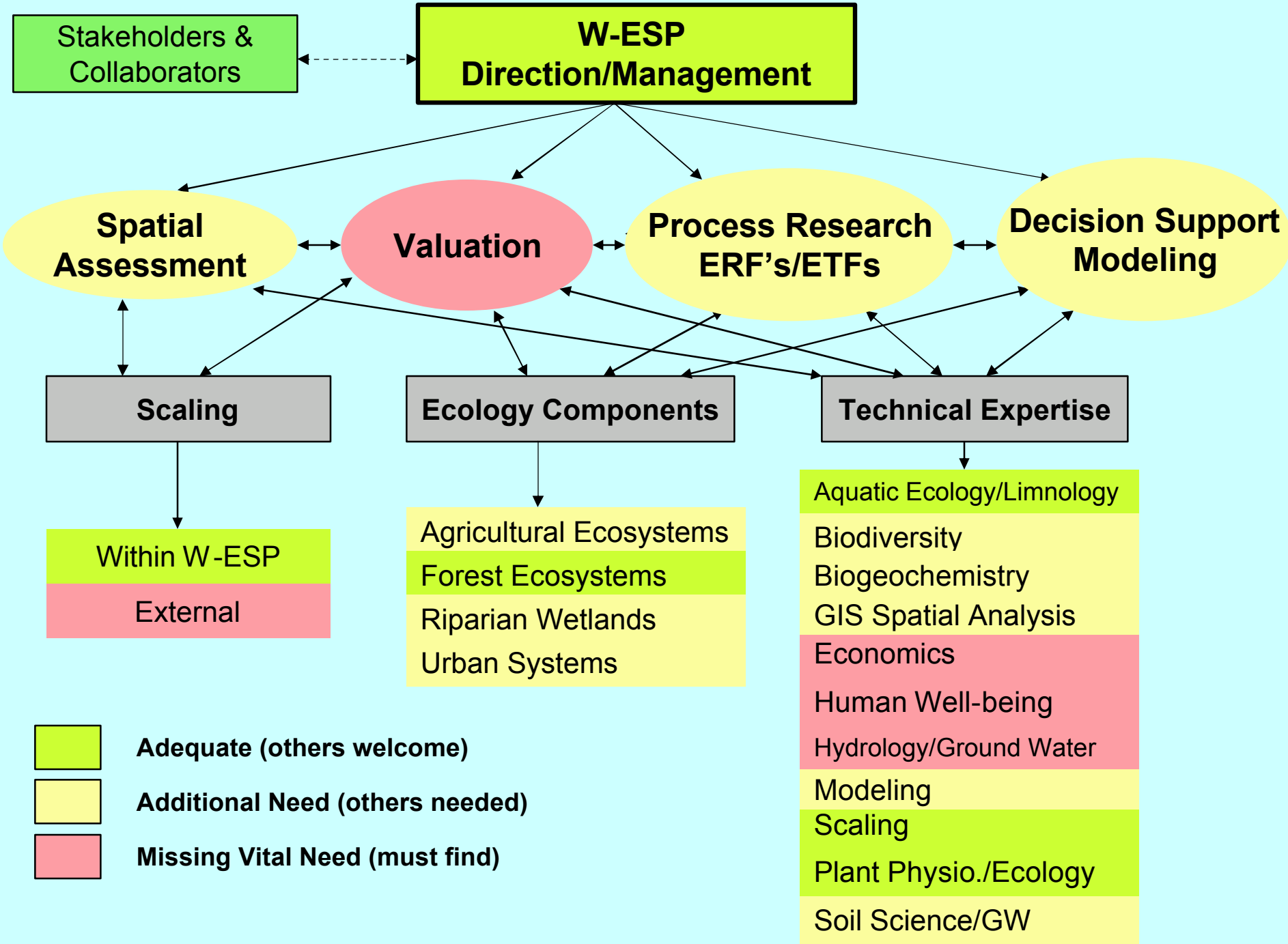
US EPA ARCHIVE DOCUMENT

Willamette-Ecosystem Services Project

"a place-based study"

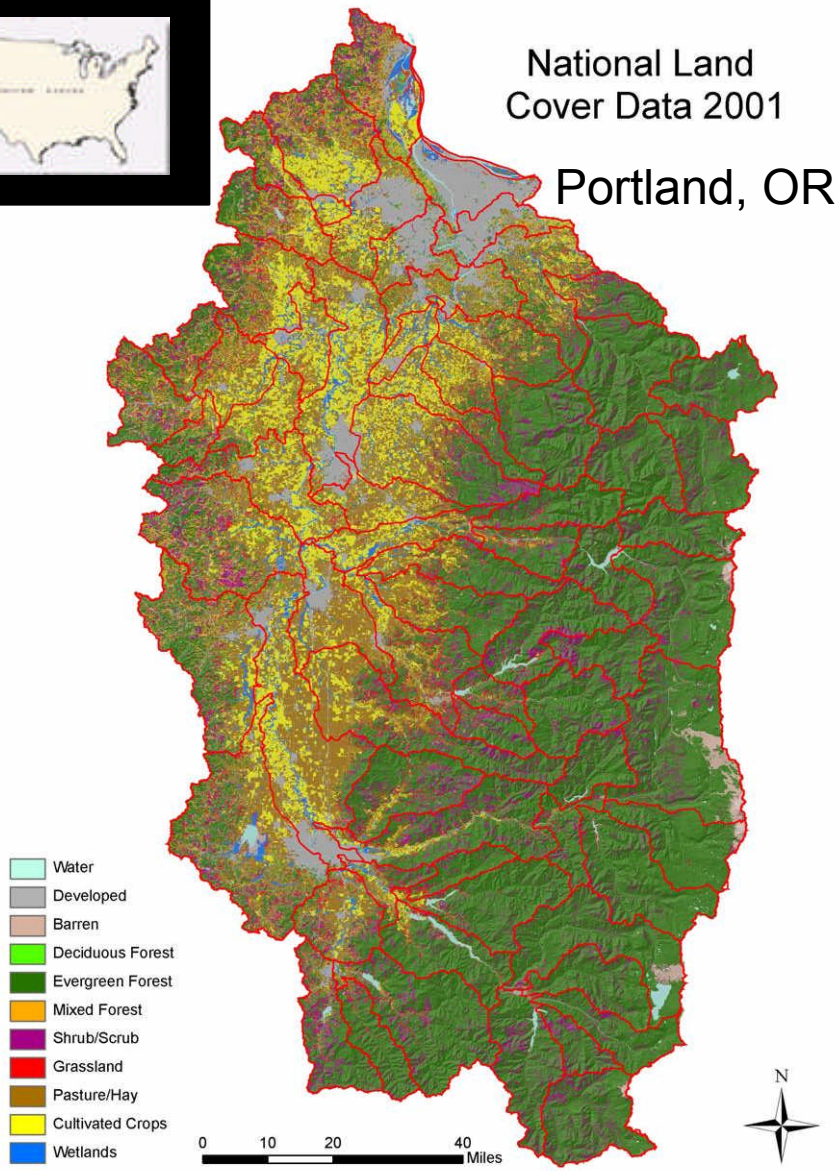
ERP Briefing 01 Oct 2007


Stakeholders & Collaborators
W-ESP Direction/Management
Spatial Assessment
Valuation
Process Research ERF's/ETFs
Decision Support Modeling
Scaling
Ecology Components
Technical Expertise
Within W-ESP
External
Agricultural Ecosystems
Forest Ecosystems
Riparian Wetlands
Urban Systems
Aquatic Ecology/Limnology
Biodiversity
Biogeochemistry
GIS Spatial Analysis
Economics
Human Well-being
Hydrology/Ground Water
Modeling
Scaling
Plant Physio./Ecology
Soil Science/GW
Adequate (others welcome)
Additional Need (others needed)
Missing Vital Need (must find)

Willamette Ecosystem Services Project

Presenters:

- Dixon Landers –Project Leader/Limnologist
  - Introduction to WESD/Wrap-up
- Jana Compton – Biogeochemist/Nitrogen
  - Approach to ES Mapping for WESD
  - Knowledge Gaps
- Bob McKane – Ecosystem Ecologist/modeler
  - Quantification of ES Responses to Stressors and Trade-offs
  - Modeling Synthesis



WESD Landscape

- 70% forest
- 20% Ag; 8% urban
- Not all forests are equal
  - High elevation (N sensitive or N retentive?)
  - Broadleaf vs. Conifer
- Cultivated *vs.* grass seed crops
- Role of wetlands (riparian and isolated)

Overall Goal:

The W-ESP seeks to provide a scientific basis in the form of a decision support system for valuing and projecting ecological services resulting from alternative management decisions

Objectives:

Provide a model-based approach that predicts responses of ecosystem services to probable future conditions.

Identify critical knowledge gaps in the ecological processes underlying ecosystem services.

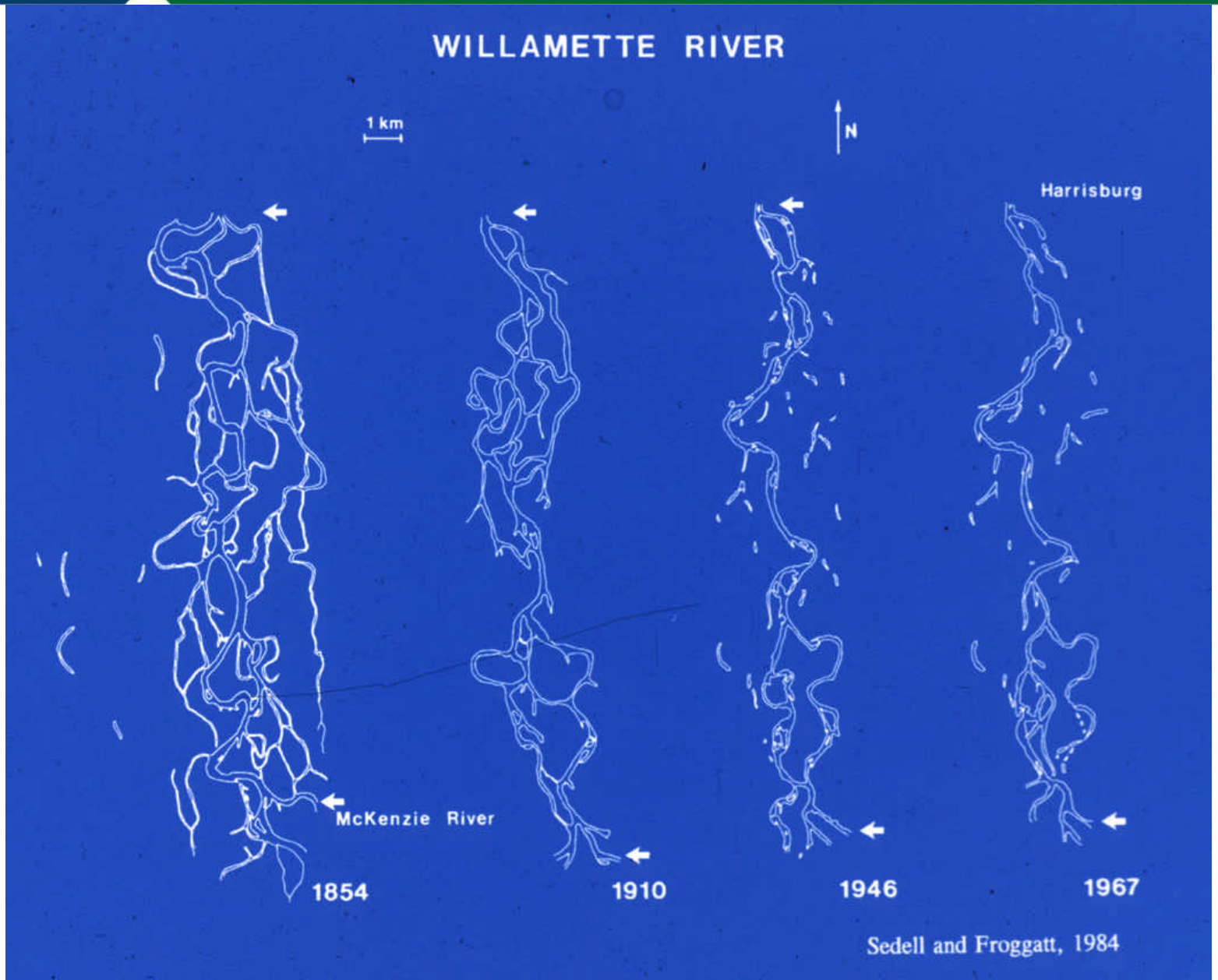
Quantify ecosystem services, including their distribution, status, and responses to current and projected future conditions.

Evaluate net benefits of bundled ecosystem services and tradeoffs among management actions that affect these services.

