

# STATE OF THE SOUND 2007

## WATER QUALITY

### TOXIC CONTAMINATION

Toxics in sediments



Toxics in chinook and coho salmon



Toxics in mussels



Toxics in harbor seal



Liver disease in English sole



Oil spills



### STORMWATER RUNOFF

Impervious surface changes



Local stormwater management programs



### POLLUTION FROM HUMAN AND ANIMAL WASTE

Safe swimming beaches



Safe, edible shellfish



## CLIMATE

Temperature



Sea level rise



Stream flow

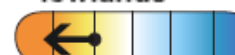


Snow pack

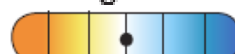


## HABITAT

Forest loss in Puget Sound lowlands



Eelgrass

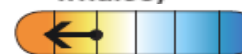


Aquatic nuisance species



## SPECIES

Orca (killer whales)



Salmon



Groundfish



Herring



Pinto abalone



Marine birds



## **Work to develop the Action Agenda will focus on these key issues:**

### **What is a healthy Puget Sound?**

The first step is to define a healthy Puget Sound. The legislation that created the Partnership established a list of goals that, although broad, form our working definition of a healthy Sound. Other goals can be added as our work proceeds.

### **What is the current status of Puget Sound's health and what are the biggest threats to it?**

Before the Partnership can successfully determine how to achieve a healthy Puget Sound, we need to fully understand its current baseline condition - status and threats. This work is necessary so that we can tell if we are making progress.

### **What actions must be taken that will move us from where we are today to a healthy Puget Sound by 2020?**

Building on the research data acquired early in this process, this step will help us understand what we need to do to achieve a healthy Sound. These actions will form the foundation of the Action Agenda.

### **Where should we start?**

Prioritizing actions is critical to achieving our goal of a healthy Sound. This list of priorities will form the Action Agenda and become the roadmap for restoring Puget Sound.

# *The Virtual Puget Sound: a Process to Evaluate Alternative Futures for Puget Sound*

Jeffrey Richey  
School of Oceanography

- \* Quick overview of PRISM
- \* What is involved in a “Virtual Scaleable Basin
- \* Example applications (terrestrial side)
- \* Next steps and opportunities





# PRISM

PUGET SOUND  
REGIONAL SYNTHESIS MODEL

- [Home](#)
- [About Us](#)
- [Education](#)
- [Service](#)
- [Research](#)
- [Resources](#)

## Hypoxia in Hood Canal

The increasing presence, persistence, and distribution of low dissolved oxygen concentrations in Hood Canal during the 1990's and the repetitive fish kills during 2002, 2003, and 2004 indicate that hypoxia (low oxygen conditions) may be increasing in Hood Canal.



Featured Story  
more.....

### Media

#### Related Stories



Evaluation of Habitat Protection

[view >](#)



Aquatic Biogeochemical Cycling

[view >](#)



PRISM Puget Sound cruise time-series

[view >](#)

[see all](#)

### Links



#### About Us

How do we describe Puget Sound's climate, and what changes are predicted for the future?



#### Education

How are the Sound's communities and economies as diverse as its natural environment?



#### Service

What tectonic, climate and other natural disturbances have shaped the form and function of Puget Sound, and what do we face in the future?



#### Research

How does the complex array of ecosystems and habitats affect the goods and services we derive from Puget Sound?



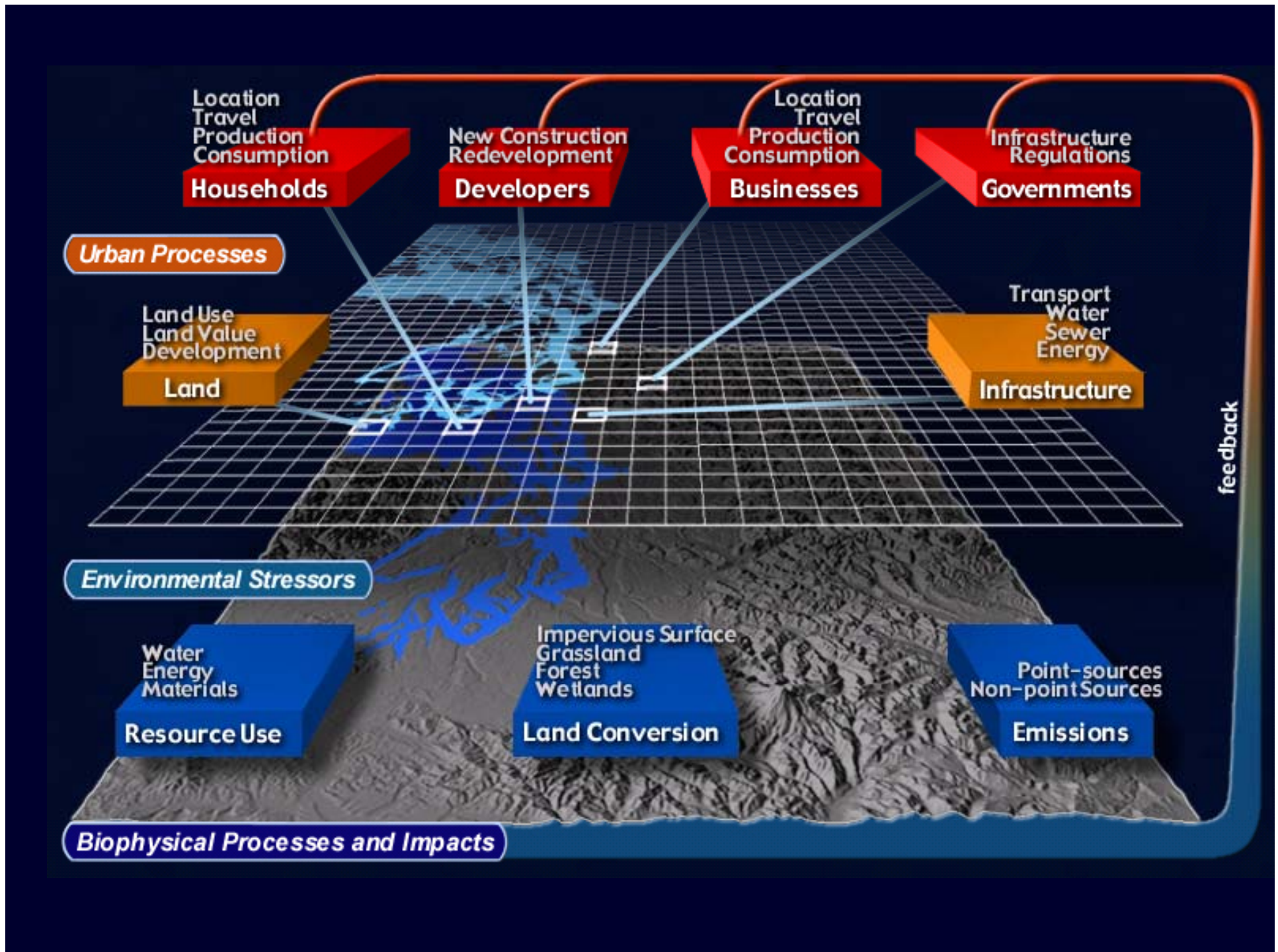
#### Resources




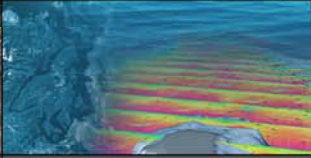
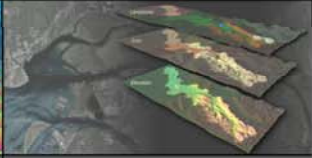




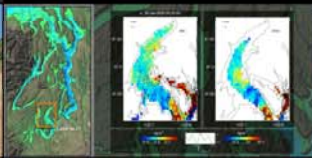
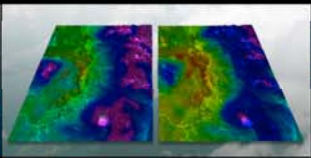





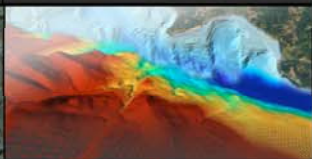
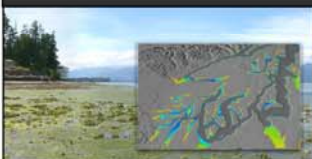

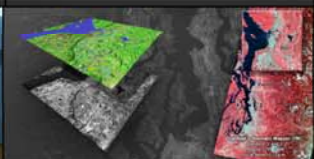







See how water drives everything, from the health of our communities and environment to the circulation of Puget Sound.



#### PRISM Success Stories

What do the past trends in the environment and society suggest about the region's future?



					
PRISM Cruises	Dissolved Oxygen in Hood Canal	Habitat Protection	The Integration of Research and Education	Marine Circulation Model	Distributed Hydrological Model
	 <p>UNIVERSITY OF WASHINGTON  <b>Puget Sound Regional Synthesis Model</b>  <a href="http://www.prism.washington.edu">www.prism.washington.edu</a></p>				
Stormwater Runoff					Nutrient Loading
					
Regional Issues	Estuary Dynamics	Water Supply and Demand	Climate and Weather	Puget Sound Beaches	Atmospheric Circulation Model
					
Remote Monitoring of Water Quality	Watersheds to Sea	Biotic Resources	Information Services	Virtual Scalable Basin	Physical Template
					
Nearshore Restoration	Aquatic Biogeochemical Cycling Model	Landcover Classification	Finding Sea Level	Nearshore Environment	Urban Growth
					
Salmon Model	Toxic Loading	Water Usage Model	Salmon Recovery	Puget Sound Digital Representation	Land Surface Dynamics

***“Virtual Scaleable Basin (VSB)”***

**A metaphor and a practical engine, for organizing and processing the information and decision needs for the Basin. The intent is, essentially, to create an “information laboratory and forum, without walls, capable of flying in time and space, reaching the citizens of the Puget Sound.”**

**Not just Puget Sound, but as an “Earth System Module”**

## Establishing such a process is not a trivial task:

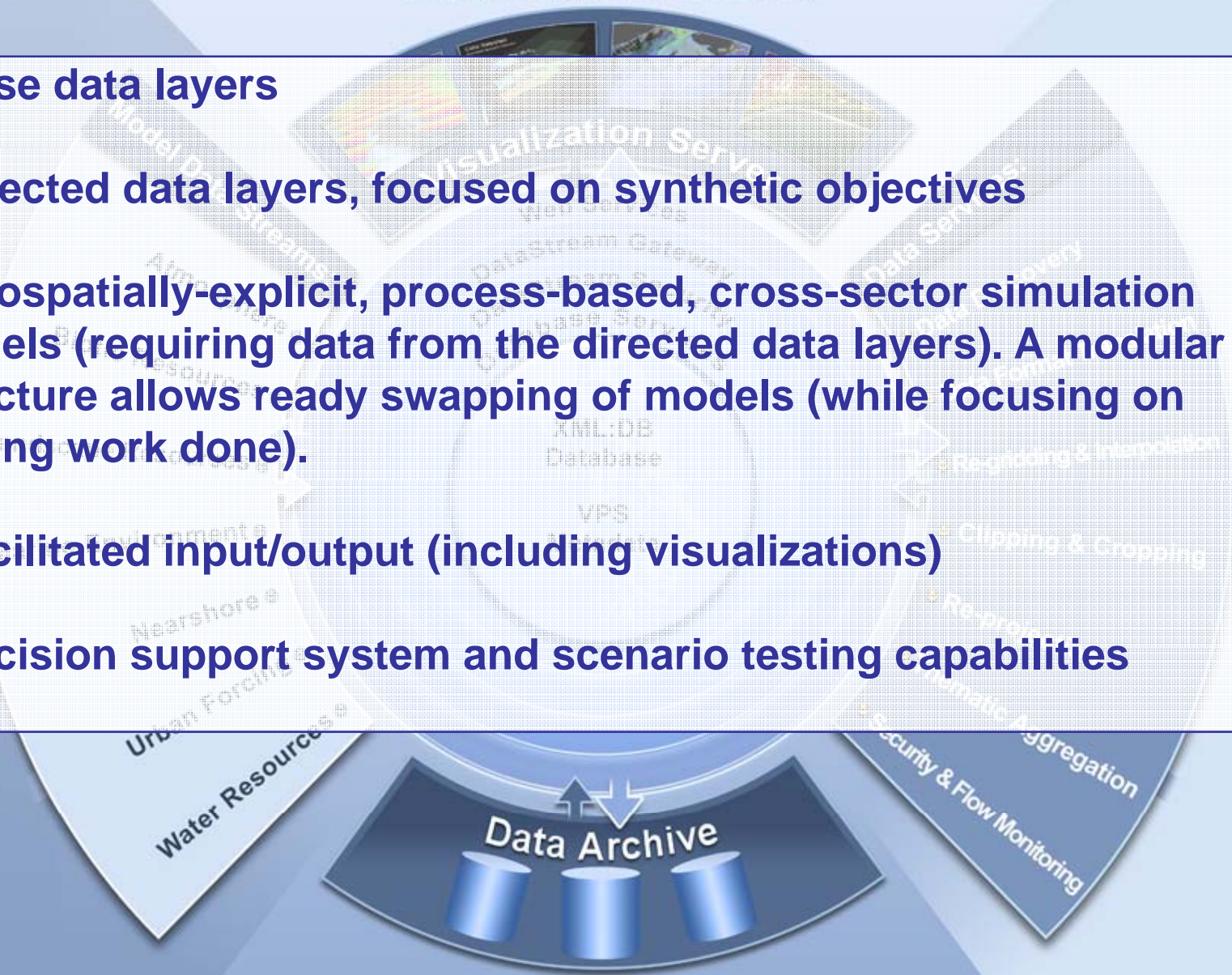
- The information required comes from multiple sources, .... multiple disciplines, which presents problems with even communication between specialists. .. New field measurements, especially holistic and cross-boundaries, are challenging.
- Dynamic simulation models recognize “non-stationarity” and nominally represent processes. But are plagued by generations of graduate students, legacy code, and overall complexity.
- Handling such diverse data and executing models is not straight-forward. There are very real problems in converting data streams into useful information that go beyond a database.
- Perhaps most challenging is how to not only create such information, but how to get it into the hands of users of different levels, from the specialist to the local and regional decision makers to the local farmer or Tim Eyman.

