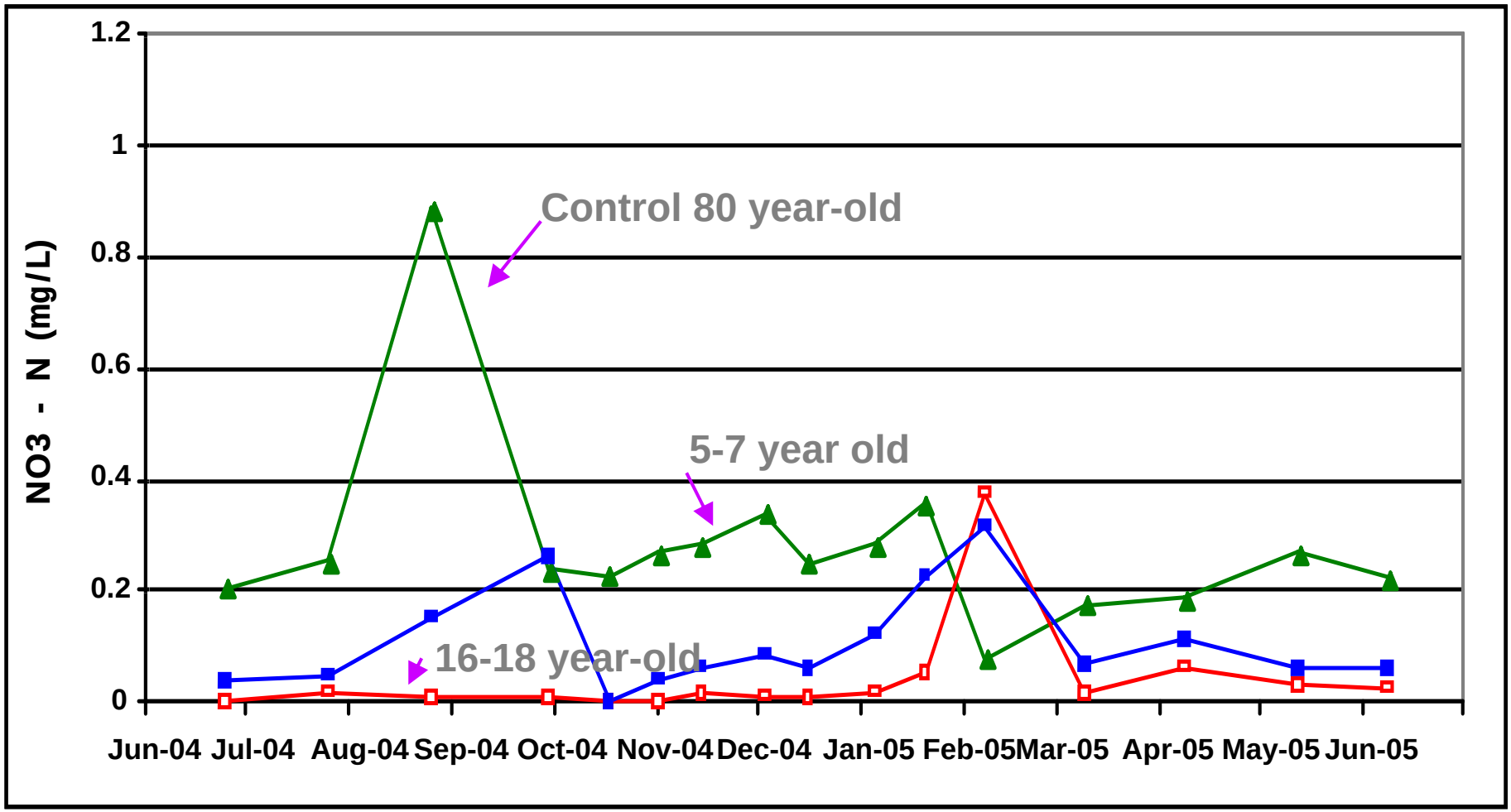


Figure 1 – Waddell Creek Watershed. Red – 5-7 year stream basins, Blue – 15-18 year stream basins, Green – Control Basins and White – Waddell Creek.