Willamette River Railroad Bridge upstream from Harrisburg, OR
March 2007

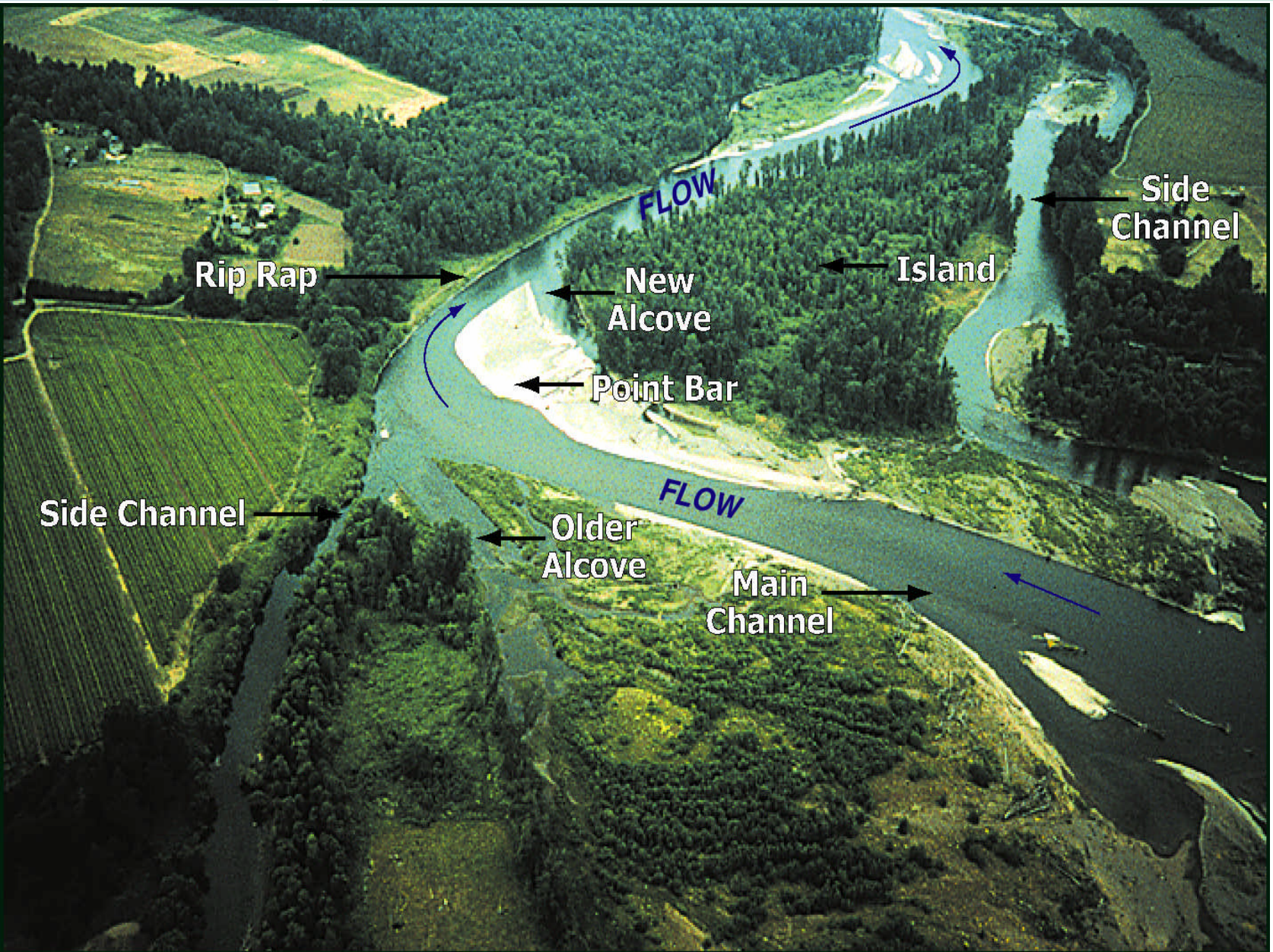
Willamette River July, 2007

Willamette River Mar 1996, looking South

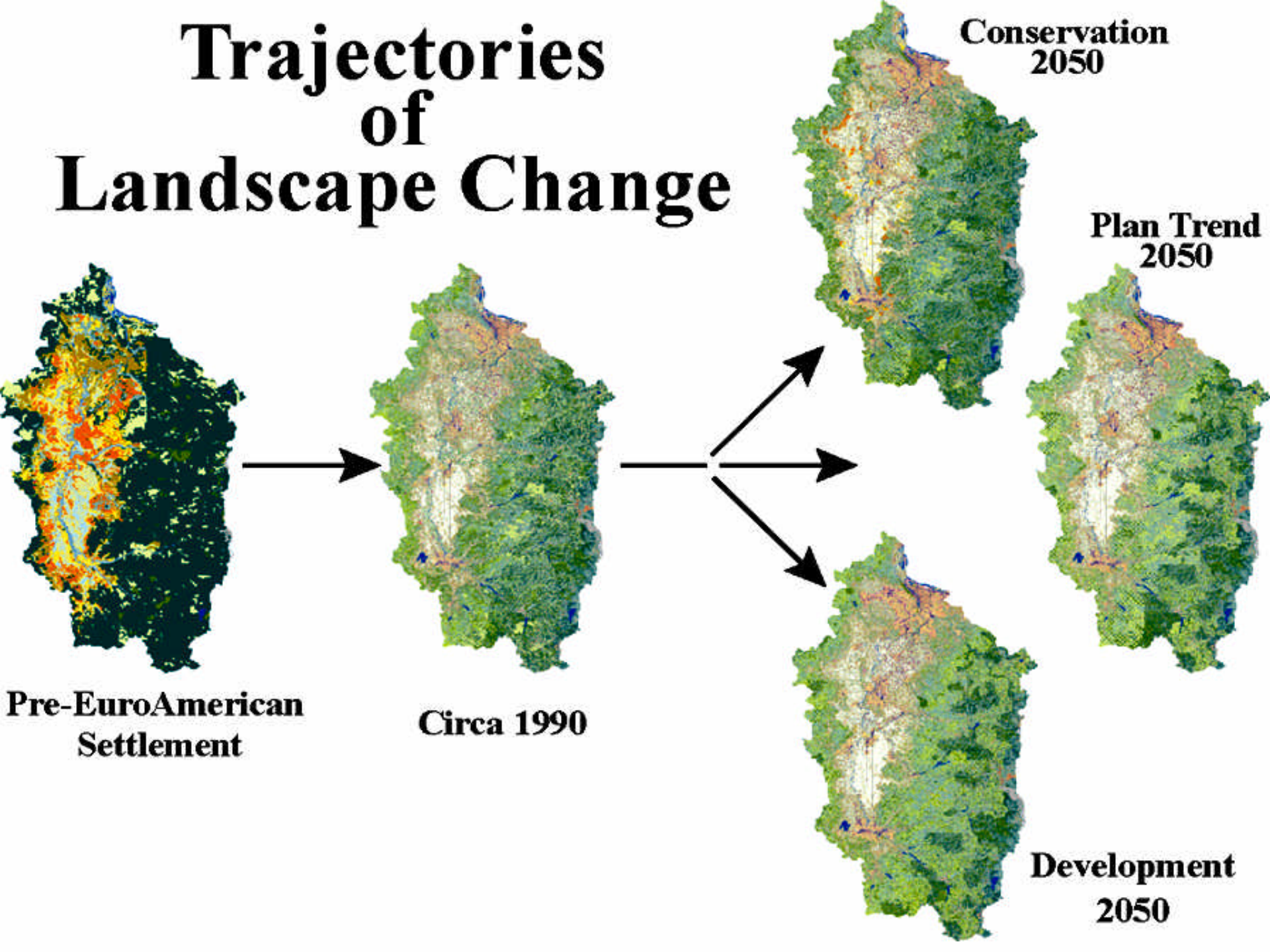

WILLAMETTE RIVER
1 km
N
Harrisburg
McKenzie River
1854
1910
1946
1967
Sedell and Froggatt, 1984

EPA

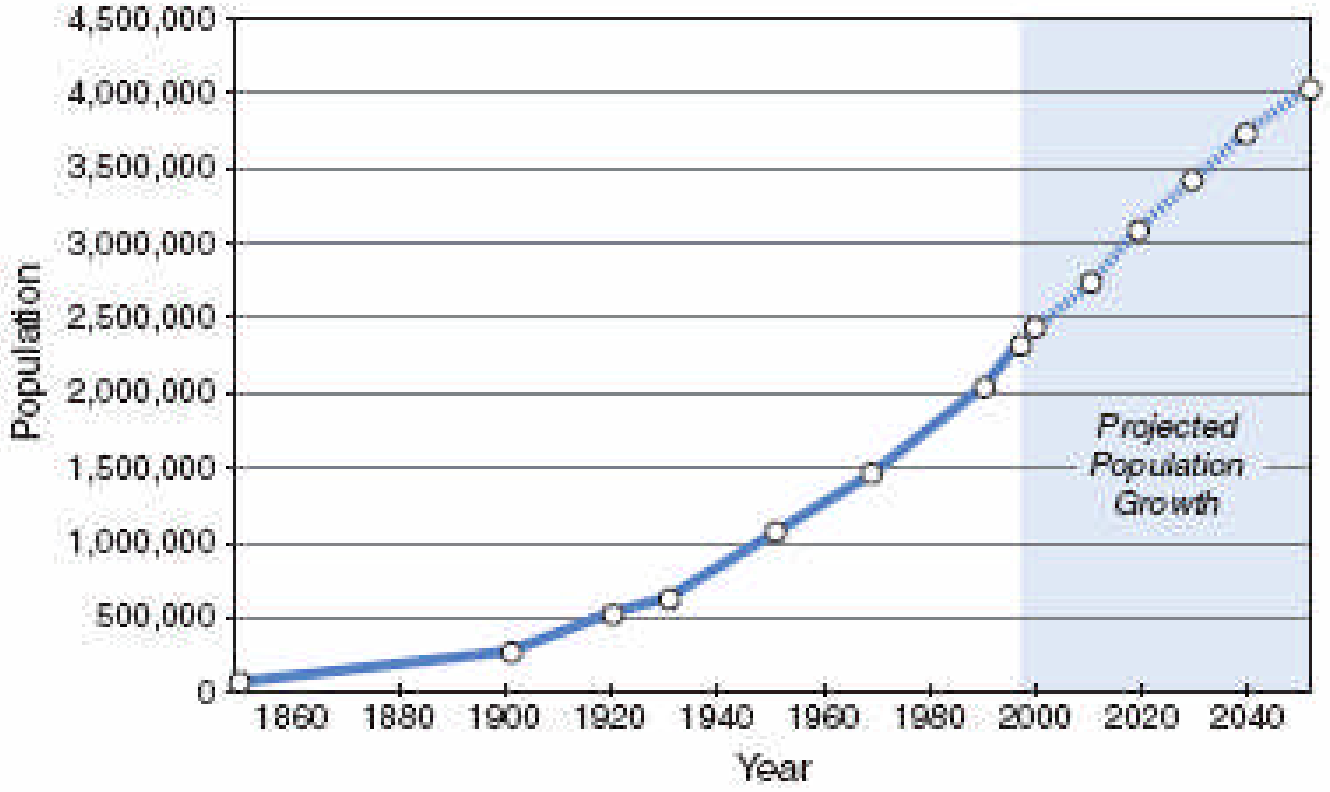
ECOLOGICAL RESEARCH PROGRAM

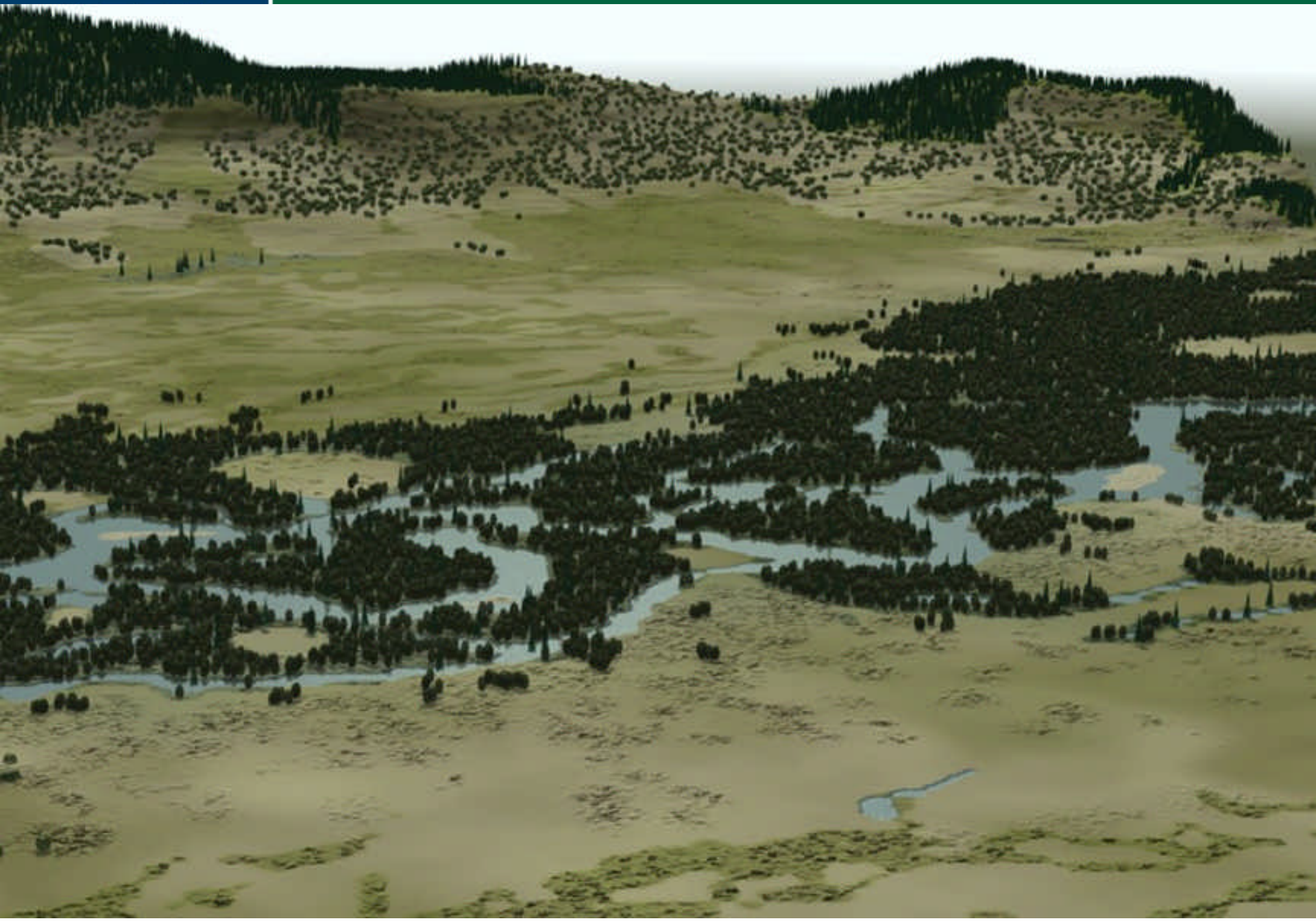


Trajectories of Landscape Change



Projected Population Change in the Willamette Ecosystem Services District



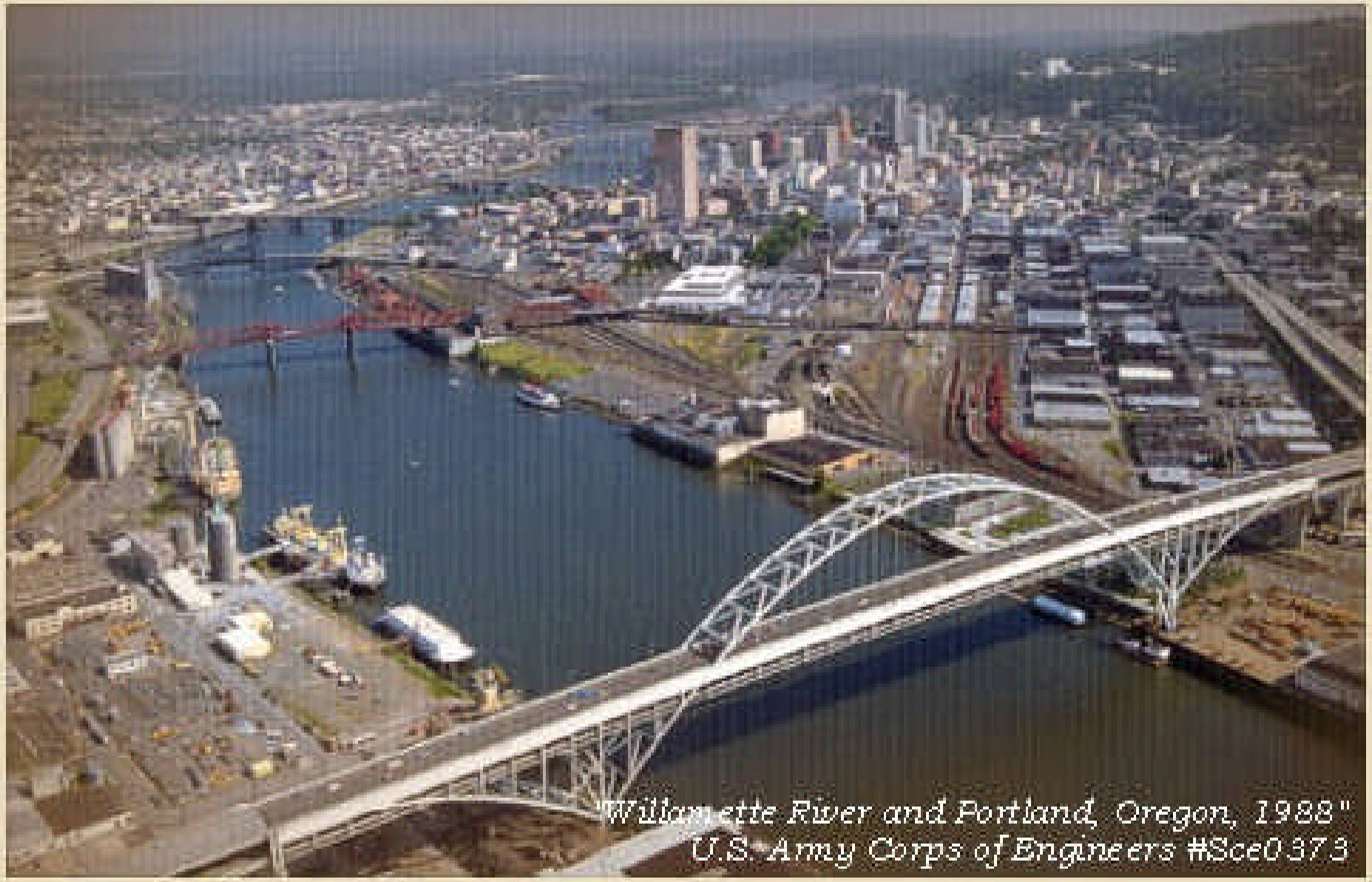


Forest/Ag Instrumented Sites

oregonprogress.oregonstate.edu

EPA

ECOLOGICAL RESEARCH PROGRAM



"Willamette River and Portland, Oregon, 1988"
U.S. Army Corps of Engineers #Sce0373

CLIMATE OF OPPORTUNITY

Why the Willamette?