# Virtual Puget Sound: Cyber-infrastructure

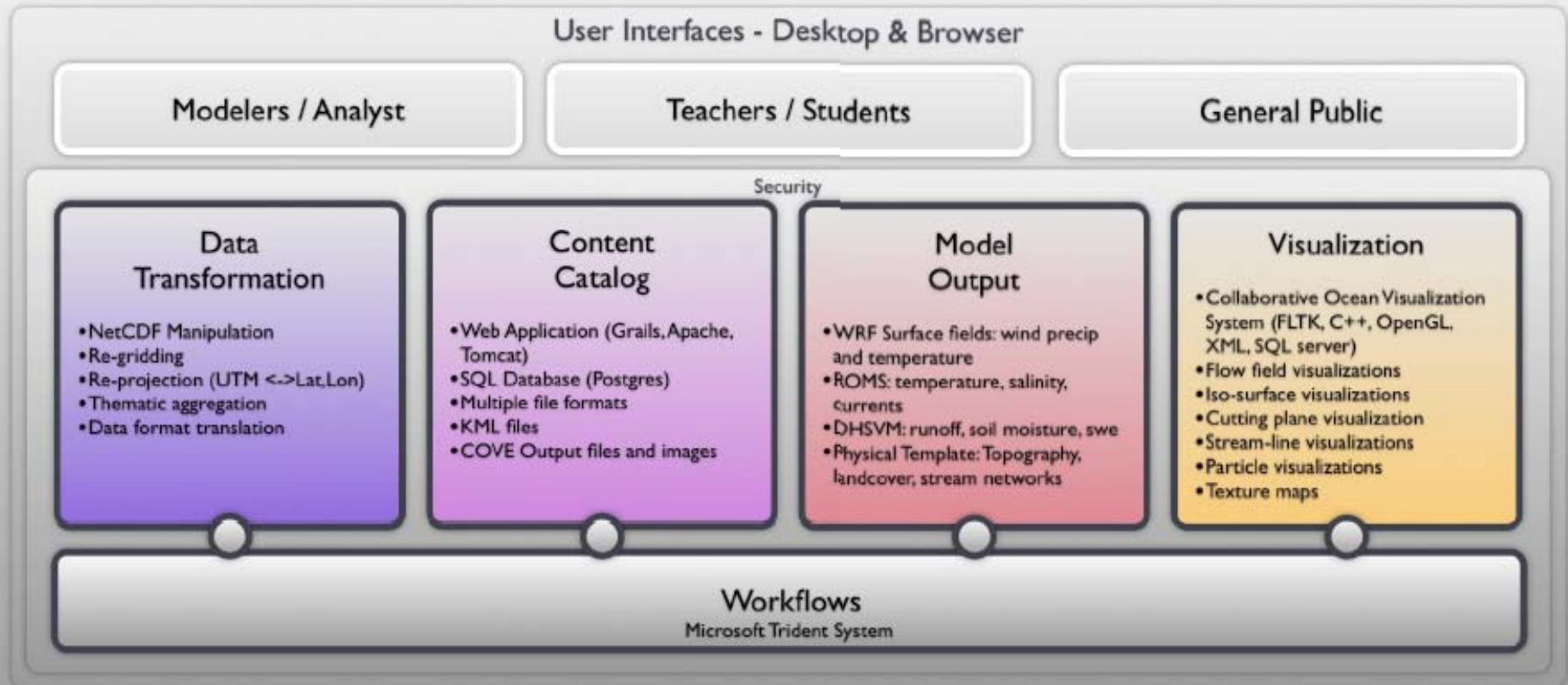
Analysis for the Multi-Scaled Biophysics and Human Dimensions in a Collaborative Land/Atmosphere/Marine System

M. Logsdon, J. Richey, B. Campbell, M. Stoermer, H. Hadaway  
University of Washington, School of Oceanography

- **Base data layers**
- **Directed data layers, focused on synthetic objectives**
- **Geospatially-explicit, process-based, cross-sector simulation models (requiring data from the directed data layers). A modular structure allows ready swapping of models (while focusing on getting work done).**
- **Facilitated input/output (including visualizations)**
- **Decision support system and scenario testing capabilities**



# PRISM Visualization Pipeline Prototype

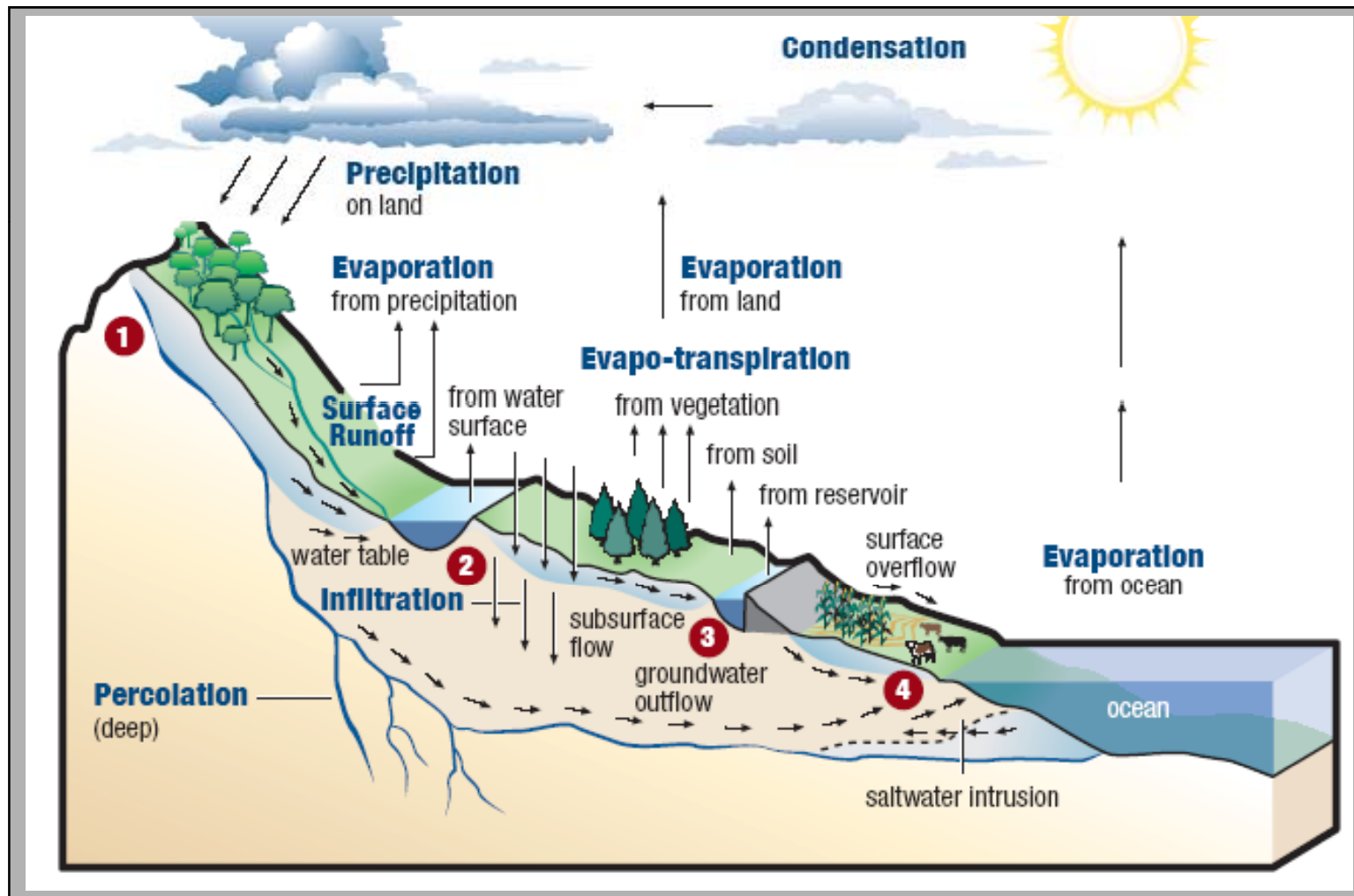


***A system that can provide visualizations in an automated fashion to a researcher's desktop and to an educational user's browser. Proposed is a system that would take PRISM model output and create 3D visualizations of the critical outputs. COVE is 3D Visualization software for geo-referenced data, with many of the features of Google Earth, however, it has been designed to work with scientific data-sets including netCDF model output***

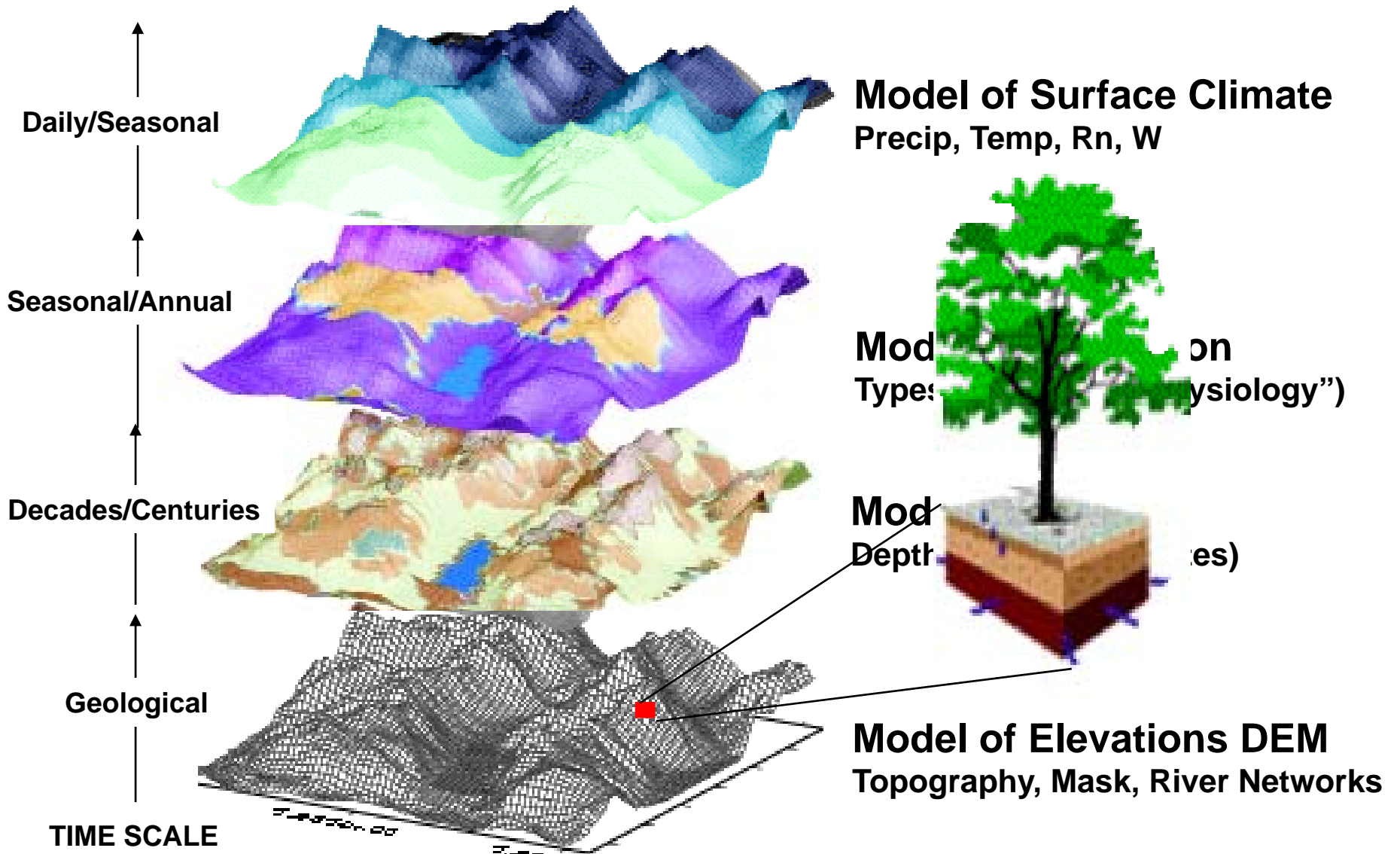
# Climate-Land Surface-Water:

## The Hydrologic Cycle as Defining Framework

$$Q \text{ (runoff)} = P \text{ (precipitation)} - ET \text{ (evapotranspiration)} + \Delta SM \text{ (soil moisture)}$$



**Express as a geospatially-explicit/process based (set of) models (noting that the devil is in the details....)**

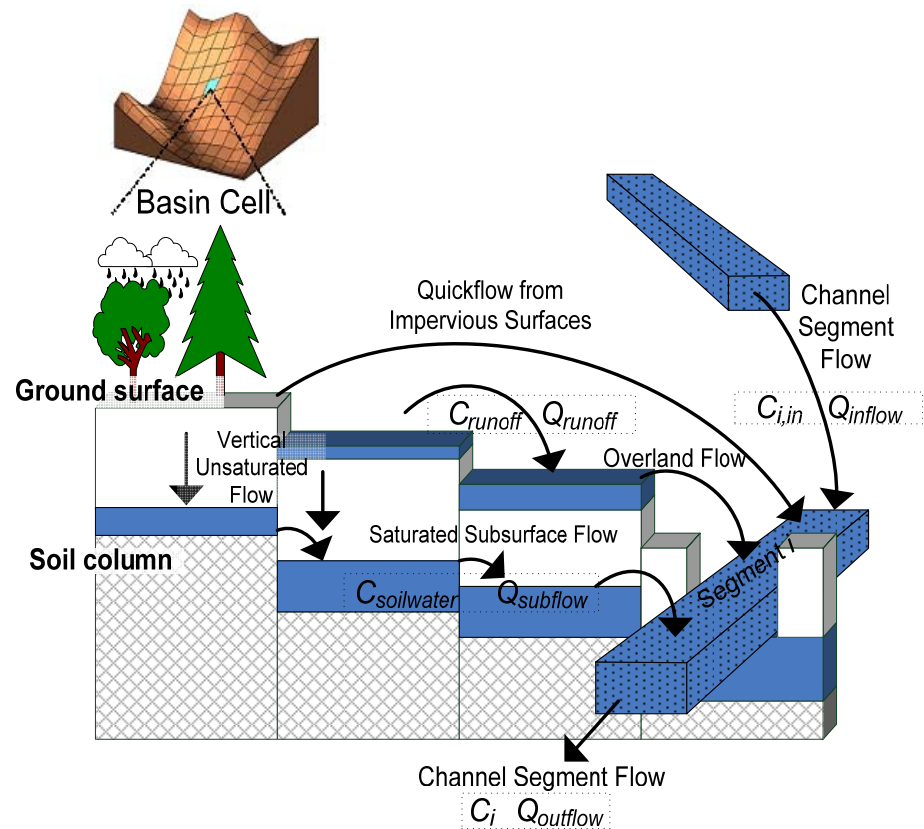


# Climate – Landsurface – Water Cycle: DHSVM/D-SEM/D3.0

Climate and landscape structure

- Interception
- Evapotranspiration
- Snow accumulation and melt
- Energy and radiation balance
- Saturation excess and infiltration excess runoff
- Unsaturated soil water movement
- Ground water recharge and discharge
- Impervious surface flow

Water and “stuff” movement

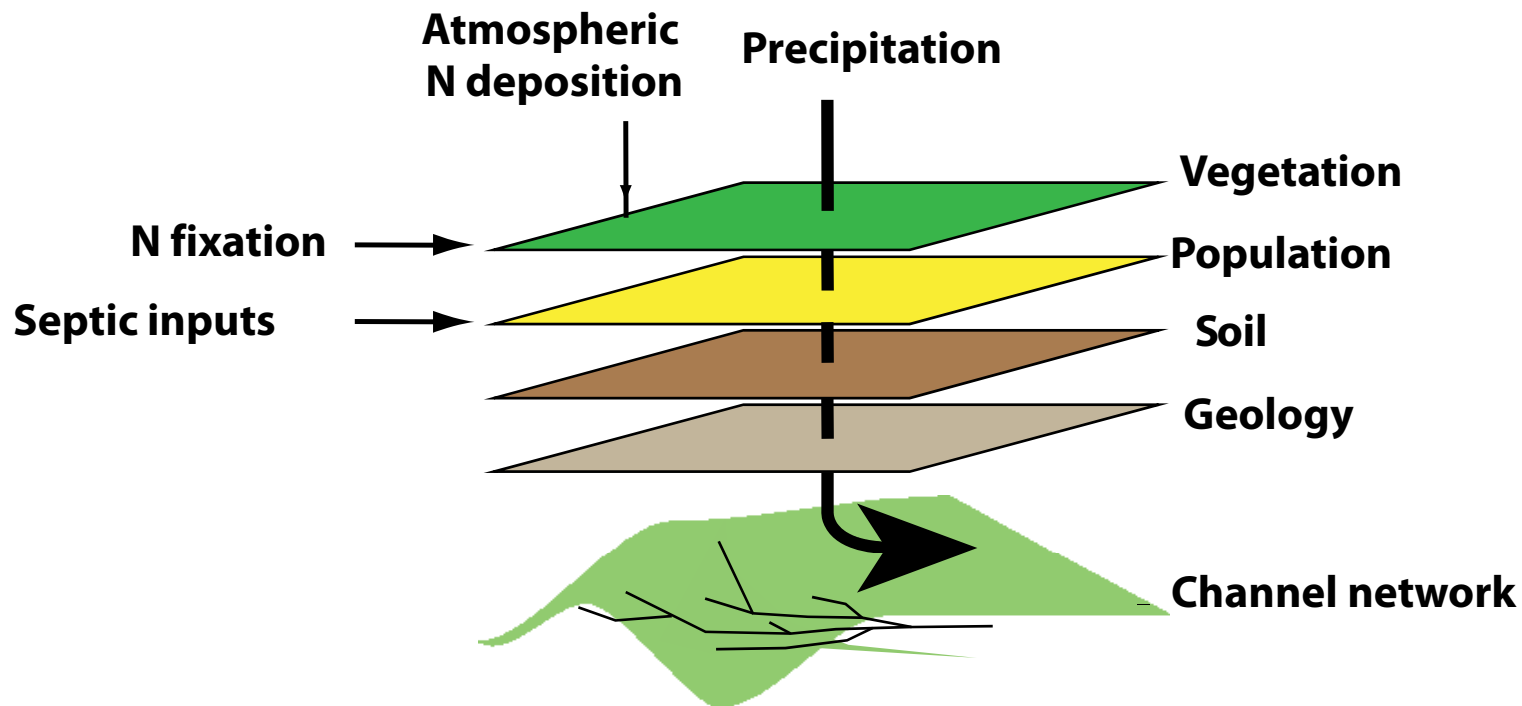




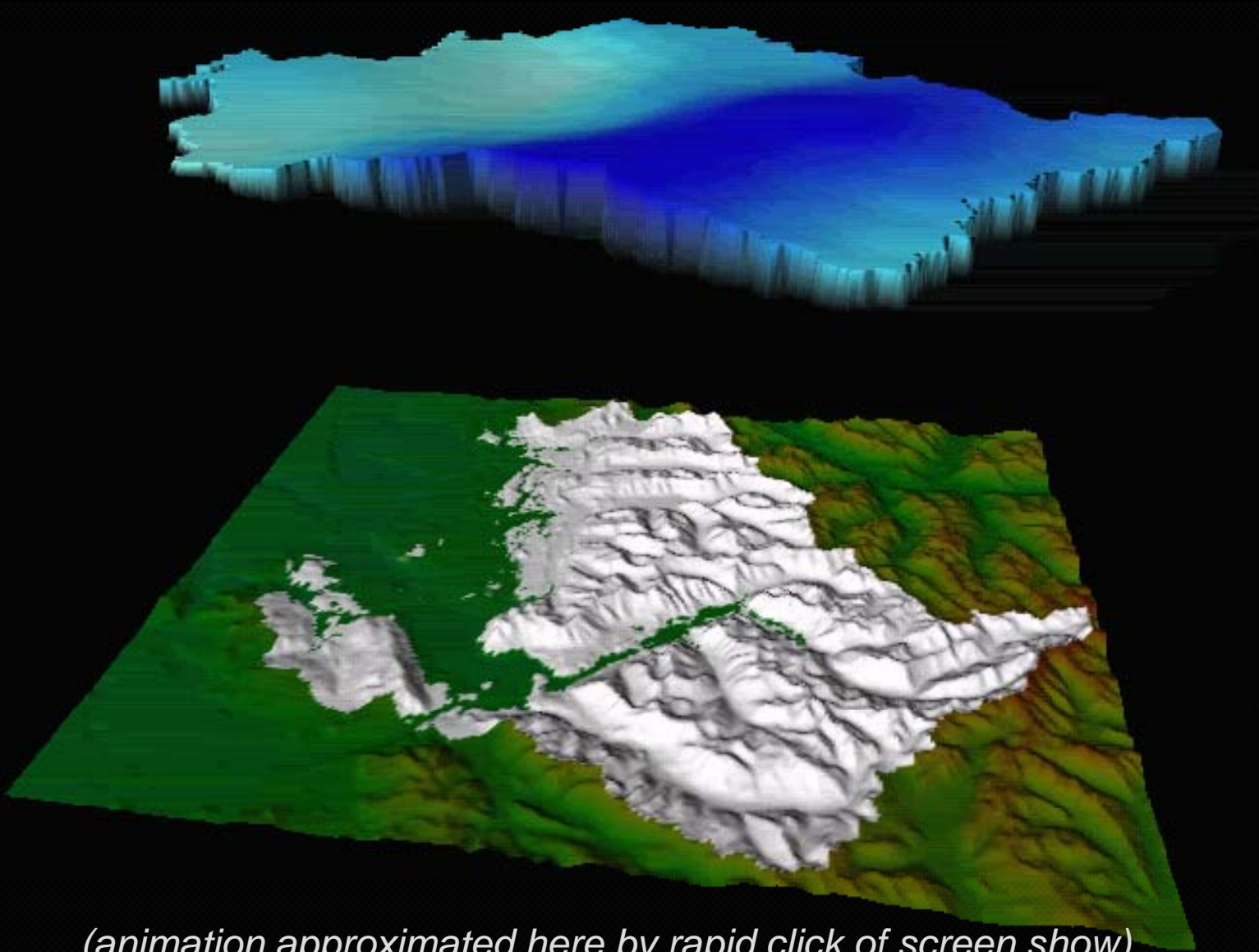
# **“MECHANISTIC” WATERSHED MODEL: DHSVM Solute Export Model (D-SEM)**

*Interpolation, process ID, future scenarios*

*Takes N inputs from deposition, red alder N fixation, and septics and routes it through soil, ground water and surface water, with removal from denitrification, adsorption, and biotic assimilation.*



e.g. for a 3-day snow event



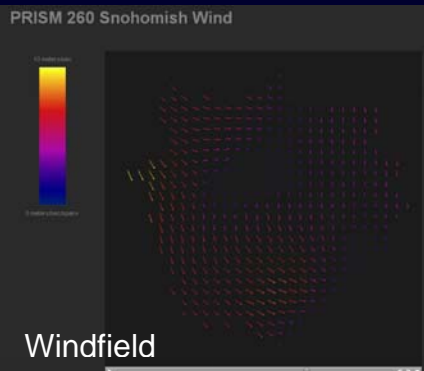
*(animation approximated here by rapid click of screen show)*