Small weirs placed on each steam with pressure transducers for measuring stage height and stream discharge

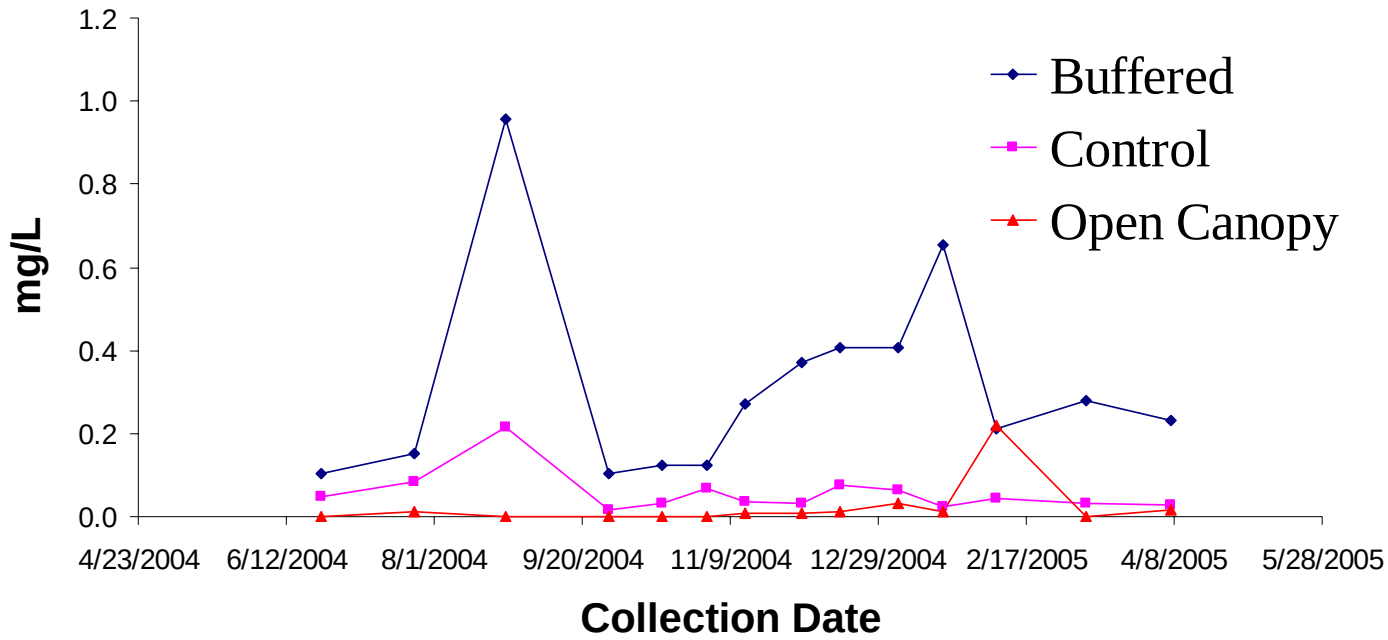
Nutrient Hypotheses (Vitousek and Reiners 1975)




1.2
1
0.8
0.6
0.4
0.2
0
NO3 - N (mg/L)
Control 80 year-old
5-7 year old
16-18 year-old
Jun-04
Jul-04
Aug-04
Sep-04
Oct-04
Nov-04
Dec-04
Jan-05
Feb-05
Mar-05
Apr-05
May-05
Jun-05

Stream monitoring is now being conducted in recently harvested watersheds and streams with riparian buffers.

Stream Nitrate-N Concentrations



Conclusions

Nitrate terribly important

Support

Funding

- USFS- Forestry Sciences Lab Olympia
- Washington State DNR
- Olympic Natural Resource Center
- The UW Water Center
- UW PRISM
- USGS
- National Park Service