- Willamette "Ecosystem Service District" provides a broad range of Land-Use/Land-Cover, stressors, gradients, and diverse, linked settings
- WED Alternative Futures research experience (mid 1990's) = rich data sets, experienced researchers, potential collaborators (NRCS, USACE, USDA-FS, USGS, OWOW, etc.)
- Well Connected Research and Regulatory Entities now Working toward future Ecosystem Service trading (Region X)
- Multiple related Star Grant recipients (OSU, OU, PSU)
- Willamette Partnership (State Non-Profit)
- Trading Scenario for Temperature (riparian wetland ecosystem service) rapidly developing – EPA Funding with Region X oversight
- ORD Multi-Year Plan – Ecosystem Research Program: provides explicitly context

Outcomes:

- Clean rivers
- Fish & Wildlife
- Flood control
- Timber& Crops
- Wetlands

Place-Based Societal Issues & Values

Forcing Variables:

- Predicted climate change
- Air pollution
- Land use management
- Population growth

Research Targeted to Develop Ecological Response Functions (ERF) and Ecological Trade-off Functions (ETF)

Natural & Anthro-pogenic Stressors

Past Present & Future

Ecosystem Structure & Functioning

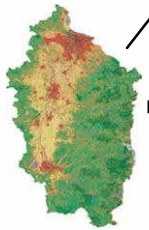
Production
Pools
Decomposition
Flows
Ag-/De-gradation
Land-Water Interactions

C-Sequestration
N-control
Critical habitat
Riparian wetland ES bundles
Other services

Mapped Ecosystem Services

ERFs ETFs

Future Projections



Projected and Quantified Bundles of Ecosystem Services

W-ESP Decision Support System

Societal Response & EPA Policy Actions

Tradable Ecosystem Service Units

Futures & Trading

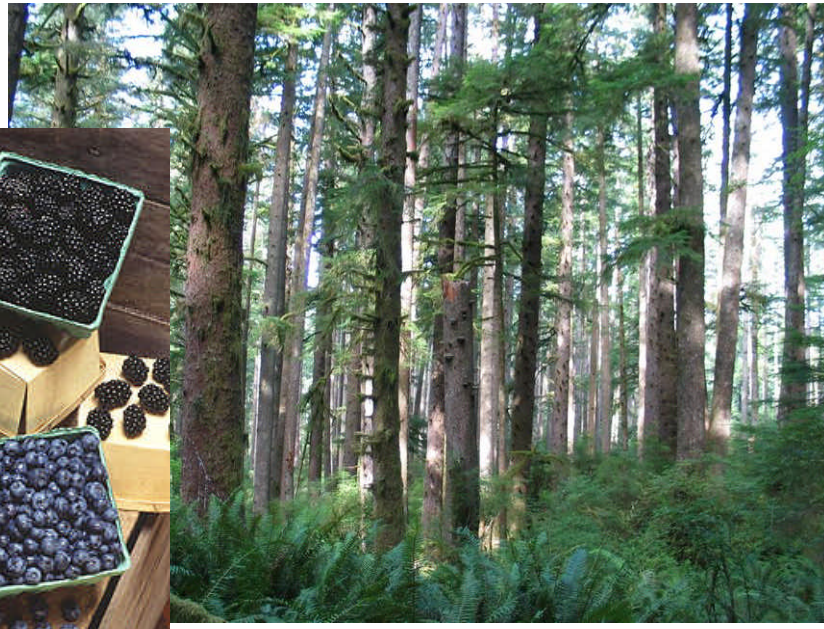
- Cost
- Optimization
- Market Forces
- Valuation

Inventory of Current Ecosystem Services: Approach and Knowledge Gaps

1. Identify key ecosystem services (ES) for WESD
2. Determine appropriate units for ES
3. Develop an approach to inventory and map ES
4. Identify knowledge gaps in assessing ES

1. Identify key ecosystem services (ES)

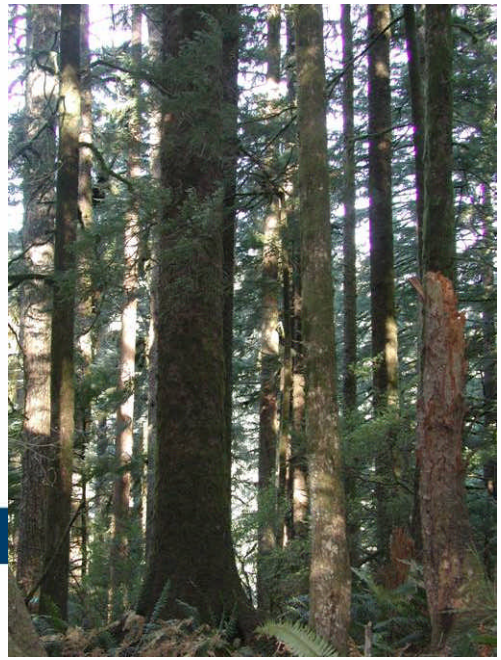
- Crop production
  - food and fiber

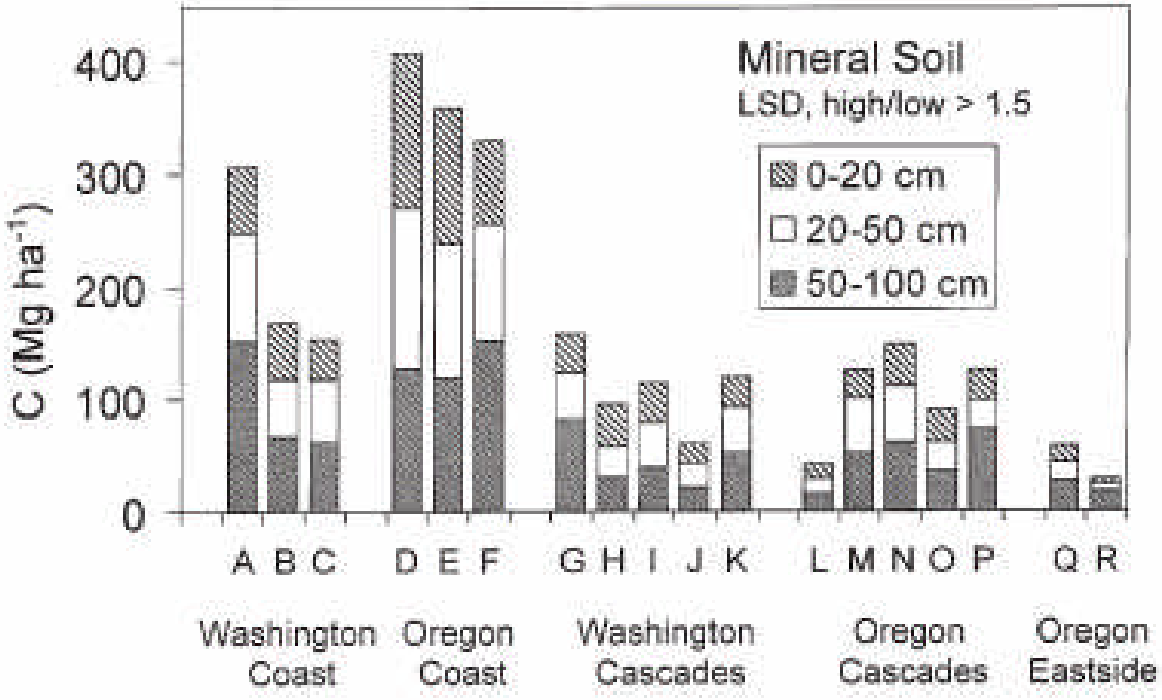


Stakeholder Interactions Ongoing…

1. Identify key ecosystem services (ES)

- Crop production
- Carbon storage
  - climate and gas regulation





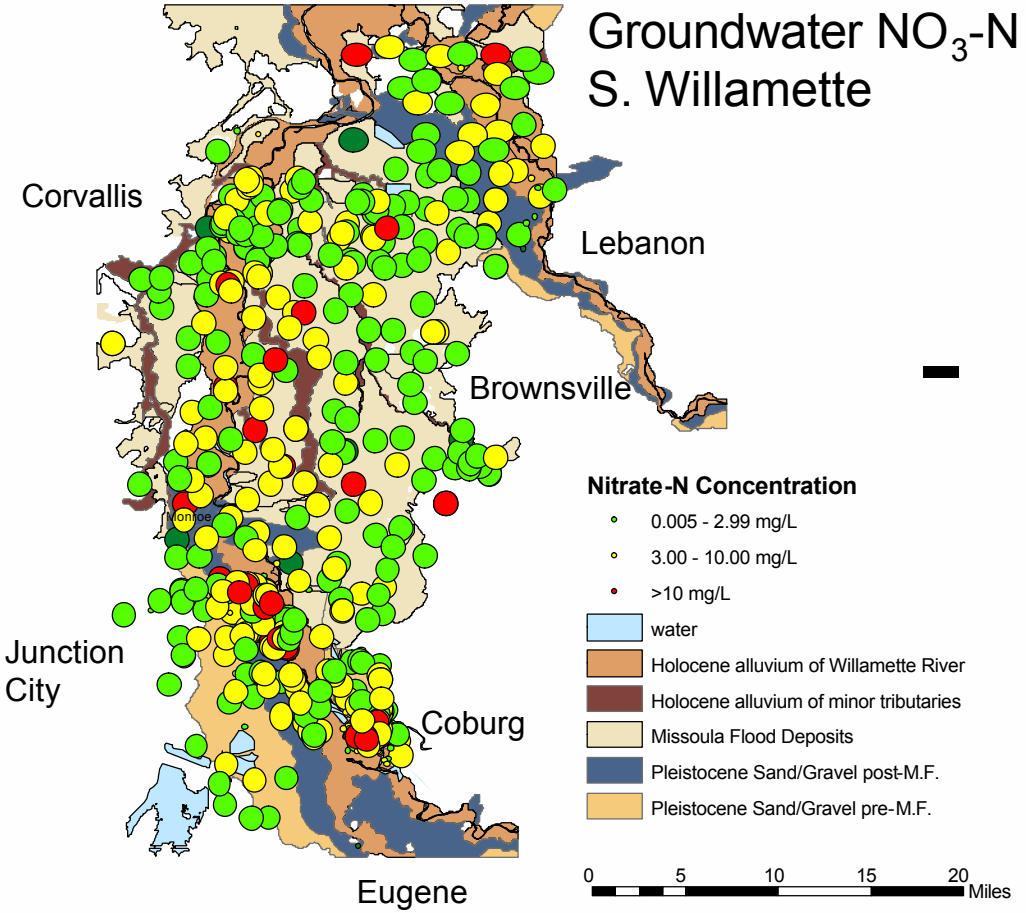
Homann et al. 1994 SSSAJ

1. Identify key ecosystem services (ES)

- Crop production
- Carbon storage
- Water purification and quality
  - focused on N removal
  - also includes mercury, temperature, P, DO and suspended sediments

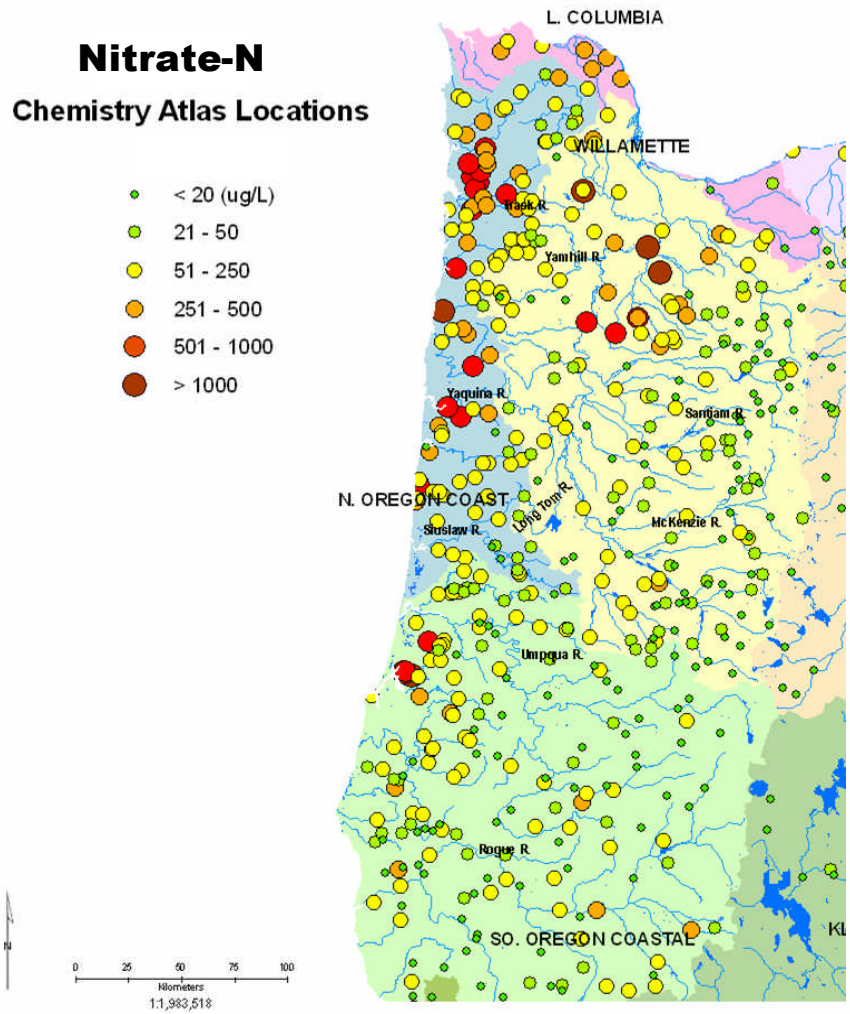
Ecosystem service: Nitrogen removal from water flowpaths

- Drinking water wells >10 mg nitrate-N L^{-1}
- Sources?
- Ecosystem service of N removal along flowpaths
  - Agroecosystems
  - Riparian areas
  - Groundwater****
    - Research gap



Relating Landscapes and stream N

- Many data points available, time resolution is poor
- Loading from atmospheric deposition models, USDA-ARS collaborators, ATtILA
- In-stream processing – models like SPARROW



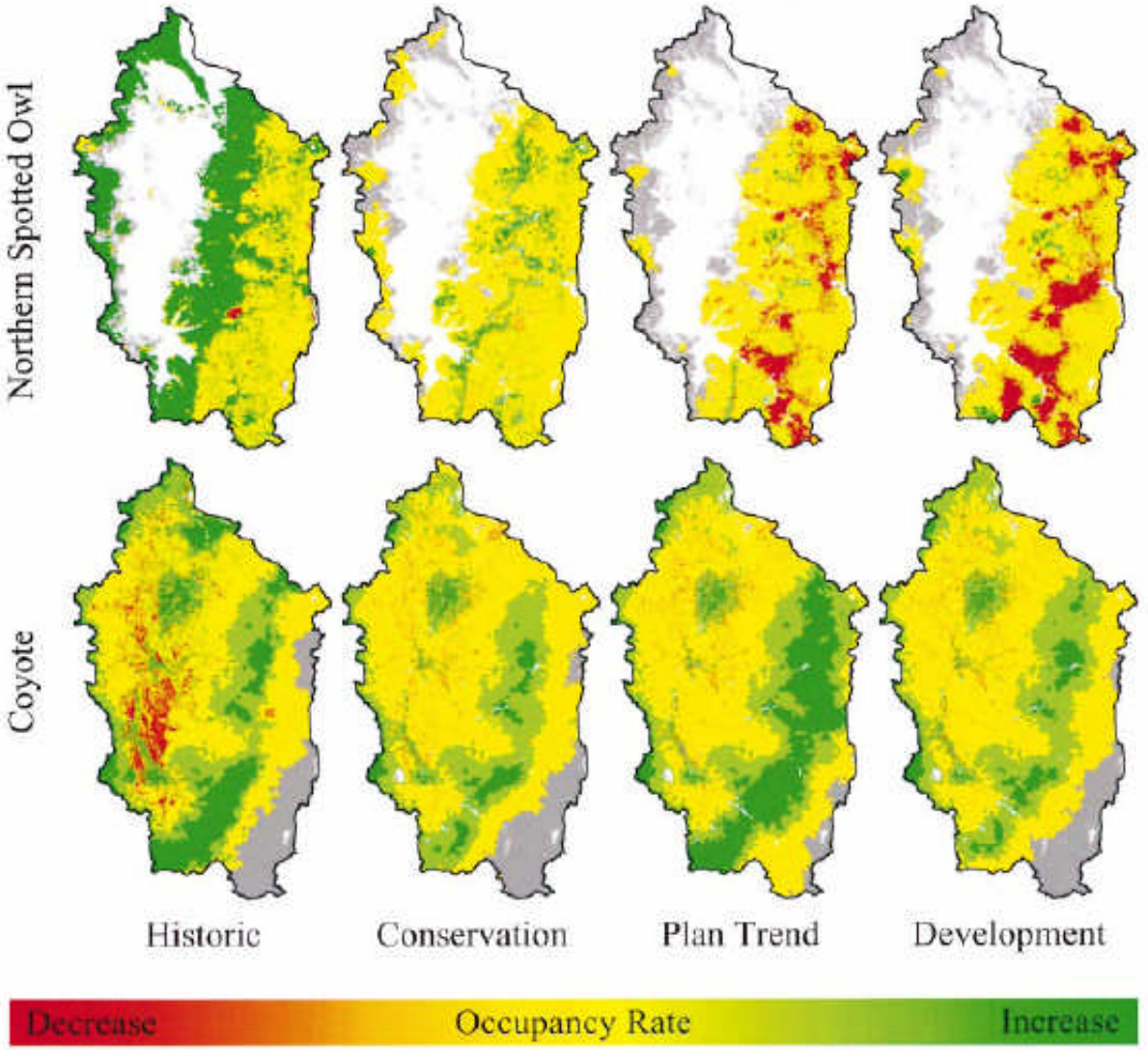
1. Identify key ecosystem services (ES)

- Crop production
- Carbon storage
- Water purification
- Water provision
  - Quantity and timing

1. Identify key ecosystem services (ES)

- Crop production
- Carbon storage
- Water purification
- Water provision
- Habitat provision
  - Aquatic (Collaboration with EPA-NERL Athens)
  - Terrestrial

Existing maps of habitat, water and crop values from the Willamette Alternative Futures work.



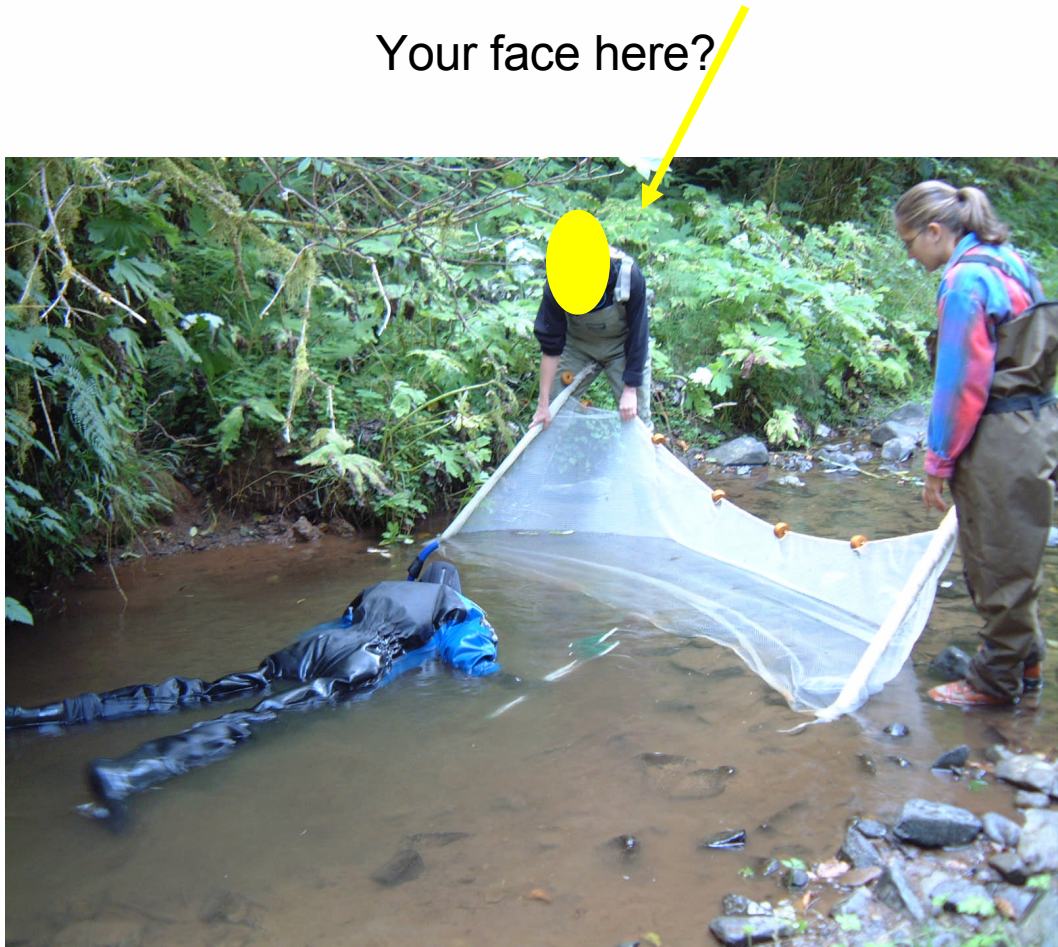
Schumaker et al. 2004 Ecol. Apps.