# Snohomish River Basin

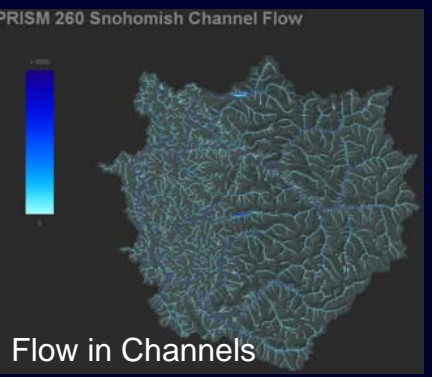
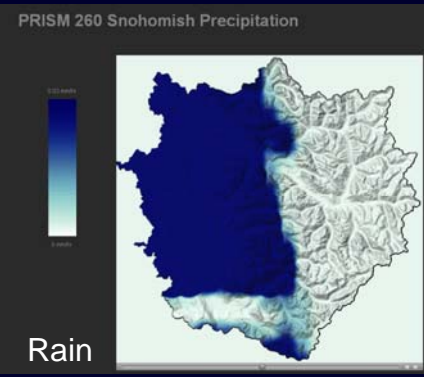
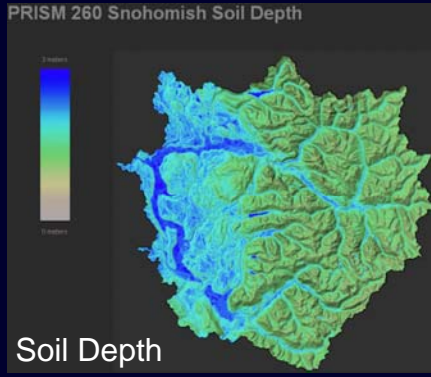
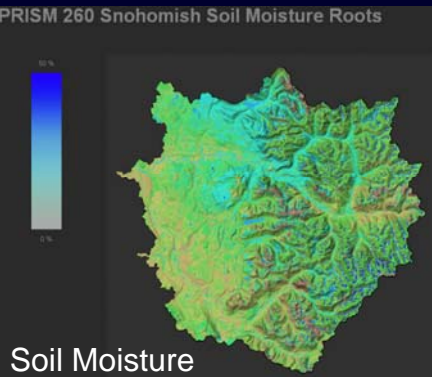
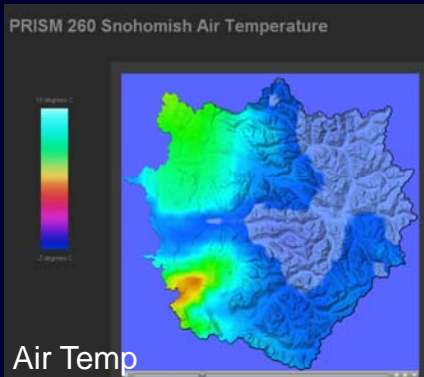
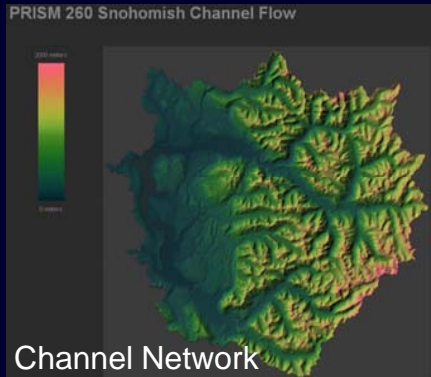
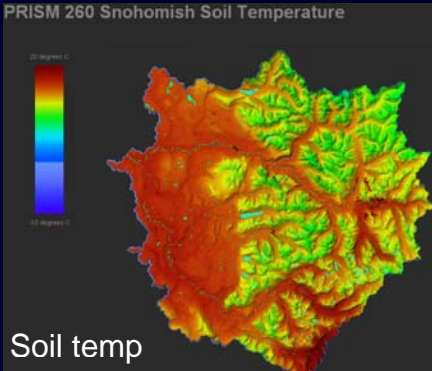
## “Template”



## Climate Forcing



## Output Fields



# Streamflow change due to land cover and climate change

Lan Cuo et al. (PRISM, CIG)

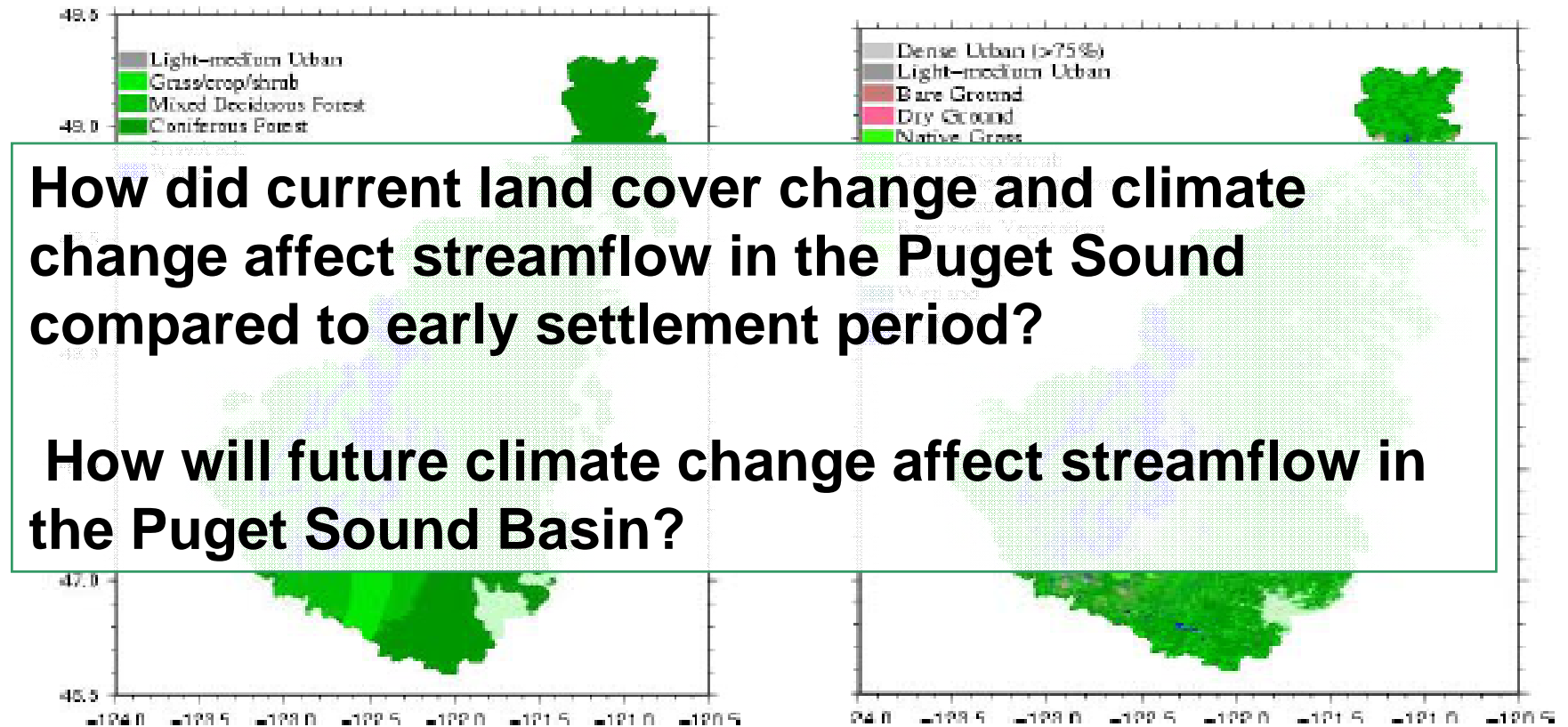


Figure 2. 1883 Land cover map (source: US Department of Interior/US Geological Survey, 1883). 152x161mm (72 x 72 DPI)

Figure 3. 2002 Land cover map (source: Alberti et al, 2004). 152x161mm (72 x 72 DPI)

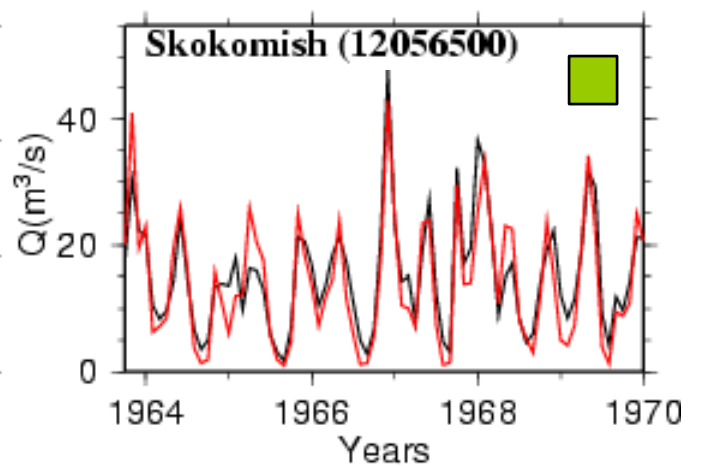
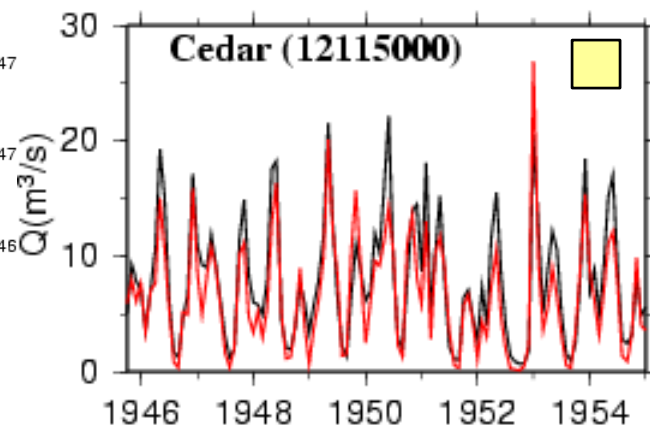
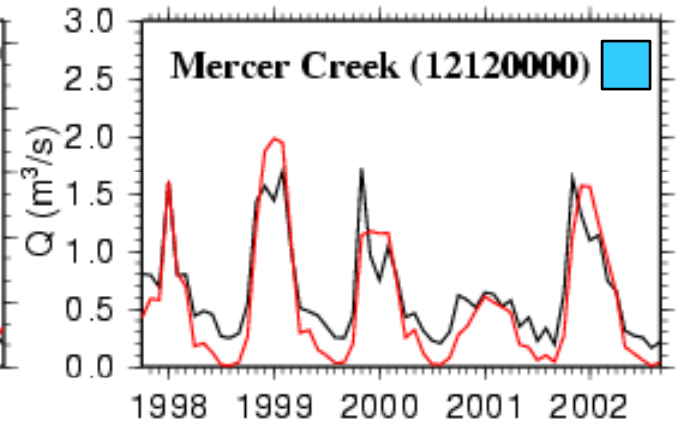
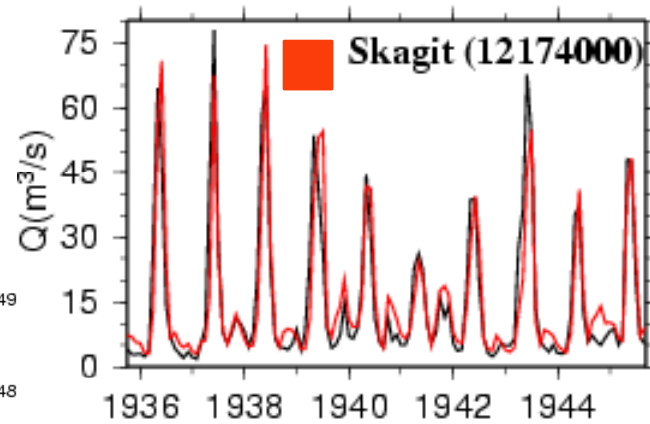
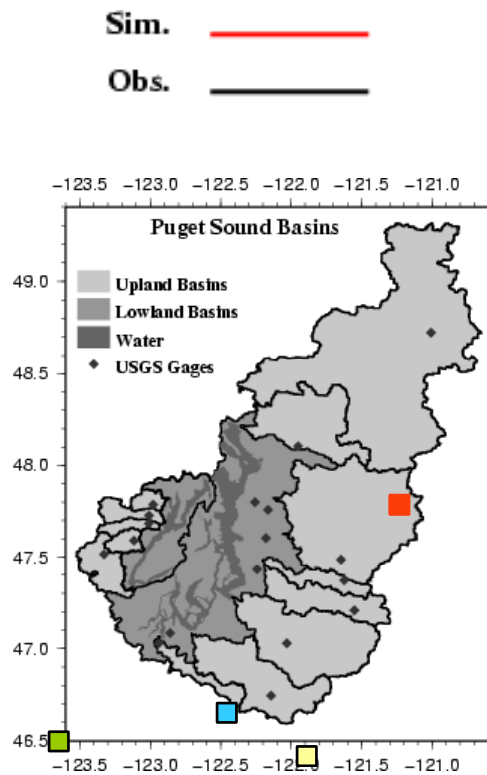
# Methodology

- 1. Generate data:**
  - **1/16<sup>th</sup> degree climate forcing data for 1915-2002.**
  - **Remove temperature trend based on 1915 and 2002 conditions.**
  - **2002 land cover map from Alberti et al. (2004) and 1883 USGS land cover map**
  - **Use A1B global emissions scenario and Delta approach to perturb the trend removed climate data.**
  
- 2. 6 scenarios:**
  - **Land cover change: 1883 and 2002.**
  - **Temperature change: 1915, 2002, 2020s and 2040s.**
  
- 3. Calibrate the Distributed-Hydrology-Soil-Vegetation Model (DHSVM) for all Puget Sound sub-basins.**
  