1. Identify key ecosystem services (ES)

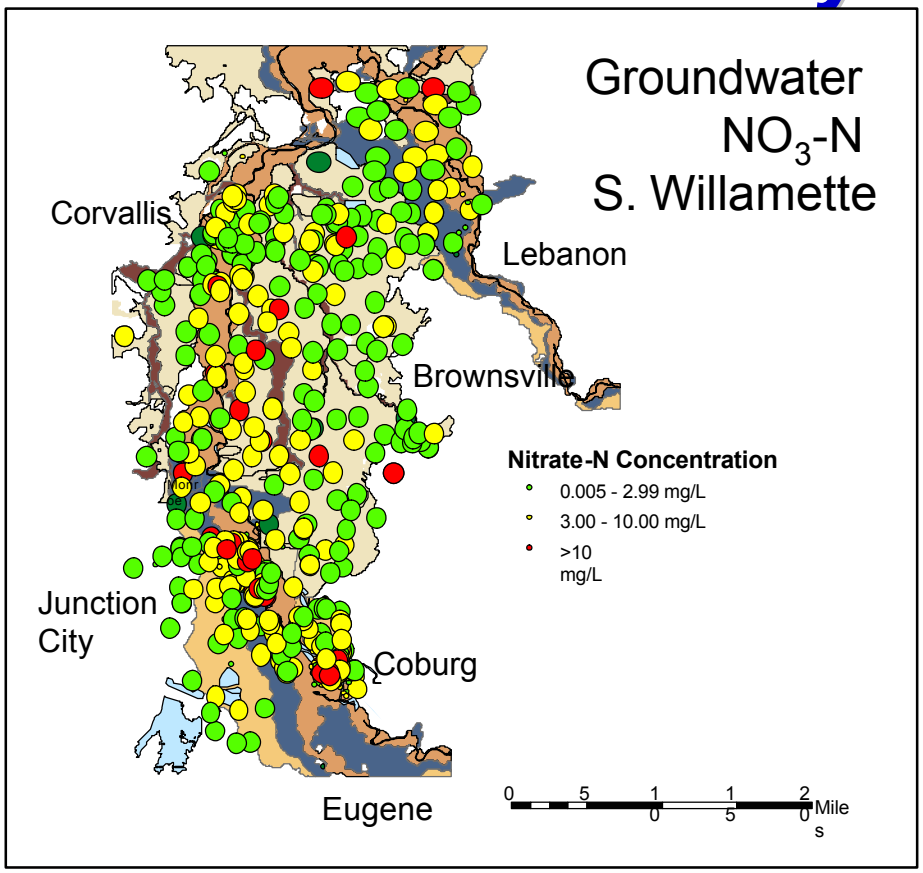
- Crop production
- Carbon storage
- Water purification
- Water provision
- Habitat provision
- Others?

1. Identify key ecosystem services (ES)

- Crop production
- Carbon storage
- Water purification
- Water provision
- Habitat provision
- Others?



2. Determine appropriate units for key ecosystem services



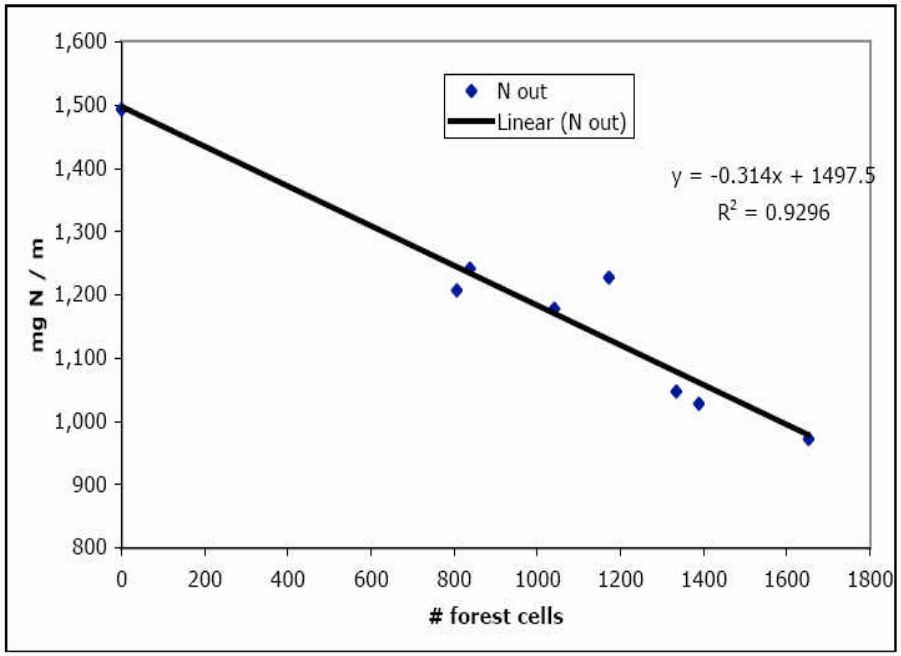
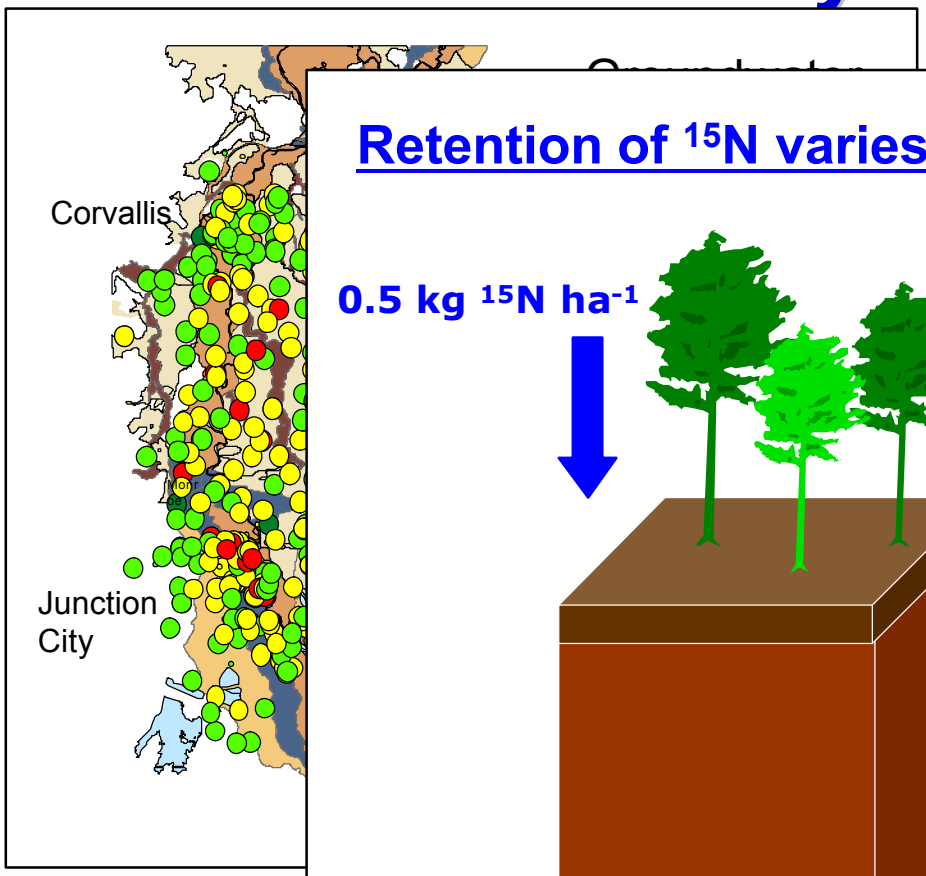


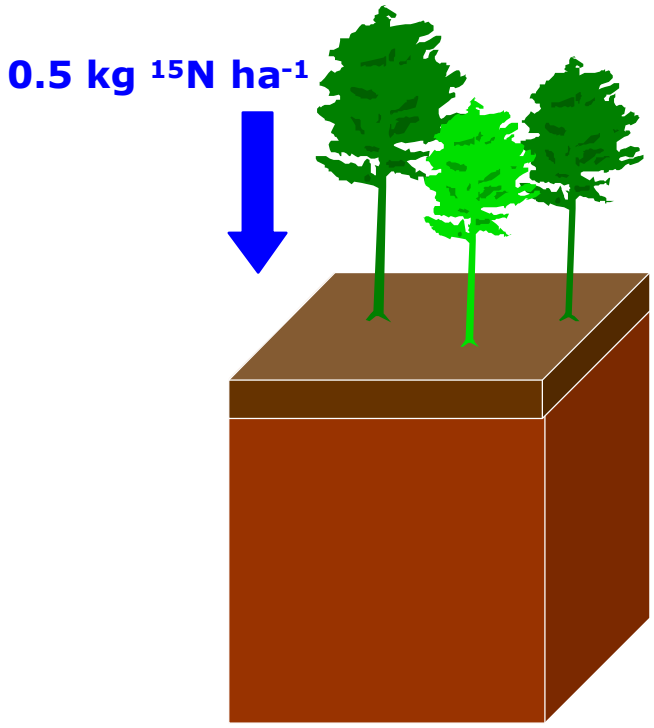
Figure 11: Response of total nitrogen in estuary to the number of forested cells on the watershed.

Costanza et al., NJ report

2. Determine appropriate units for key ecosystem services



Retention of ^{15}N varies by ecosystem type

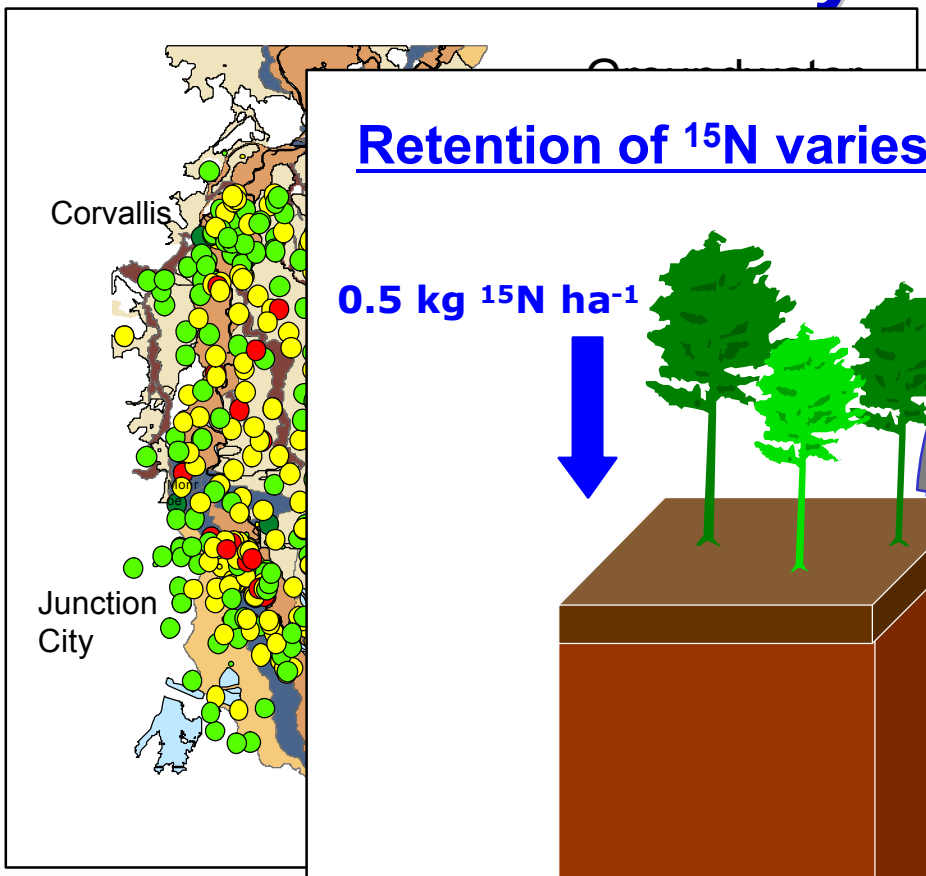


Fate

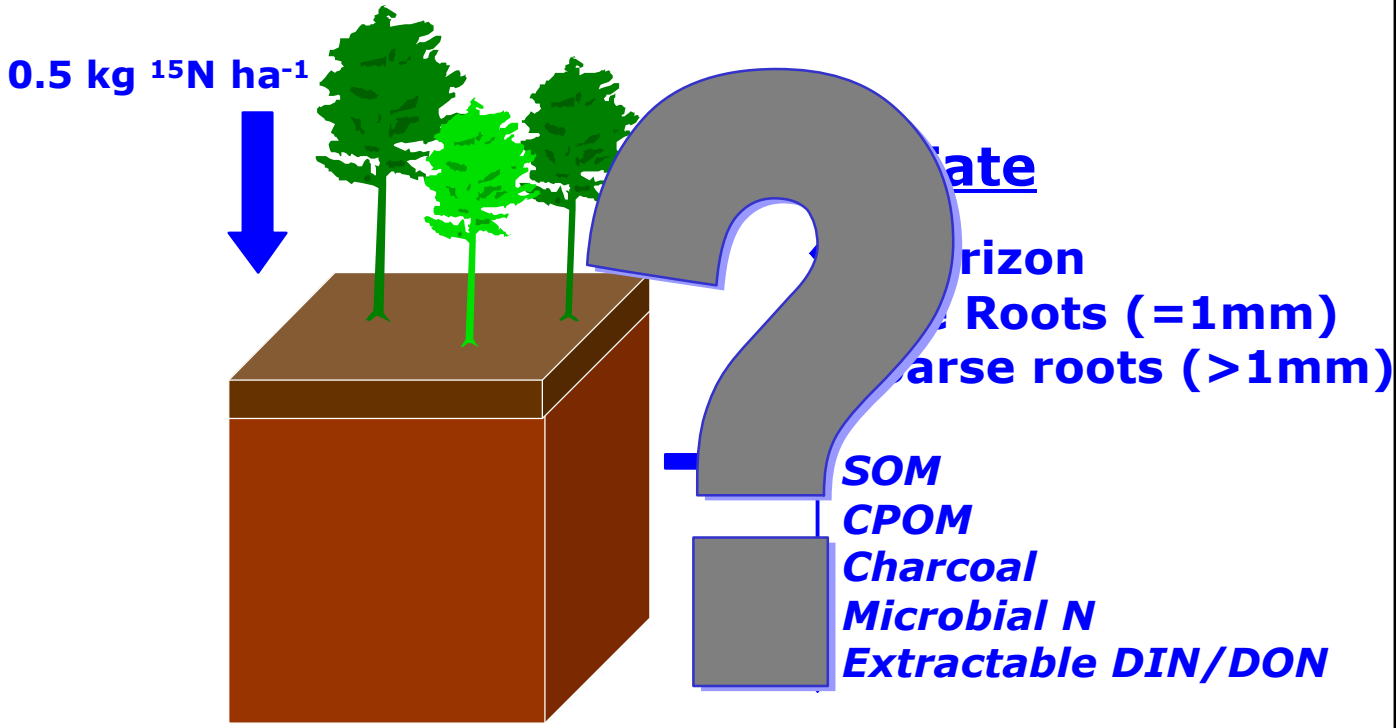
O horizon
Fine Roots (=1mm)
Coarse roots (>1mm)

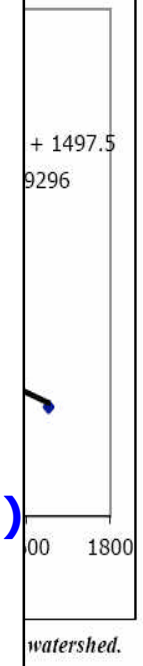
SOM
CPOM
Charcoal
Microbial N
Extractable DIN/DON

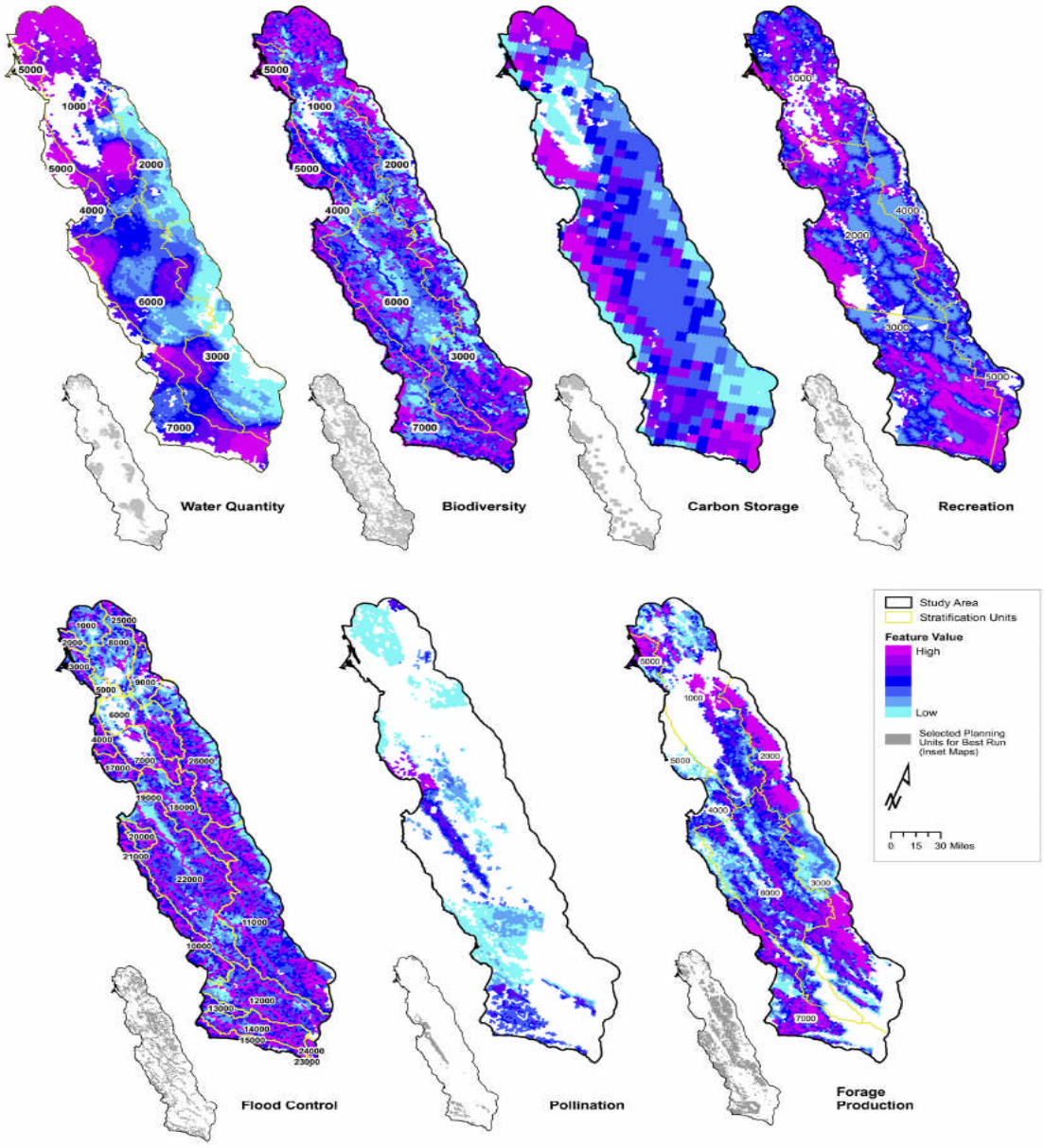
2. Determine appropriate units for key ecosystem services



Retention of ^{15}N varies by ecosystem type







3. Develop an approach to inventory and map ES

Inventory and mapping the location and value of Ecosystem Services is an essential component of

W-ESP (Chan et al. 2006)

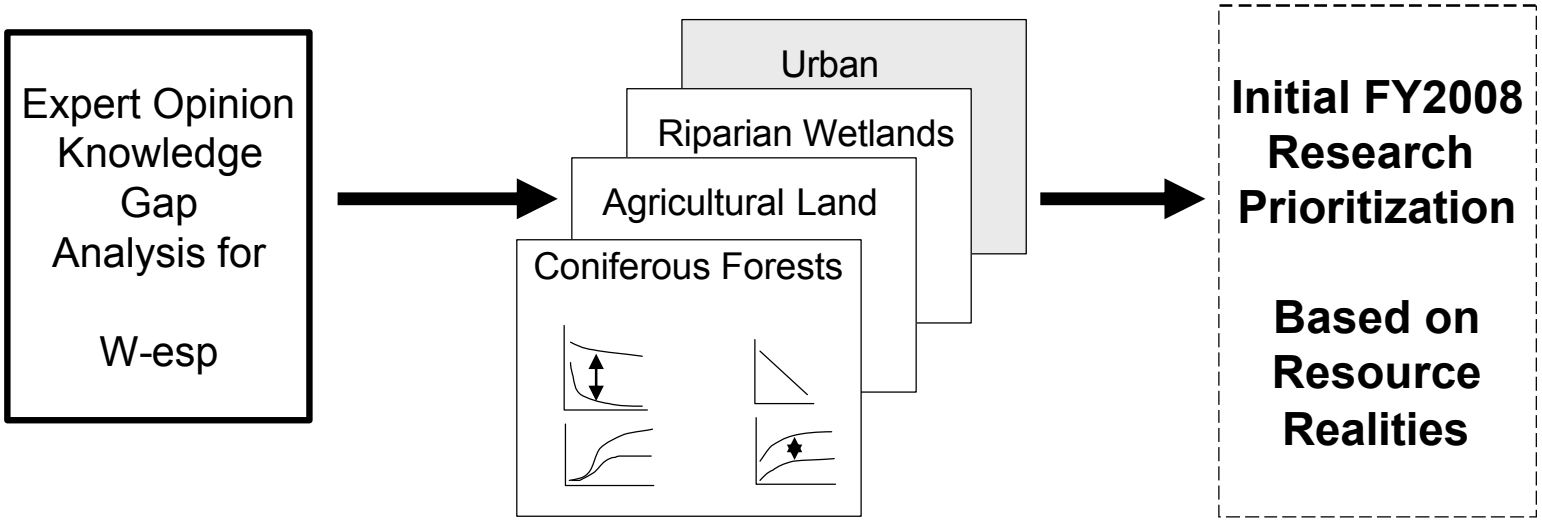
3. Develop an approach to inventory and map ES

- Early Product for W-ESP
- Cuts across all place-based research
- Illustrates the natural "bundling" of services by land use
- Provides a visual of ecosystem services
- Good way to share information with stakeholders

4. Identify knowledge gaps in assessing WESD ecosystem services

- Ecosystem type
- Stressor
- Ecosystem service

Approach to Conceptualizing W-ESP Forcing Variables and Their Priority



Major Land Use Categories
Willamette Ecosystem Service
District

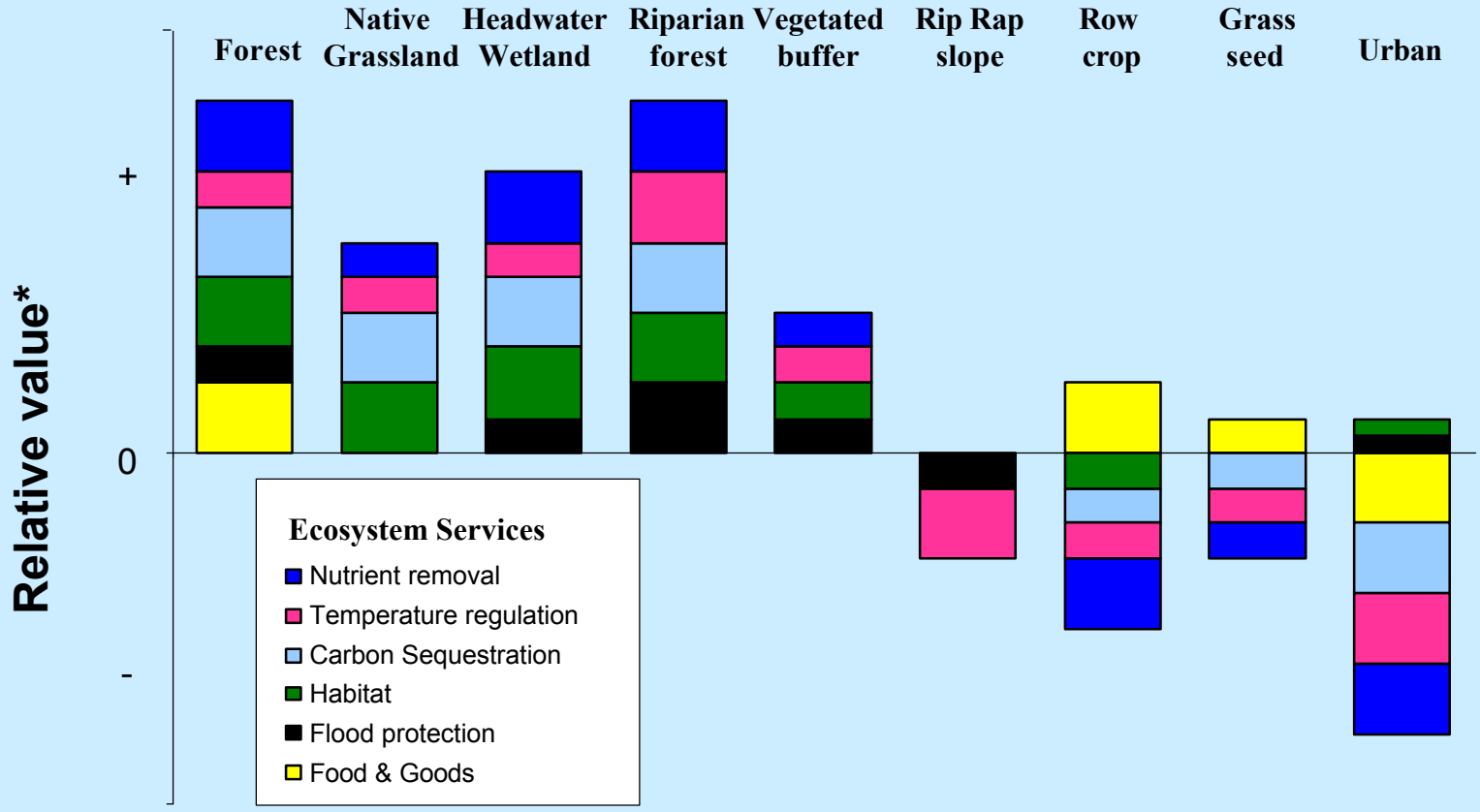
Table 2-3 Expert opinion research prioritization on Water Supply, by land use in the Willamette Basin.

Ecosystem type	2001 Spatial extent* %	Expected change in spatial extent of ecosystem type (--- to +++)	Impact on Service (--- to +++)	Knowledge gaps (+-+++)
Urban/Developed	7.7	++	---	+
Wetland	2.0	0/+	++/-	++
Grassland	2.9	-/0	+	+
Water	1.0	0/+	++/--	+ ?climate change
Oak Savannas	nq	-	+	+
Barren	0.9			
Snow/Ice	0.3	---	+++	+++

89%

Hypothetical ecosystem service values:

Bundled by land use in the Willamette ESD

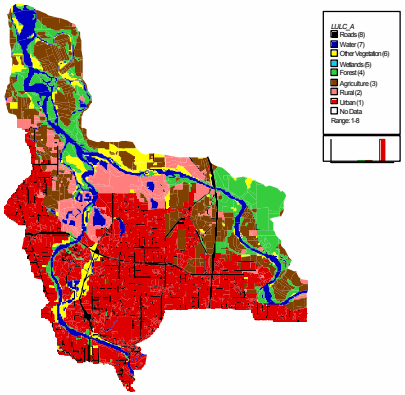


*Relative value could be a rate, say kg/ha/yr, or represent economic or social value.

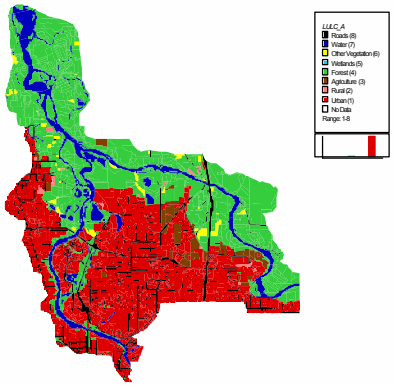
River corridor restoration:

Multiple ecosystem service benefits

Initial Conditions



50-Yr Conservation Run

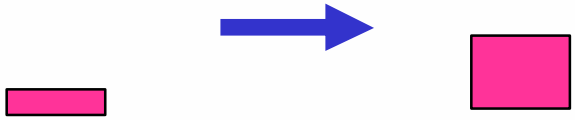


Scenarios

Evoland output, Gregory & Bolte, OSU

Ecosystem Service:

Temp. Reg.

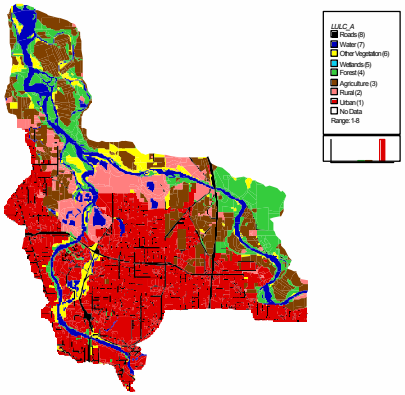


Temperature regulation

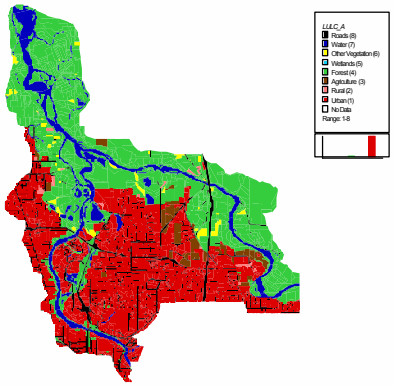
River corridor restoration:

Multiple ecosystem service benefits

Initial Conditions

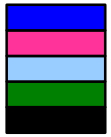


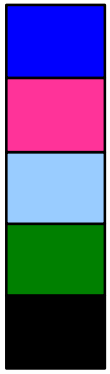
50-Yr Conservation Run



Scenarios
(Evoland output, Gregory & Bolte, OSU)

Ecosystem Services: Multiple





- Nutrient removal
- Temperature regulation
- Carbon Sequestration
- Habitat
- Flood protection

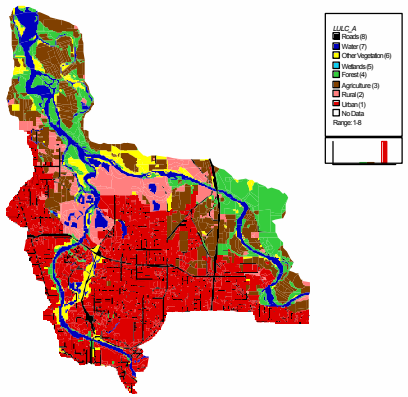
River corridor restoration:

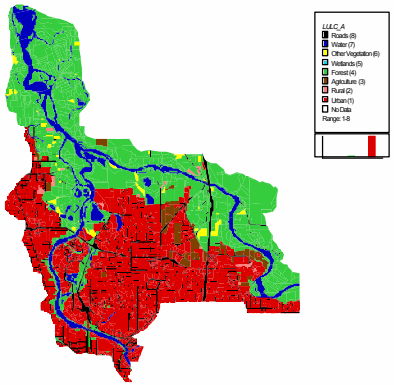
Influence of stressors?