- 4. Use the calibrated DHSVM to simulate streamflow for 6 scenarios.**
  
- 5. Compare streamflow.**

# Results: Calibration

## High Elevation

## Low Elevation

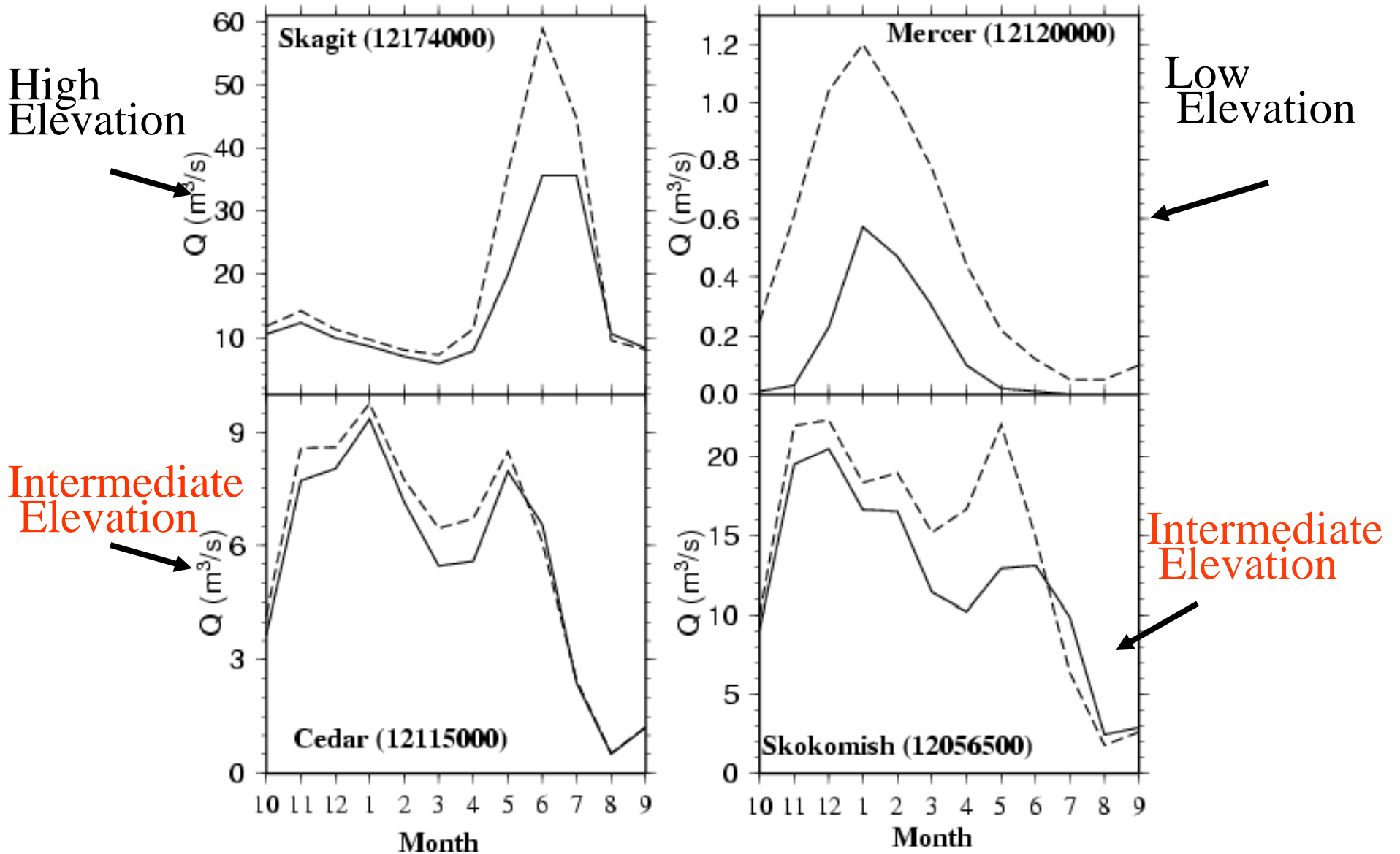


## Intermediate Elevation

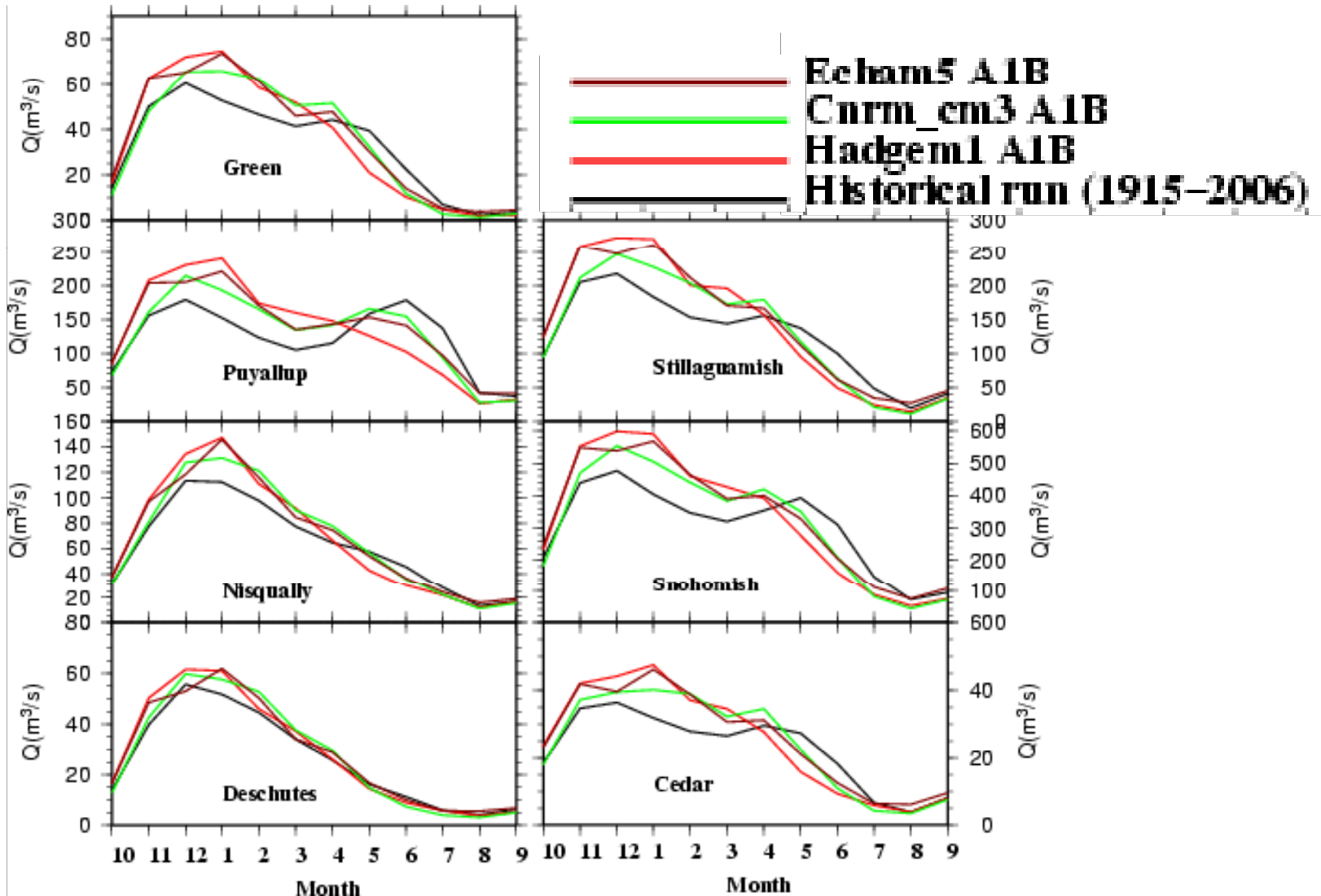
# Land cover change effects: Seasonal flow

— Land Cover 1883

- - Land Cover 2002



**e.g., Streamflow simulation with historical forcing and projected forcings in Cascade side.**



## Conclusions – Land Cover Study

- **In upland basins, fall, winter and spring streamflows are higher under current land cover condition because of lower ET. Summer streamflow is lower in 2002 scenario because of less water storage in the basin.**
- **On average, mean annual streamflows are slightly higher under current land cover condition.**
- **Peak flows are affected by the combination of ET and infiltration excess runoff. Peak flows tend to be higher under current land cover condition for most basins.**
- **Chances of getting peak flows are higher under current land cover condition.**

## **Conclusions – Climate Study**

- **Temperature change has larger effects on streamflow in basins located in intermediate elevation zone and not so much in high-elevation basins and lowland basins.**
- **Temperature change mainly affects seasonal streamflow distribution in mid- and high-elevation basins.**
- **In general, warmer climate will result in more winter precipitation falling as rain rather than snow throughout much of the Puget Sound. This change will result in higher fall, winter, early spring streamflows, earlier peak spring streamflow, and lower summer streamflows.**
- **Land cover change dominates in the lowland where urbanization occurs. Temperature and land cover change both function in the upland basins.**



## What's Going On?

**The Dissolved Oxygen Issue in Hood Canal**

**Science of Hood Canal Hypoxia**

**Key Messages**

**What are We Doing About it?**

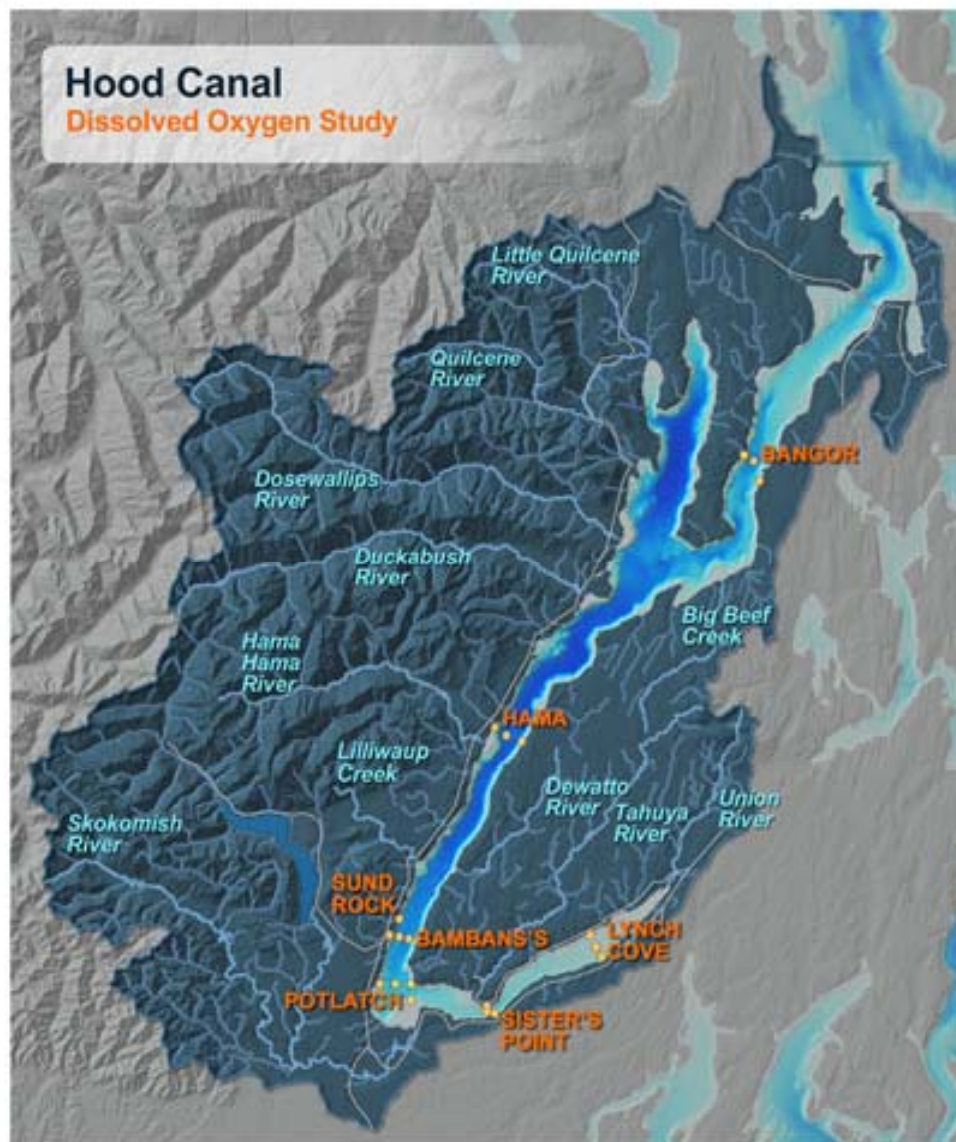
**HCDOP - IAM**

**Resources**

**News Links**

*Seen a Fish Kill or Algae Bloom? Call Ecology's Emergency Response Number:*

**1-800-OILS-911**  
(1-800-6457-911)



**HCDOP IAM Study Preliminary Results**  
Click here to see video of the summary presentation at the Hood Canal Science Summit