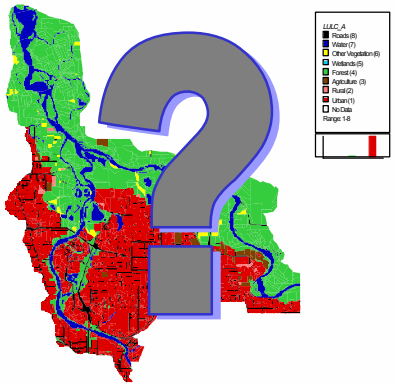
Initial Conditions

50-Yr Conservation Run

50-Yr Conservation + Climate change

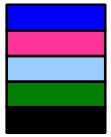


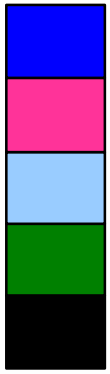




Scenarios
(Evoland output, Gregory & Bolte, OSU)

Ecosystem Services:
Multiple





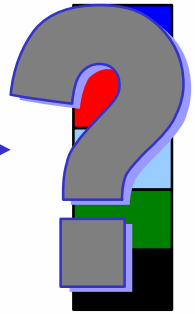
Nutrient removal

Temperature regulation

Carbon Sequestration

Habitat

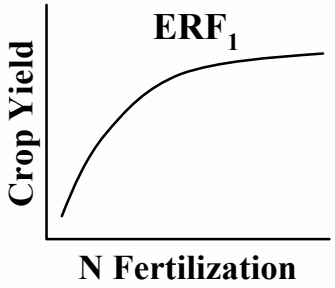
Flood protection



Definition of Terms

- Forcing Variables (Stressors)
  - Factors, both natural and anthropogenic, affecting quantifiable changes in the status (e.g. amounts & fluxes) of ecosystem processes
- ERF: Ecological Response Function
  - The response of an ecosystem service to a particular forcing variable
- ETF: Ecological Trade-off Function
  - The relationships between two (or more) ecosystem services in response to the same forcing variable (…and, eventually, multiple forcing variables)

Ecosystem Service vs. Forcing Variable = ERF



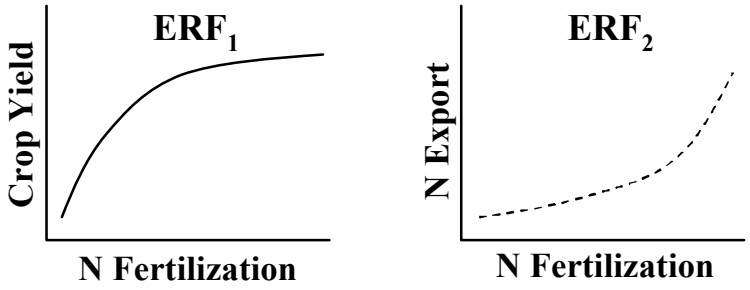
ERF Y-axis: Ecosystem Services

- Crop Yield
- Water Quality
- Water Quantity
- Carbon Sequestration
- N_2O, NO_x, CH_4

ERF X-axis: Forcing Variables

- N Fertilization (amount, timing)
- Harvest (interval, intensity, residues)
- Climate (Temp, Precip, Light, CO_2)
- Cover type (% landscape coverage)
- Riparian buffers (width, age, species)

Ecosystem Service vs. Forcing Variable = ERF



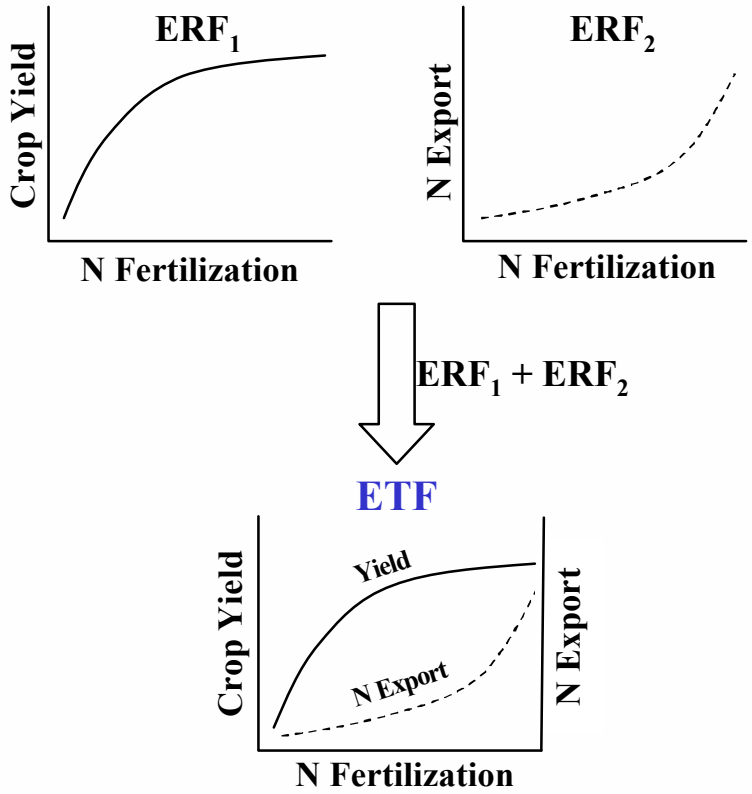
ERF Y-axis: Ecosystem Services

- Crop Yield
- Water Quality
- Water Quantity
- Carbon Sequestration
- N_2O, NO_x, CH_4

ERF X-axis: Forcing Variables

- N Fertilization (amount, timing)
- Harvest (interval, intensity, residues)
- Climate (Temp, Precip, Light, CO_2)
- Cover type (% landscape coverage)
- Riparian buffers (width, age, species)

Ecosystem Service vs. Forcing Variable = ERF



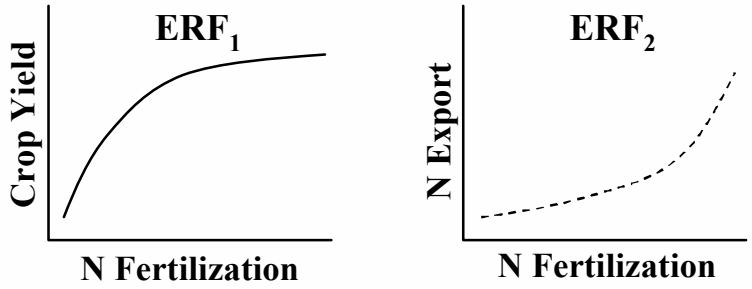
ERF Y-axis: Ecosystem Services

- Crop Yield
- Water Quality
- Water Quantity
- Carbon Sequestration
- N_2O, NO_x, CH_4

ERF X-axis: Forcing Variables

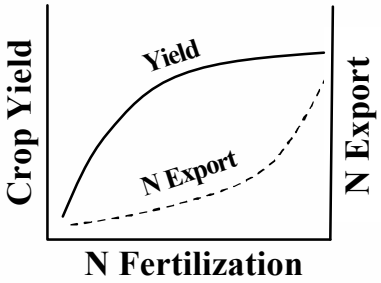
- N Fertilization (amount, timing)
- Harvest (interval, intensity, residues)
- Climate (Temp, Precip, Light, CO_2)
- Cover type (% landscape coverage)
- Riparian buffers (width, age, species)

Ecosystem Service vs. Forcing Variable = ERF



$ERF_1 + ERF_2$

ETF



Socioeconomics

Valuation & Trading of Ecosystem Services

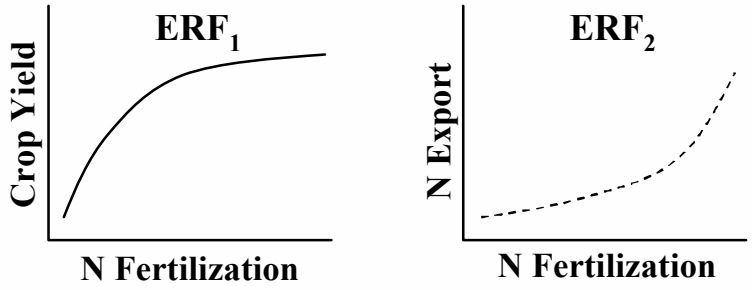
ERF Y-axis: Ecosystem Services

- Crop Yield
- Water Quality
- Water Quantity
- Carbon Sequestration
- N_2O, NO_x, CH_4

ERF X-axis: Forcing Variables

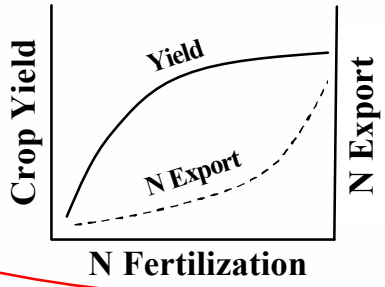
- N Fertilization (amount, timing)
- Harvest (interval, intensity, residues)
- Climate (Temp, Precip, Light, CO_2)
- Cover type (% landscape coverage)
- Riparian buffers (width, age, species)

Ecosystem Service vs. Forcing Variable = ERF



$ERF_1 + ERF_2$

ETF



Socioeconomics

Valuation & Trading of Ecosystem Services

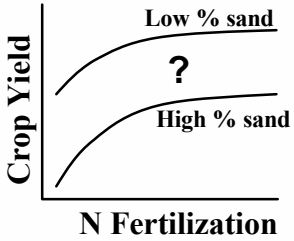
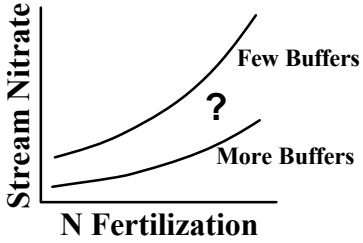
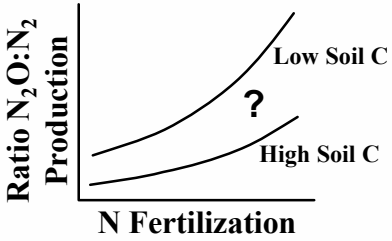
ERF Y-axis: Ecosystem Services

- Crop Yield
- Water Quality
- Water Quantity
- Carbon Sequestration
- N_2O, NO_x, CH_4

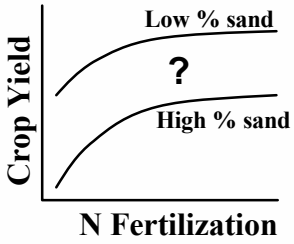
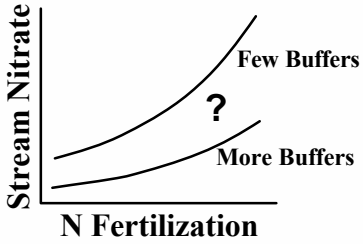
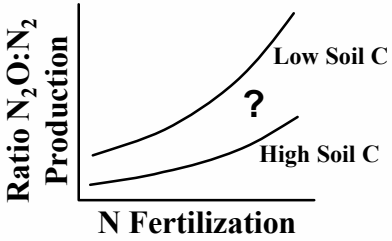
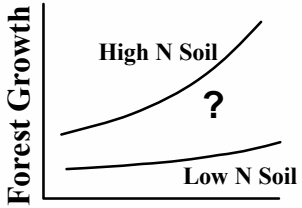
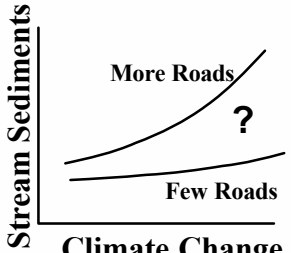
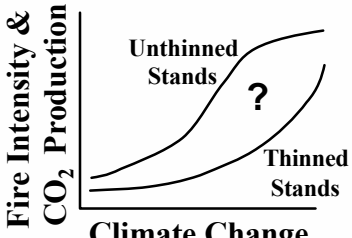
ERF X-axis: Forcing Variables

- N Fertilization (amount, timing)
- Harvest (interval, intensity, residues)
- Climate (Temp, Precip, Light, CO_2)
- Cover type (% landscape coverage)
- Riparian buffers (width, age, species)

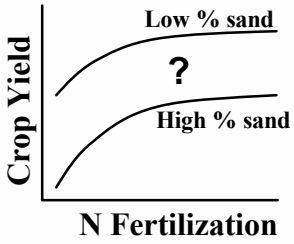
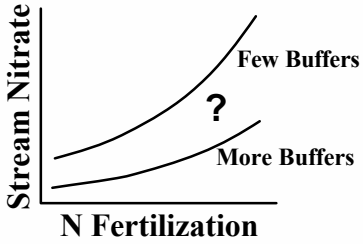
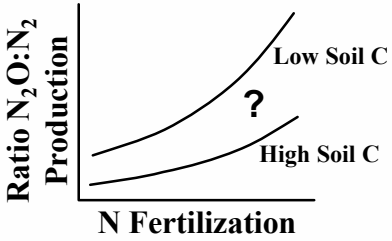
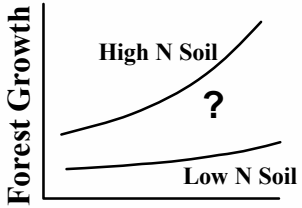
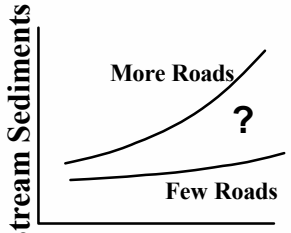
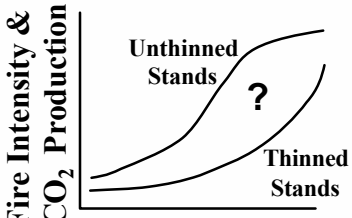
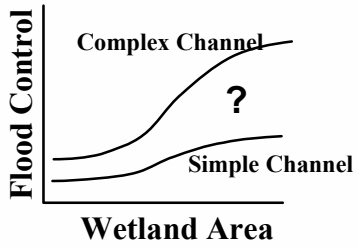
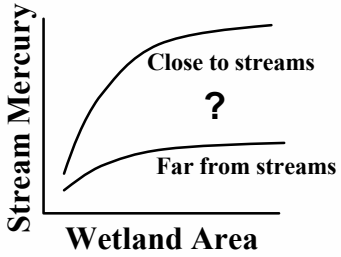
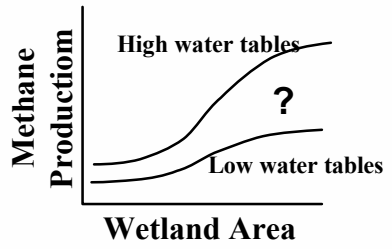
Knowledge Gap Analysis in an ERF (& ETF) Format

	Crop & Water Yield	Water Quality	Greenhouse Gases
Agricultural Lands			

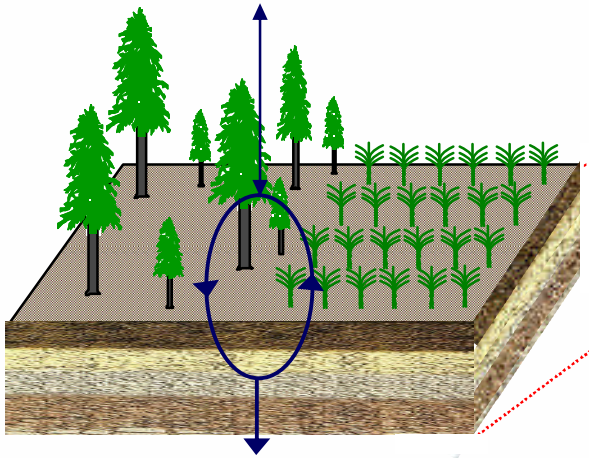
Knowledge Gap Analysis in an ERF (& ETF) Format

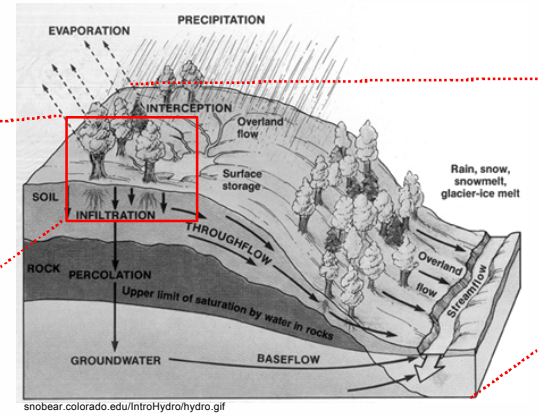
	Crop & Water Yield	Water Quality	Greenhouse Gases
Agricultural Lands			
Coniferous Forests			

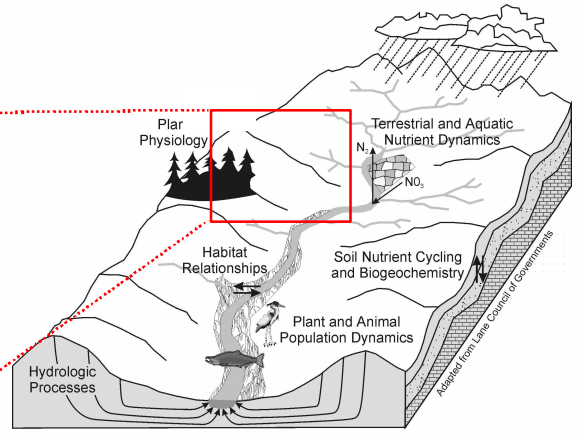
Knowledge Gap Analysis in an ERF (& ETF) Format

	Crop & Water Yield	Water Quality	Greenhouse Gases
Agricultural Lands			
Coniferous Forests			
Riparian Wetlands			

Scaling Up Ecosystem Services

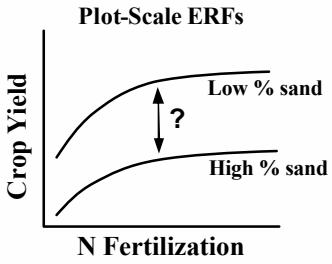


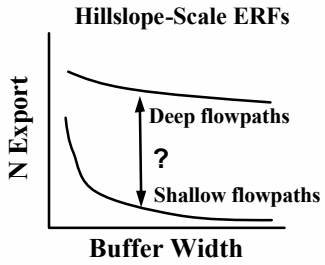


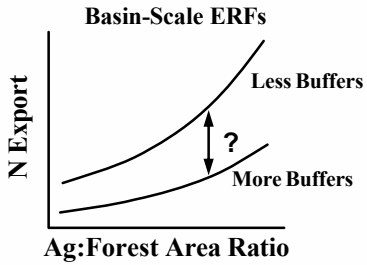


Plots, Stands ***Hillslopes, Catchments*** ***Basin, Region***

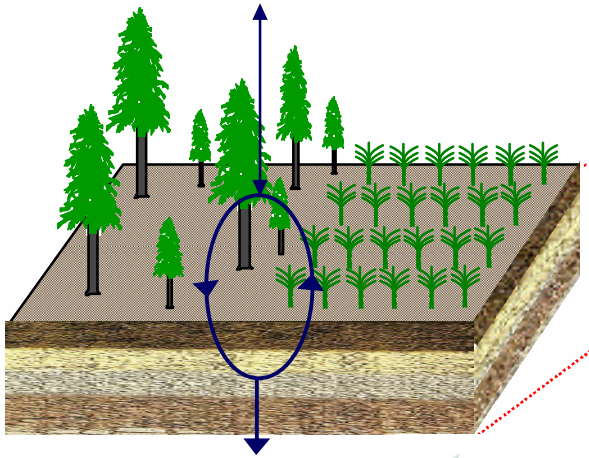
Using nitrogen addition & export as an example…

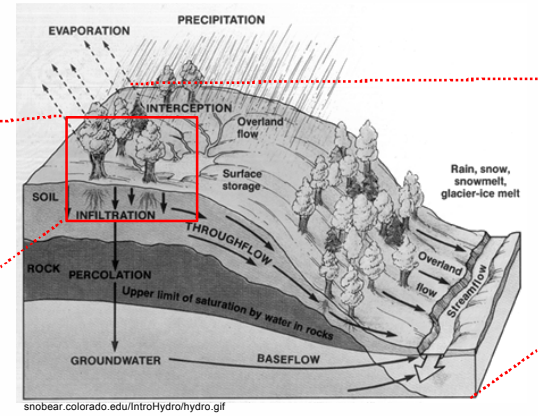


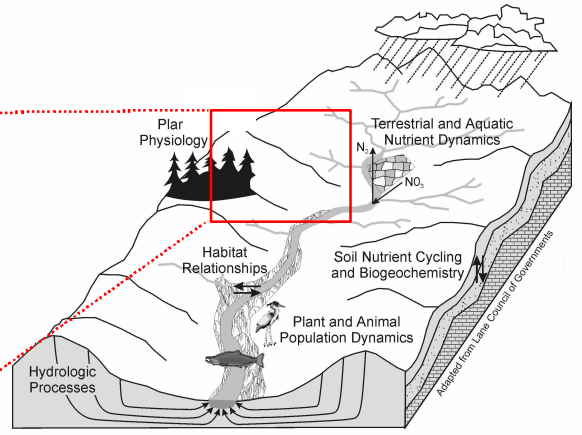




Scaling Up Ecosystem Services

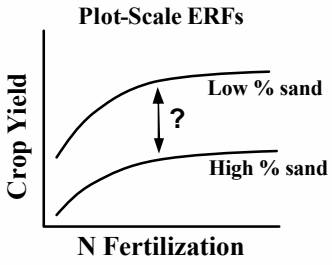


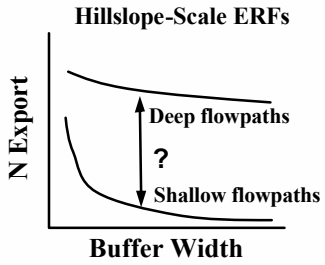


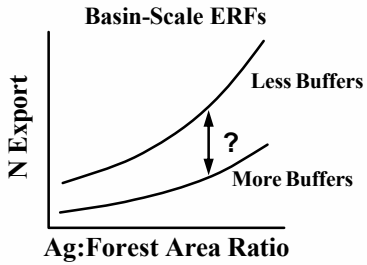


Plots, Stands ***Hillslopes, Catchments*** ***Basin, Region***

Using nitrogen addition & export as an example…



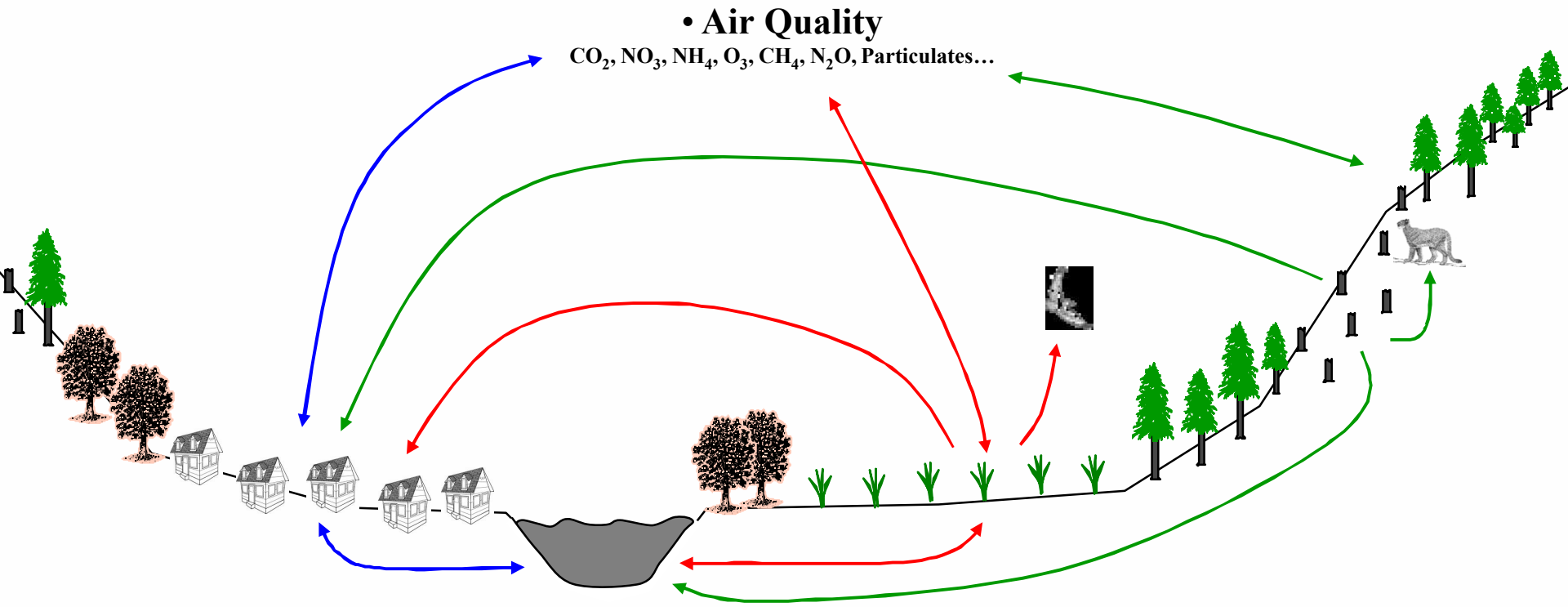




Models: Statistical and Process-Based

Synthesize & Scale Up Data → Plots to Region, Days to Centuries

Bundled Services → Land, Air, Water Tradeoffs



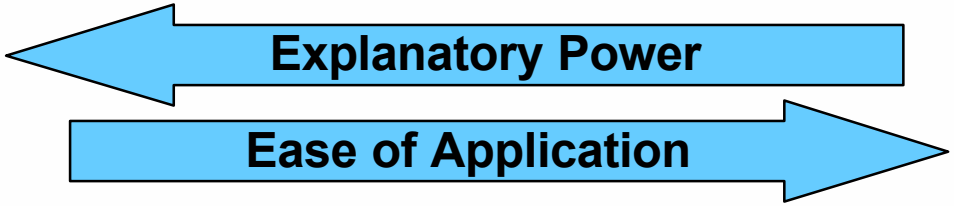
- Human Impacts & Well-being
- Water Quality & Quantity
- Ag Products
- Forest Products
- Aquatic Habitats & Wildlife
- Terrestrial Habitats & Wildlife

Models for Willamette Ecosystem Services

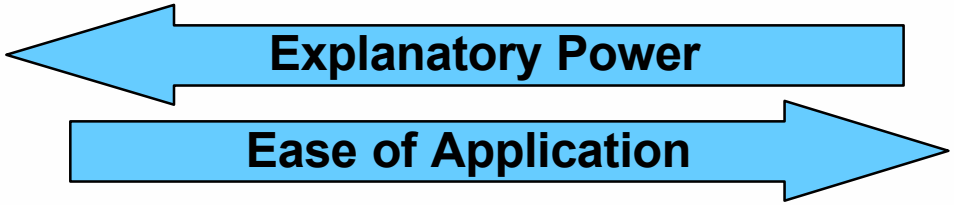
	Air Quality (CO_2, NO_x, N deposition)	Ag & Forest Products	Water Quantity	Water Quality (N, P, sediment)
CENTURY	✓	✓		
GT-MEL	✓	✓	✓	✓
AGWA			✓	✓
SPARROW				✓

Scaling Issues

	Plots	Hillslopes	Water-sheds	Basin, Region
CENTURY	✓			
GT-MEL	✓	✓	✓	
AGWA			✓	✓
SPARROW				✓



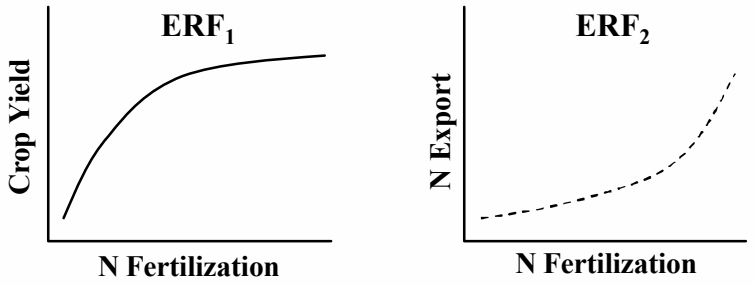
	Plots	Hillslopes	Water-sheds	Basin, Region
CENTURY	✓			
GT-MEL	✓	✓	✓	
AGWA			✓	✓
SPARROW				✓



	Plots	Hillslopes	Water-sheds	Basin, Region
CENTURY	✓			
GT-MEL	✓	✓	✓	
AGWA			✓	✓
SPARROW				✓

Other Modelers Welcome!

Ecosystem Service vs. Forcing Variable = ERF



ERF Y-axis: Ecosystem Services

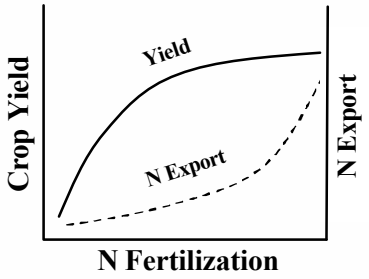
- Crop Yield
- Water Quality
- Water Quantity
- Carbon Sequestration
- N_2O, NO_x, CH_4

ERF X-axis: Forcing Variables

- N Fertilization (rate, timing, form)
- Harvest (interval, intensity, residues)
- Climate (Temp, Precip, Light, CO_2)
- Cover type (% landscape coverage)

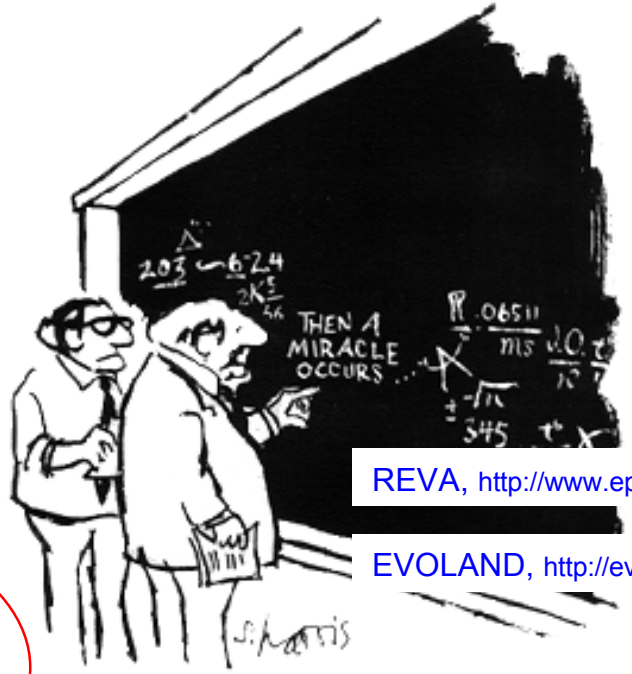
$ERF_1 + ERF_2$

ETF



Socioeconomics

Valuation & Trading of Ecosystem Services

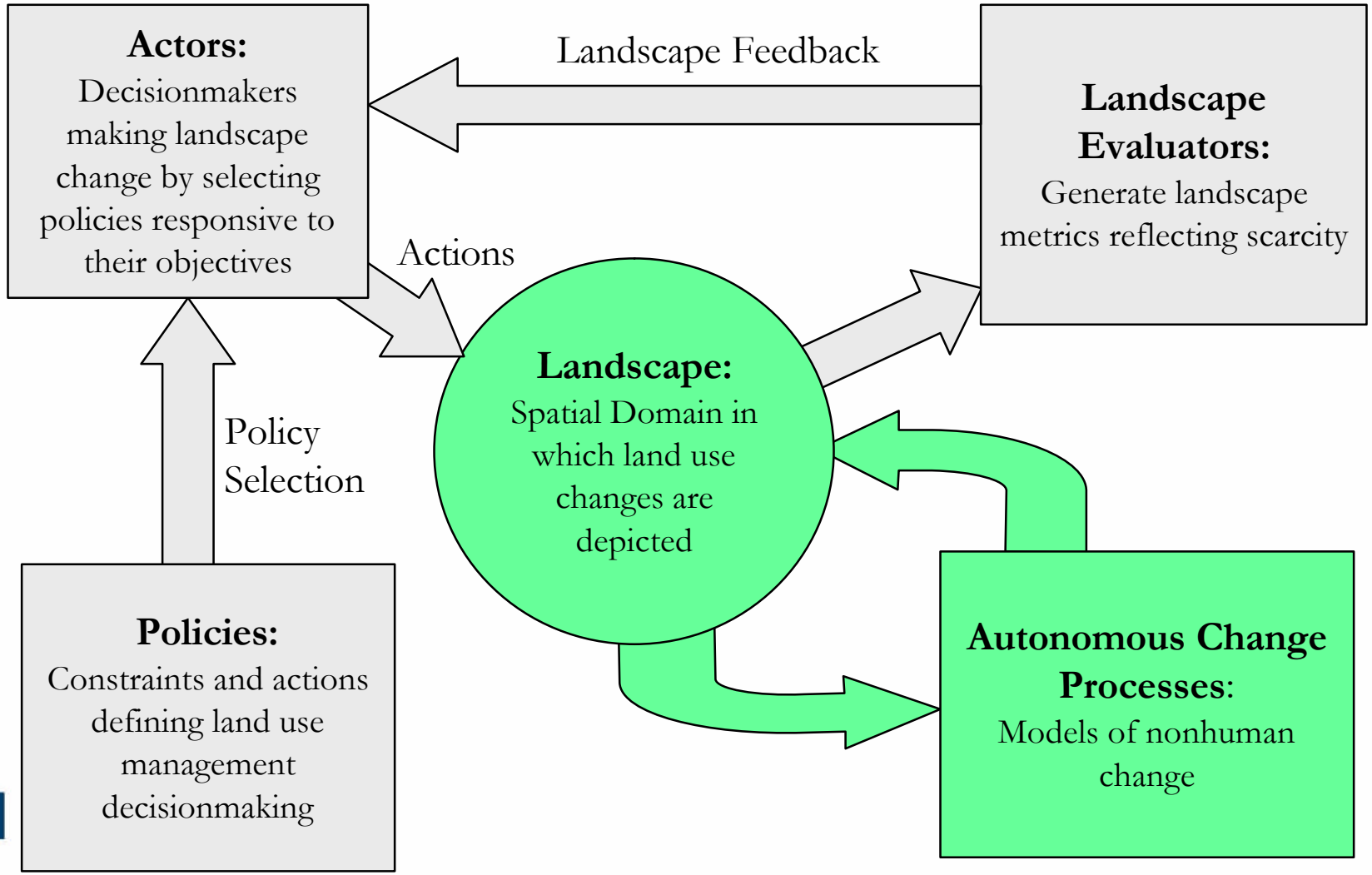


"I think you should be more explicit here in step two."

REVA, http://www.epa.gov/reva/

EVOLAND, http://evoland.bioe.orst.edu/

Evoland – General Structure



John Bolte, Oregon State University

Willamette Ecosystem Services Project

Annual Performance Goals

Year 1 APG (FY 2008) Apply the Environmental Decision Toolkit to existing Willamette alternative futures data sets to determine its feasibility as a preliminary decision support tool for WESP.

Year 2 APG (FY 2009) Map and inventory of status and trends for key ecosystem components and processes in the Willamette River Basin.

Year 3 APG (FY 2010) Address critical knowledge gaps between ecological processes and ecosystem services, so that measured processes can be translated into quantifiable ecosystem services.

Year 4 APG (2011) At an appropriate scale, determine the location and value of bundled ecosystem services in the Willamette Valley incorporating W- ESP research outputs that link Ecosystem service indicators and functions.

Year 5 APG (FY 2012) **Provide tool(s) that are used by Region X decision makers during FY 2013 to evaluate bundles of ecosystem services and options for their management and protection in the Willamette ecosystem services district.**

GRANDIOSE MODEL!!