Click here to download preliminary study results and conclusions

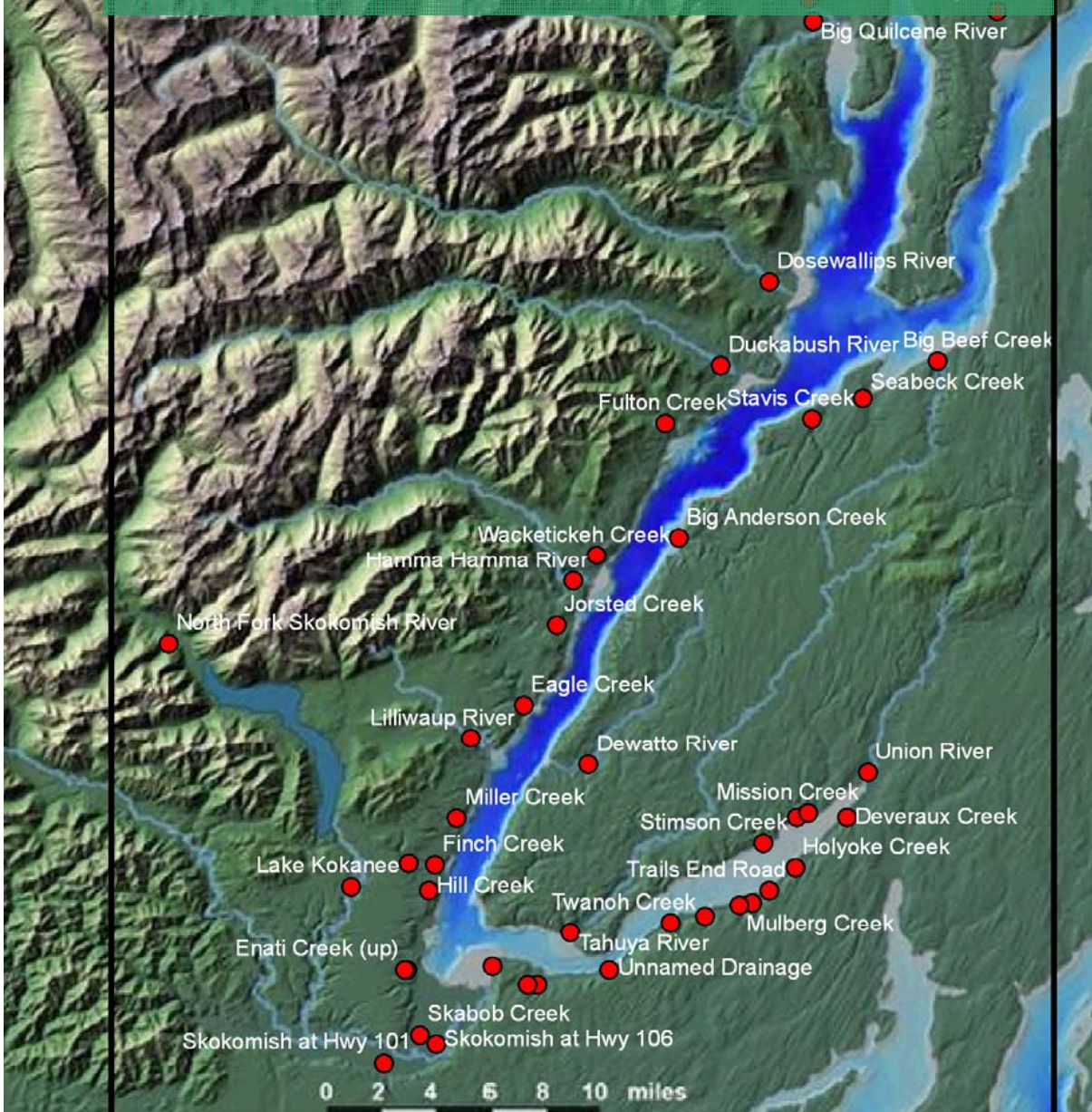


# ***WATERSHED NITROGEN INPUTS TO HOOD CANAL- HOW MUCH COMES FROM WHERE WHY?***

- Direct measurements of water chemistry
- Geospatial model of landsurface properties
- Assess freshwater inputs, using gauge records and DHSVM
- Coupled hydrology/geochemical modeling
- Loading/partitioning analysis of current conditions
- What would happen in the future? (not idle – House Bill pending)



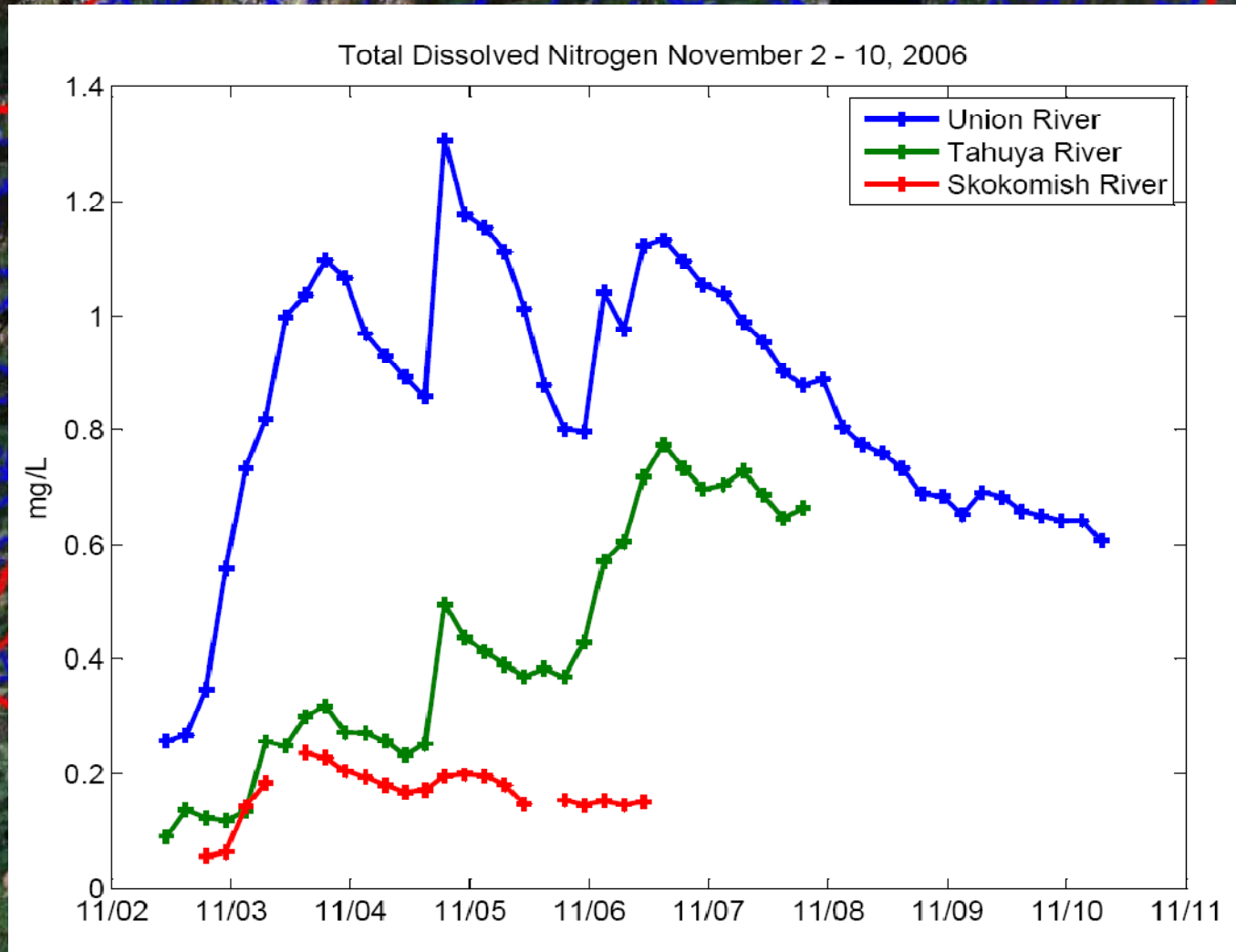
# MONTHLY SAMPLING OF 43 STREAMS: JAN'2005 - Present



## Cooperative Sampling by:

- UW PRISM
- USGS
- HCSEG
- Skokomish Tribe
- Jefferson Conservation
- Kitsap Health District
- Mason Conservation District
- Mason County Health Dept.
- EnviroVision

# STORM EVENT SAMPLING



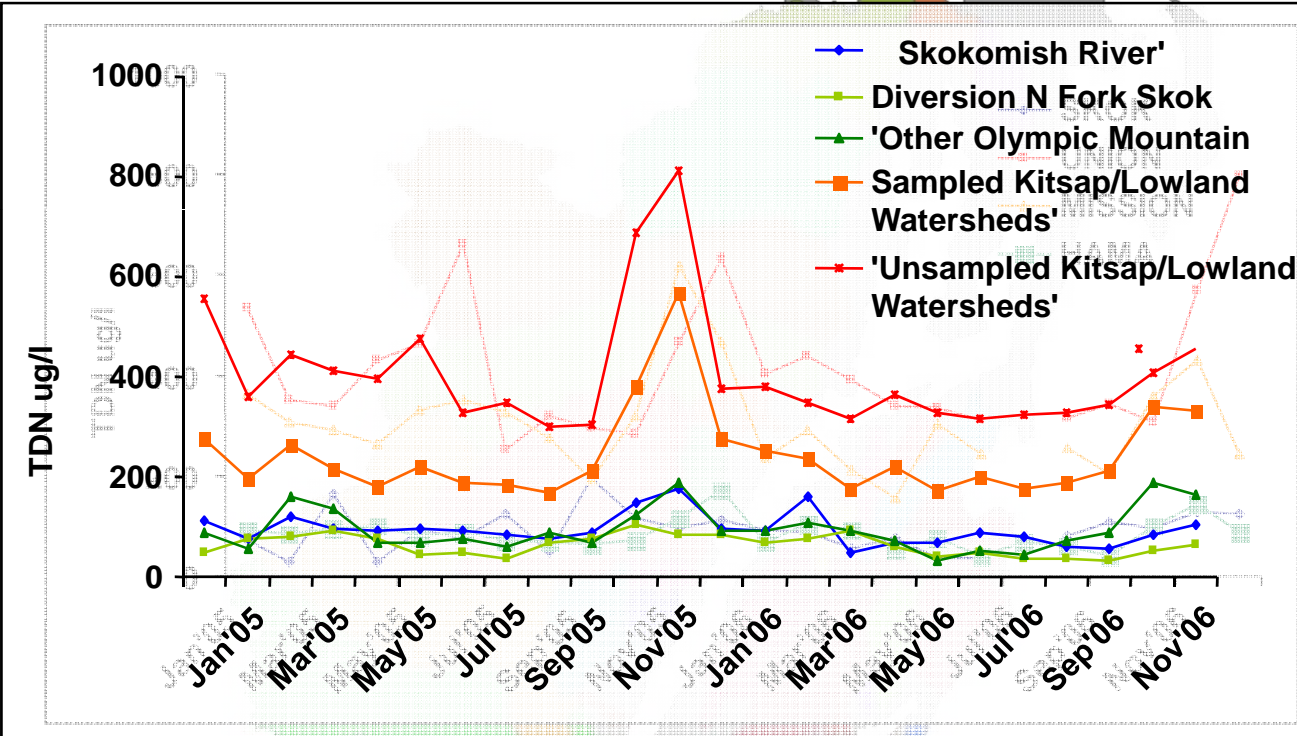
Peter Steinberg

© 2007 Europa Technologies  
Image © 2007 TerraMetrics

McNeil Island

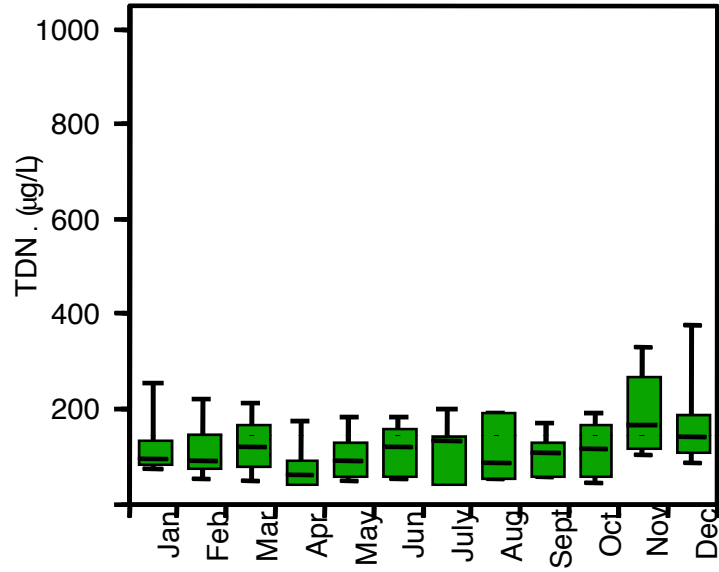
# TDN IN HOOD CANAL RIVERS AND STREAMS

Sampled subwatersheds (39) and unsampled areas (in gray)