Status Assessment

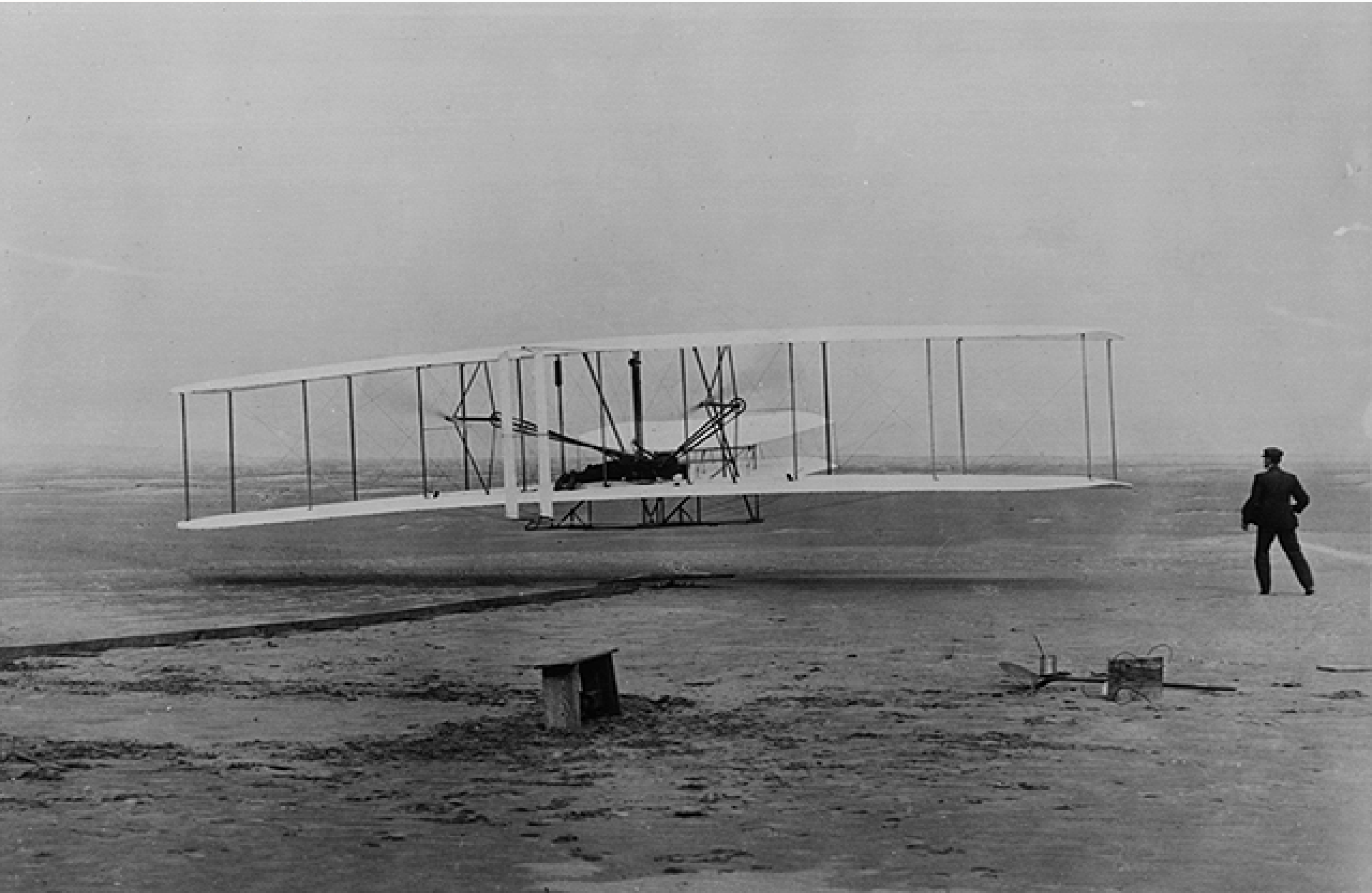
- Strengths
  - - ~ 7 Ecology (aqua.,terr., soil, plant)/3 Modeling FTE
  - Strong research experience and buy-in to WESP
  - Strong Division Support
  - Excellent and engaged research community and pledges of collaboration
  - Engaged 1º Client – Region X
- Weaknesses
  - Thin in some critical skill areas: valuation, spatial eco-economics
  - Current projected budget is restrictive

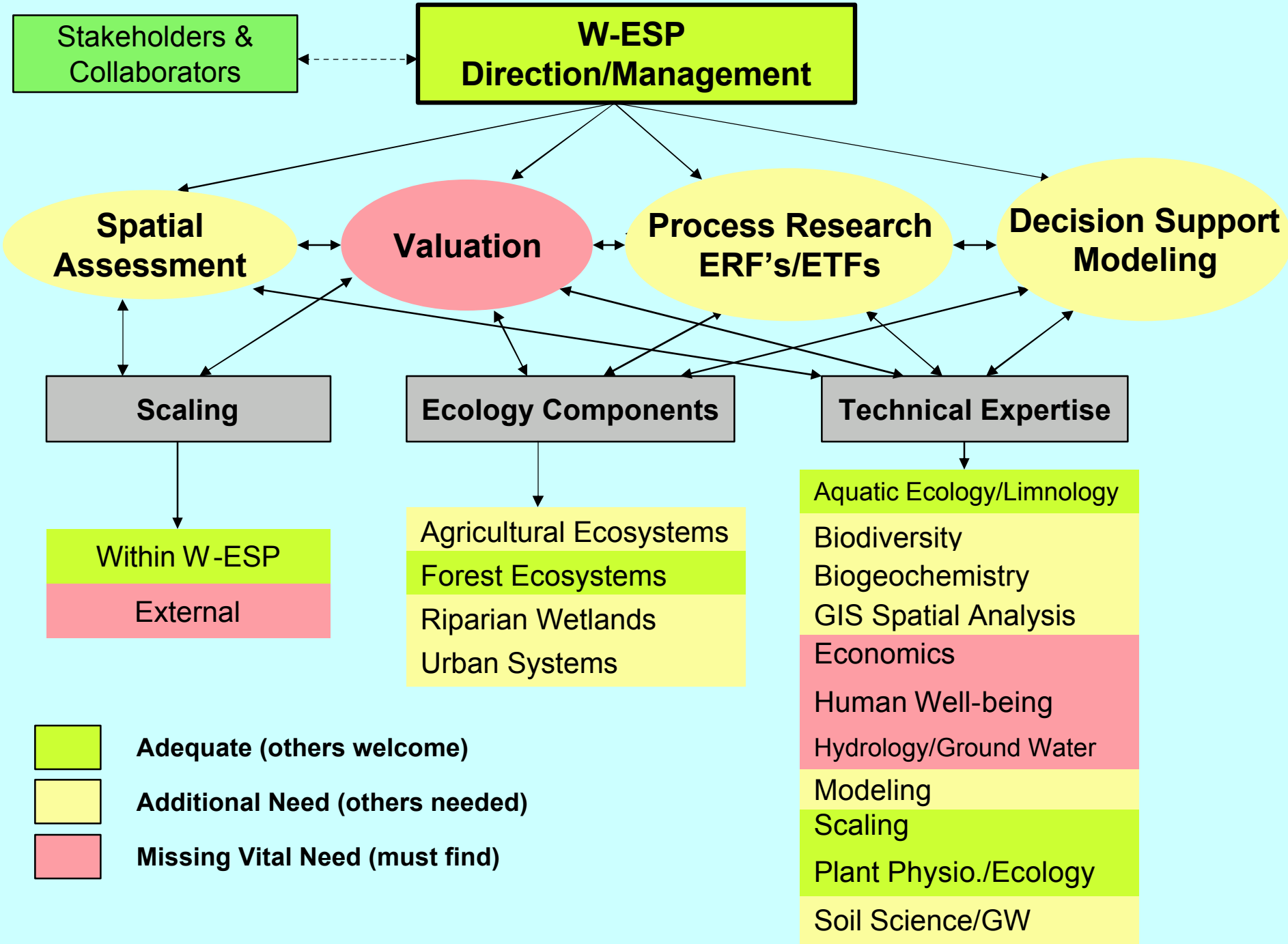
EPA

ECOLOGICAL RESEARCH PROGRAM

EPA

ECOLOGICAL RESEARCH PROGRAM

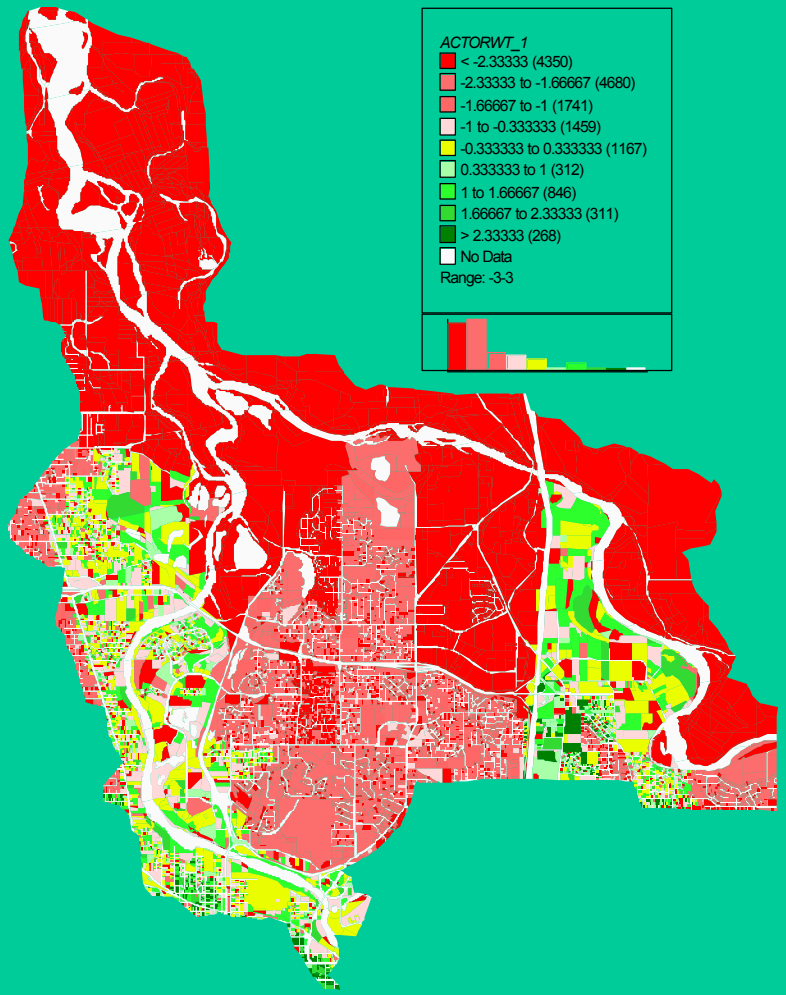



Stakeholders & Collaborators
W-ESP Direction/Management
Spatial Assessment
Valuation
Process Research ERF's/ETFs
Decision Support Modeling
Scaling
Ecology Components
Technical Expertise
Within W-ESP
External
Agricultural Ecosystems
Forest Ecosystems
Riparian Wetlands
Urban Systems
Aquatic Ecology/Limnology
Biodiversity
Biogeochemistry
GIS Spatial Analysis
Economics
Human Well-being
Hydrology/Ground Water
Modeling
Scaling
Plant Physio./Ecology
Soil Science/GW
Adequate (others welcome)
Additional Need (others needed)
Missing Vital Need (must find)

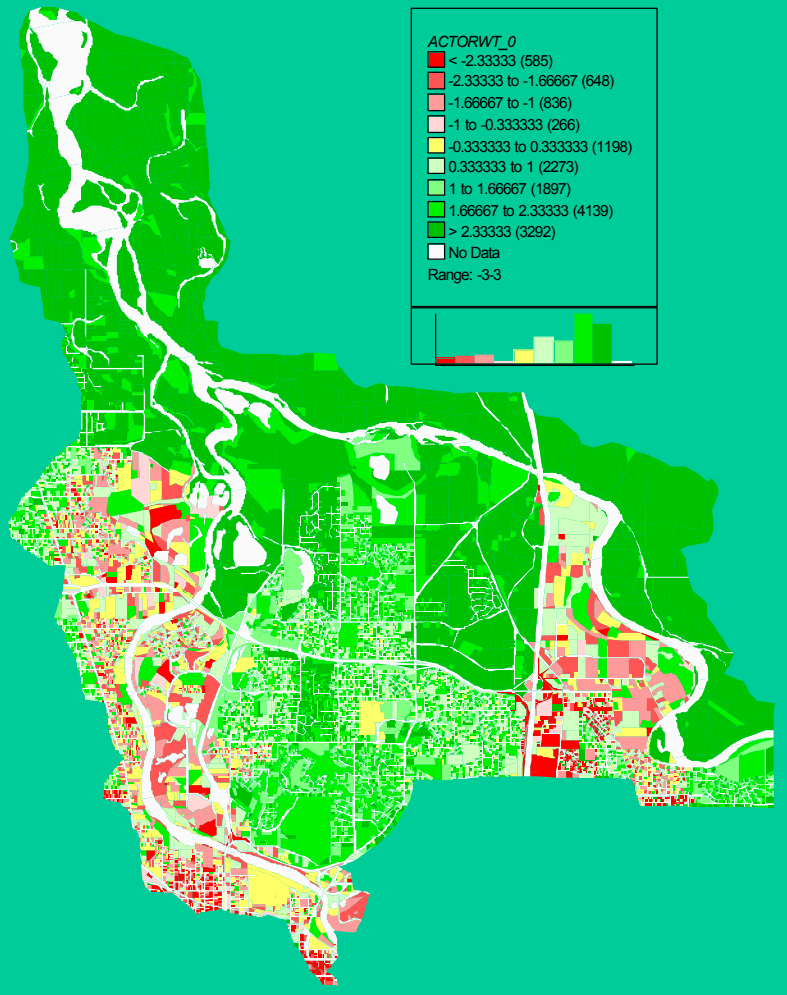
Let's Get to Work…

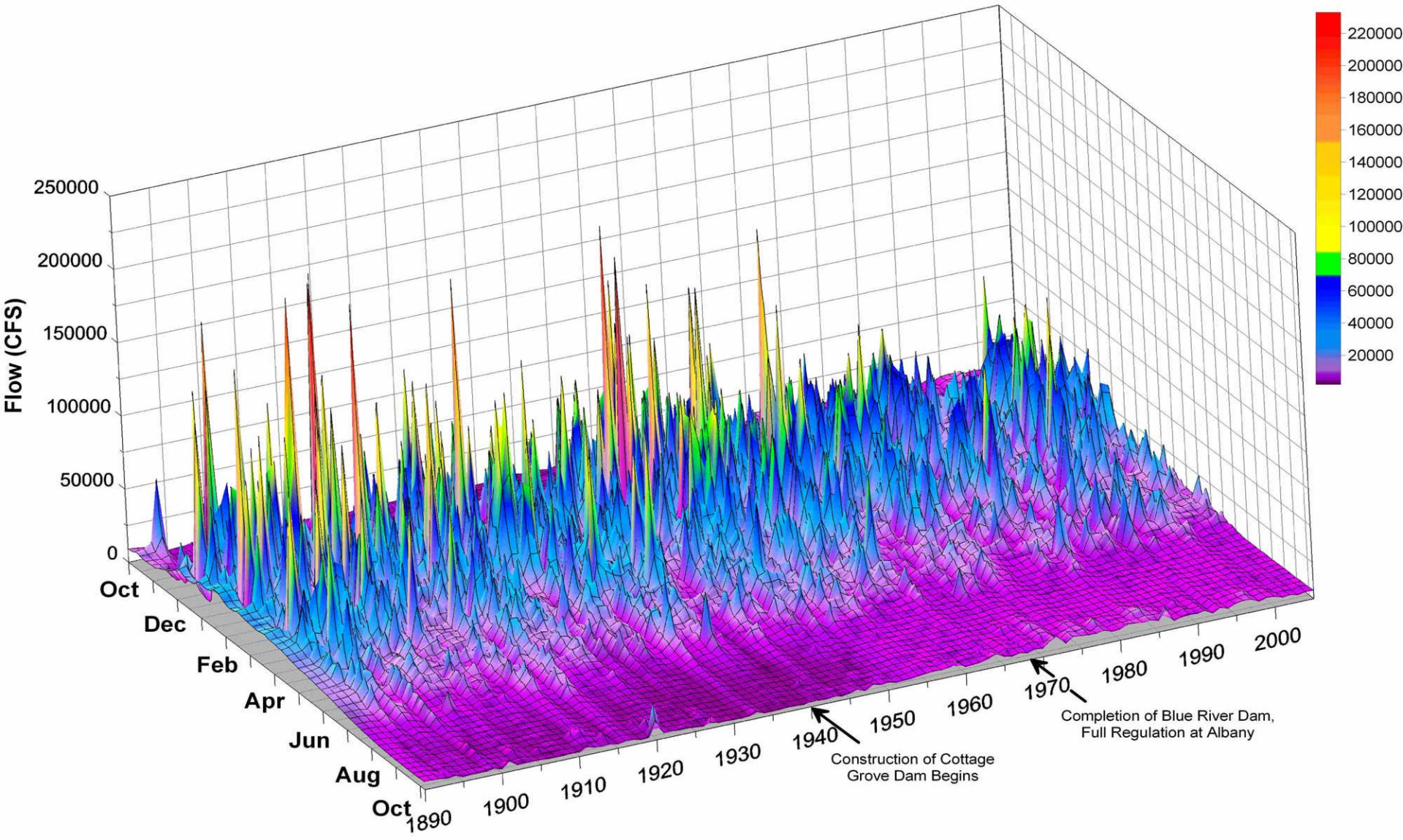
Actor Value Mapping

Ecosystem Health



Economics



John Bolte, Oregon State University

Observed Flow at USGS 14174000, Willamette River at Albany, OR