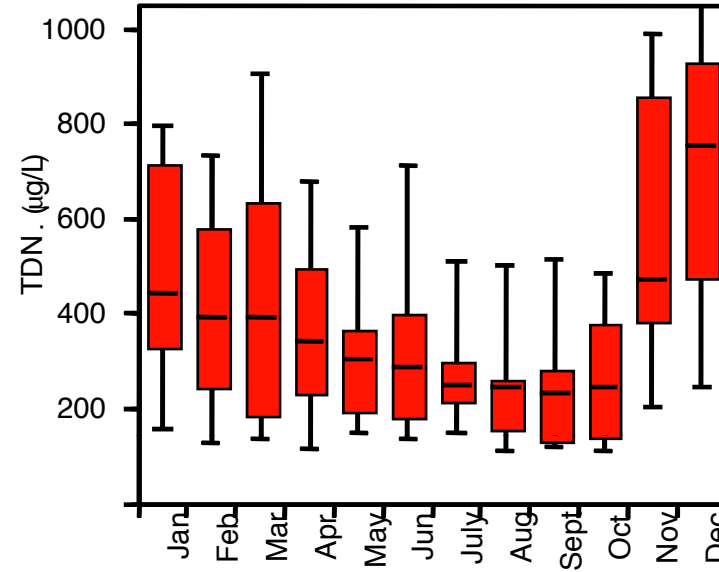


# AVERAGE MONTHLY TDN IN TEN MOST...

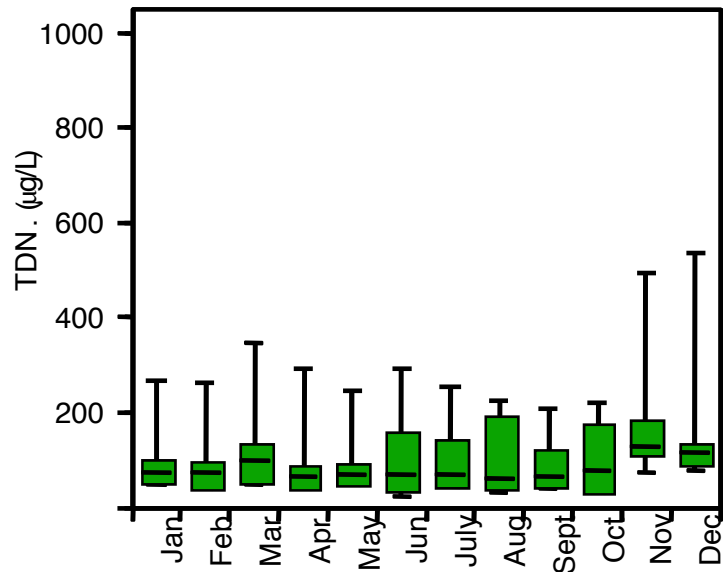
## *mature coniferous forest*



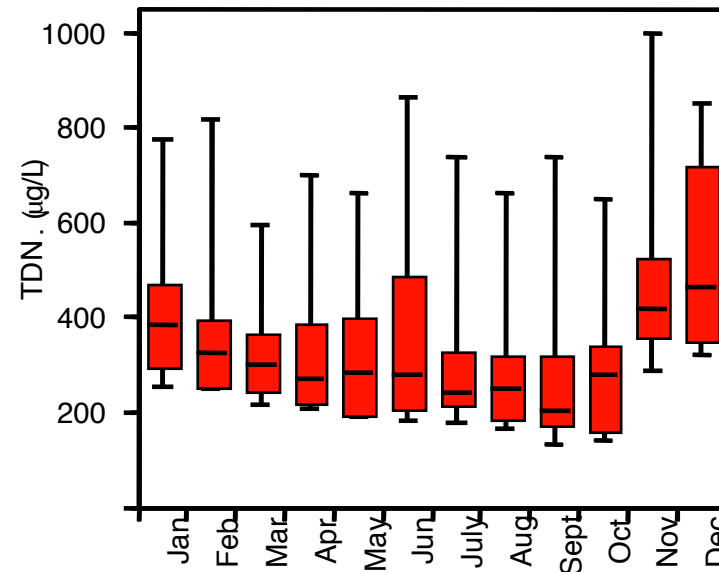
## *mixed deciduous forest*



## *least densely populated watersheds*



## *most densely populated watersheds*

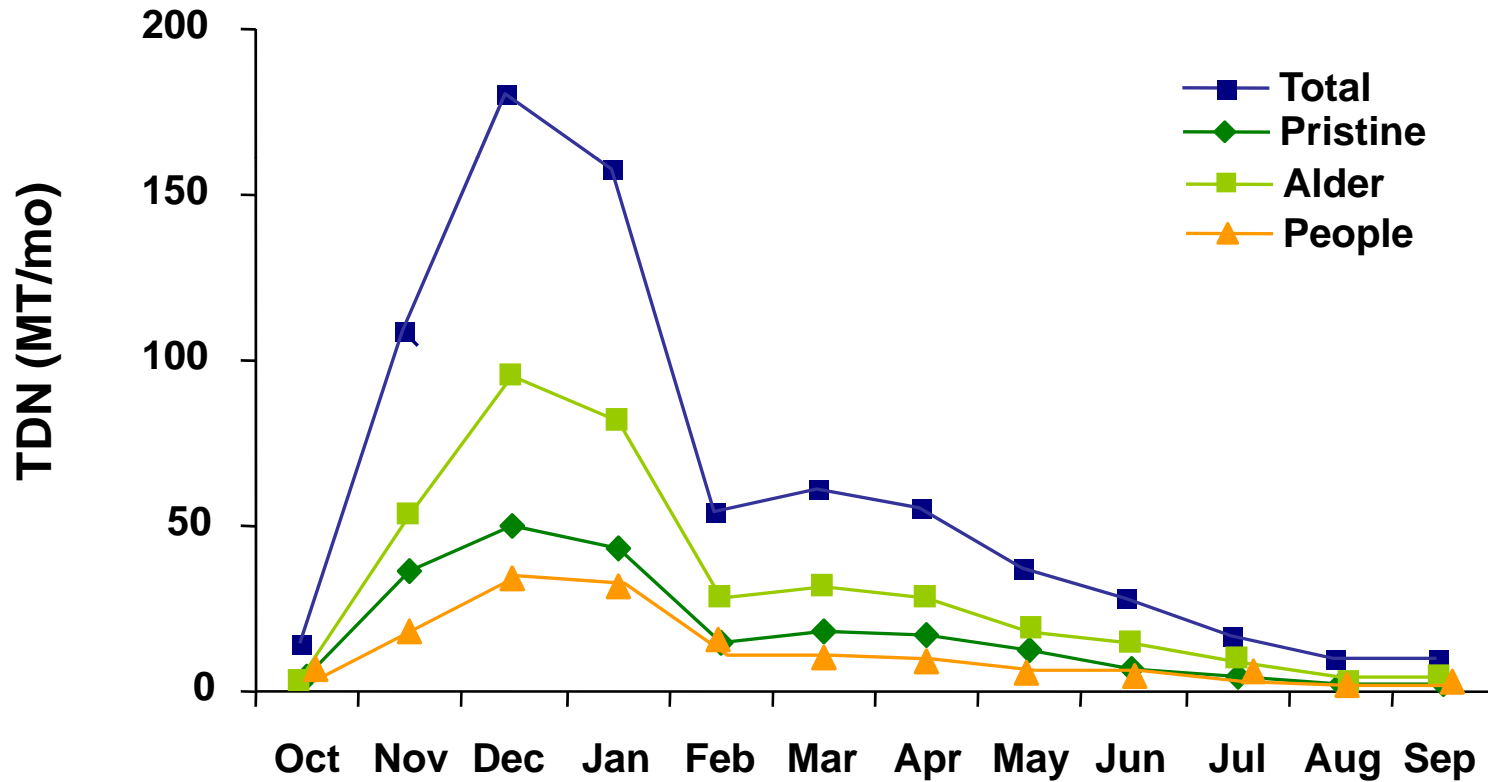


# HOOD CANAL TOTAL TDN LOADING

2005: 715 MT/y

2006: 686 MT/y

USGS 1971-2002: 495 MT (DIN) surface, 139 MT groundwater



# TDN LOADING TO LOWER HOOD CANAL

## EXPLANATION

- Intertidal area
- Zone 1, South shore
- Zone 2, Lynch Cove terminus
- Zone 3, North shore

1200

900

600

300

0

Kg/day (DSEM)

**SURFACE WATER (DSEM) ~60 MT/y**

**DIRECT GROUNDWATER (USGS) ~50-100 MT/y**

7 cm/d

Average seepage rates, in centimeters per day

86.0 MT/yr

Nitrogen loading for zone in metric tons per year of dissolved nitrogen

900

600

300

0

Sep-05

Mar-06

Oct-06

Apr-07

Nov-07

0 1 2 3 4 5 MILES

Union River  
Belfair

Tukwila

London Road

Lynch Cove

Sunset Beach

Sisters

27 cm/d

8 cm/d

1.8 MT/yr

10.1 MT/yr

13 cm/d

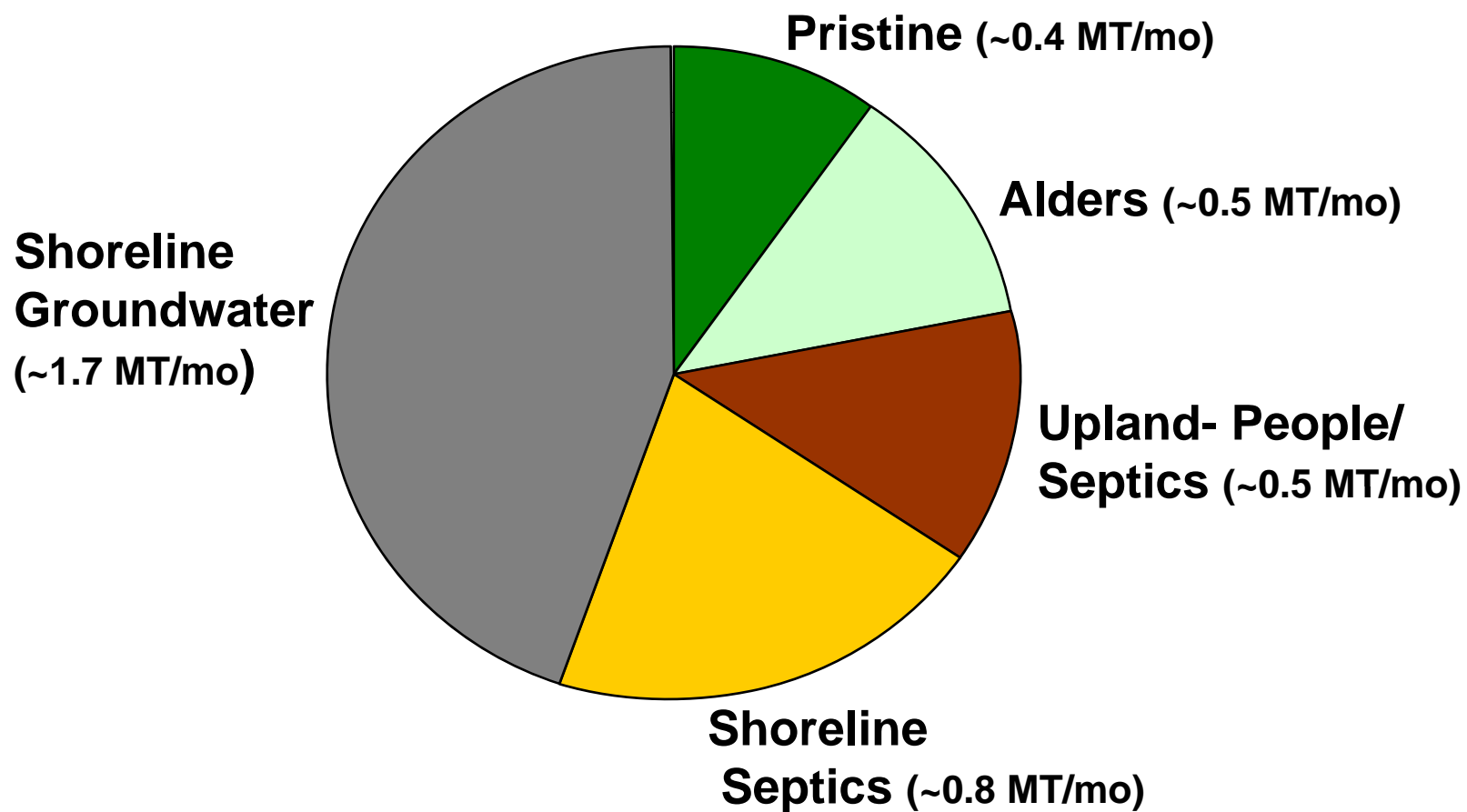
7 cm/d

86.0 MT/yr

# SUMMERTIME IN LOWER HOOD CANAL

## July – October Composite

*Average Monthly Combined Watershed Loading; ~ 4MT/mo*



# CONCLUSIONS

*“Does the Hood Canal watershed play a role .... through TDN surface and groundwater loading ....?”*

- Is there an anthropogenic impact, above “Pristine,” on TDN loading? *Yes! Partitioned between alders and OSS (and fertilizers and dogs...and...)*
- How ‘sure’ are we of the numbers? *Not extremely ... the important issue is the trends that are appearing*
- Does this N make a difference to the marine? *Seemingly, consistent as the “tipping” point*
- Regardless of the marine impact.... *Results show a very significant alteration in the freshwaters of Hood Canal watershed – important, “unto itself”.....*

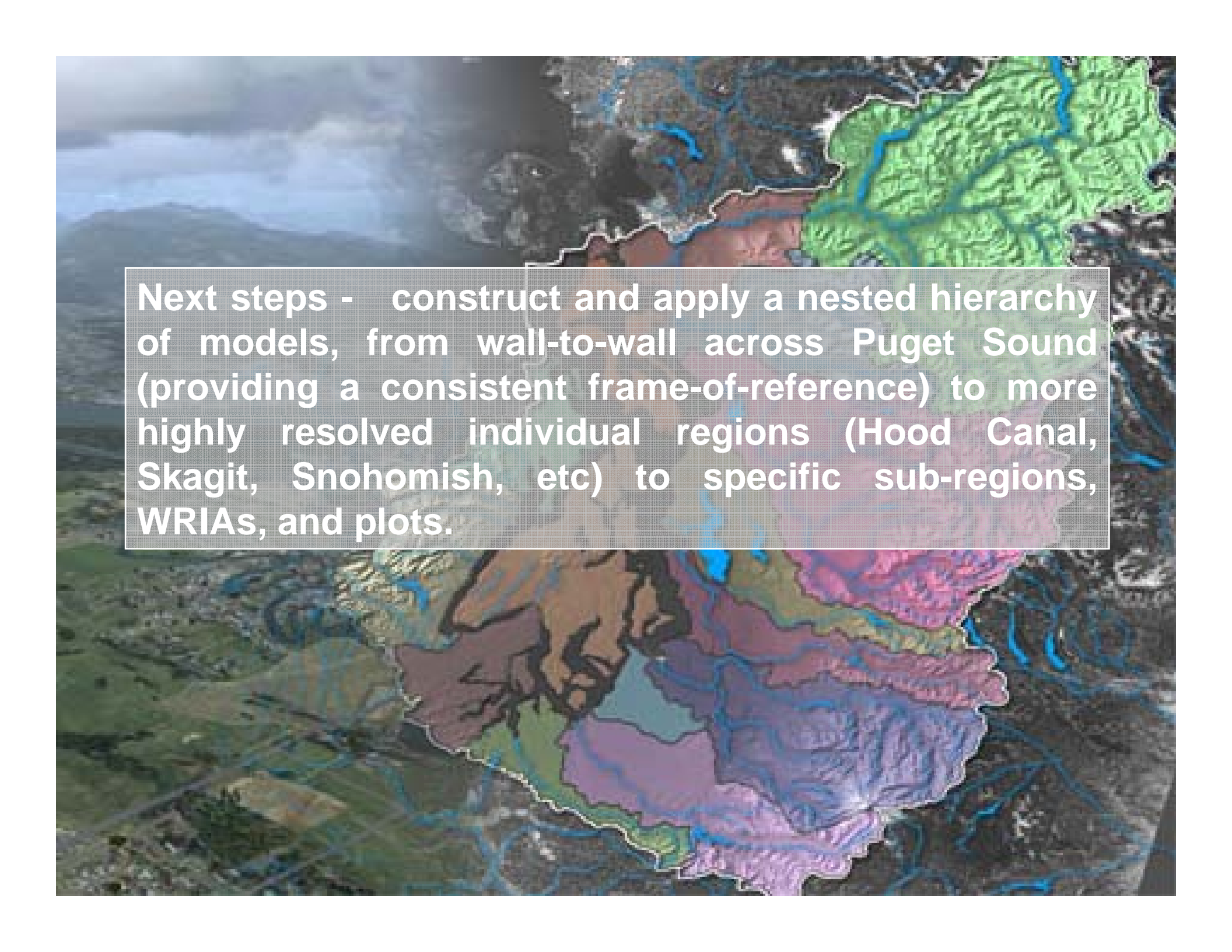
Skagit River Delta

# Skagit Alternative Futures Project

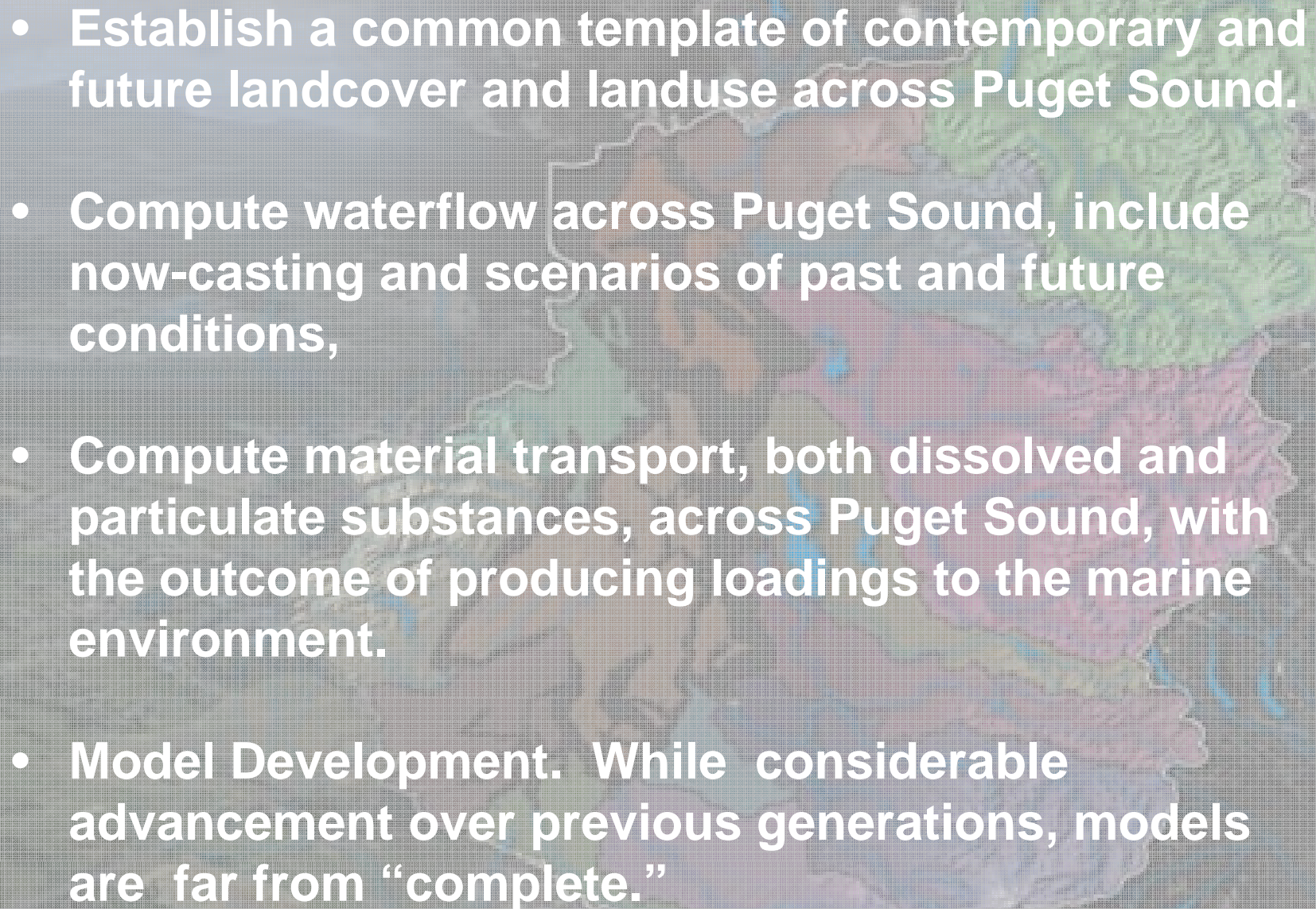
EPA Targeted Watershed Grants 2008 Puget Sound Initiative

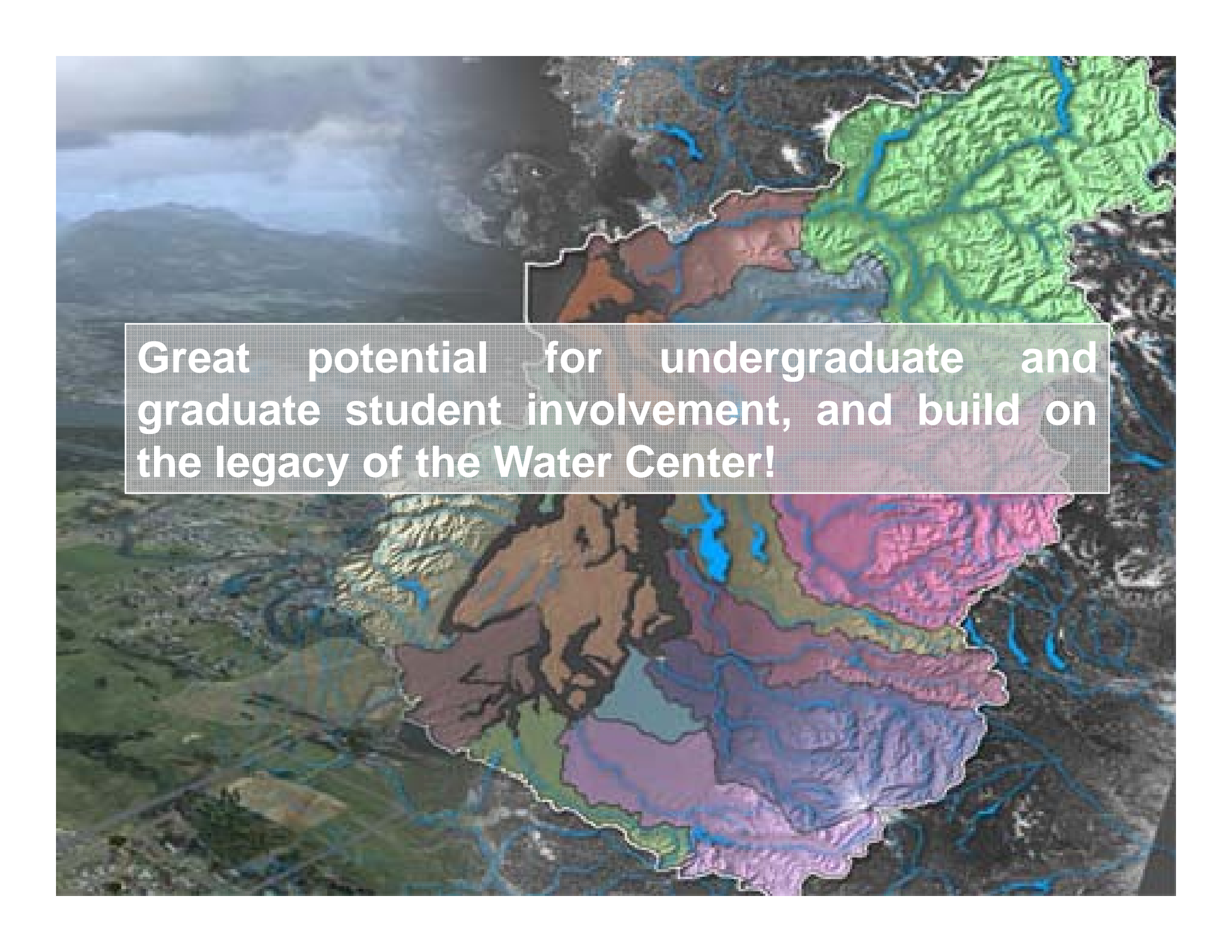
*This starting-up project is applying the “alternative futures” process (with improvements drawn from the experiences of the Willamette River basin and Kitsap County) to the seemingly intractable conflicts between ecosystem restoration, farmland preservation, and growth management in the Skagit River watershed*



An aerial photograph of the Puget Sound region in Washington state, showing the coastline, mountains, and various water bodies. A semi-transparent text box is overlaid on the center of the image. The text inside the box describes the next steps in a modeling project, involving a nested hierarchy of models from a wide regional scale to highly resolved sub-regions and plots.

Next steps - construct and apply a nested hierarchy of models, from wall-to-wall across Puget Sound (providing a consistent frame-of-reference) to more highly resolved individual regions (Hood Canal, Skagit, Snohomish, etc) to specific sub-regions, WRIAs, and plots.

- 
- Establish a common template of contemporary and future landcover and landuse across Puget Sound.
  - Compute waterflow across Puget Sound, include now-casting and scenarios of past and future conditions,
  - Compute material transport, both dissolved and particulate substances, across Puget Sound, with the outcome of producing loadings to the marine environment.
  - Model Development. While considerable advancement over previous generations, models are far from “complete.”

An aerial photograph of a mountainous region with a complex network of blue streams and rivers. A semi-transparent map overlay is placed on top of the photograph, showing the same watershed area divided into various colored sub-basins. The colors include shades of green, brown, purple, and pink. The map overlay is centered on the main body of the watershed, with some areas extending towards the top and bottom edges of the image. The background shows a mix of green forested slopes and grey rocky terrain under a cloudy sky.

**Great potential for undergraduate and graduate student involvement, and build on the legacy of the Water Center!**