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Climate Change and Shifts in Water Related Ecosystem Services in the Tualatin and Yamhill River Basins

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Ecosystem Services

- Ecological characteristics, functions, or processes that directly or indirectly contribute to human well-being.
- In short, the benefits we receive from “natural capital”
- Market services (e.g., food, energy, timber)
- Nonmarket services (e.g., pollution filtering, temperature regulation, biodiversity habitat, aesthetics)

Humans benefits from a multitude of resources and processes that are supplied by natural ecosystems. Collectively, these benefits are known as **ecosystem services** and include products like clean drinking water and processes such as the decomposition of wastes.

Types of Ecosystem Services

1. **Provisioning** (e.g., food, timber, water)

2. **Regulating** (e.g., flood control, carbon sequestration, pollination)

3. **Cultural** (e.g., recreation, aesthetics, cultural identity)

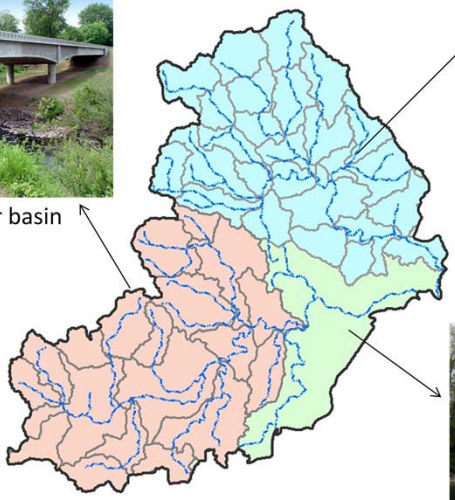
4. **Supporting** (e.g., soil formation, nutrient cycling, habitat provision - indirectly affect human benefits by facilitating provisioning, regulating and cultural services).

Source: Millennium Ecosystem Assessment (2005)

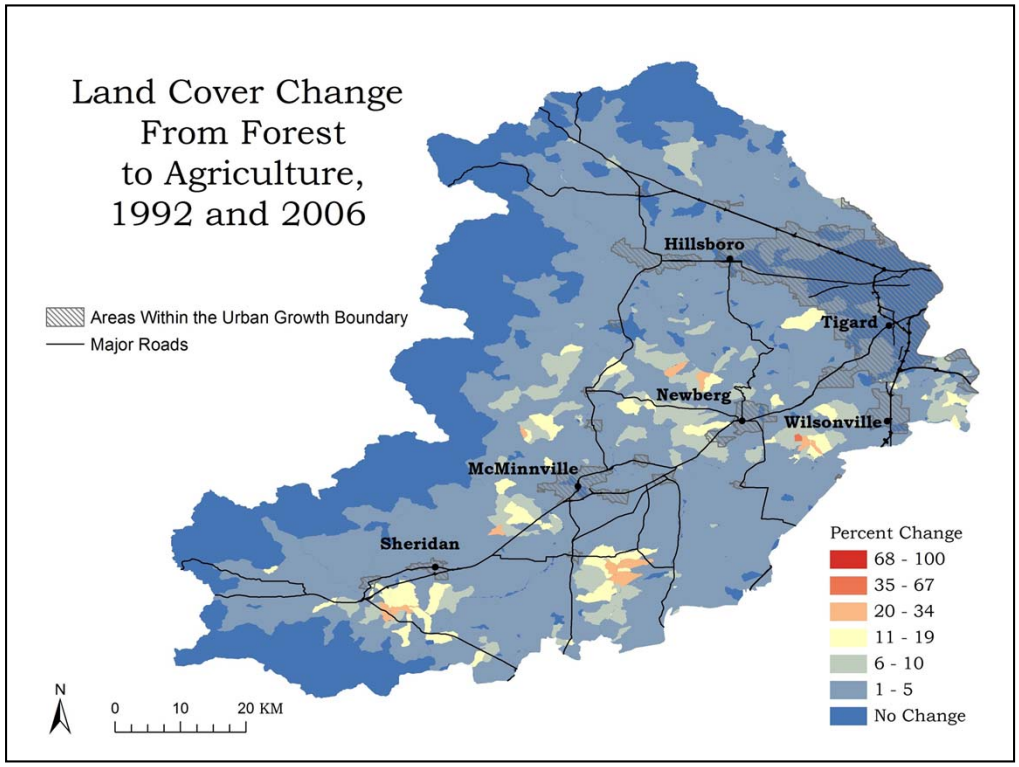
Study Area

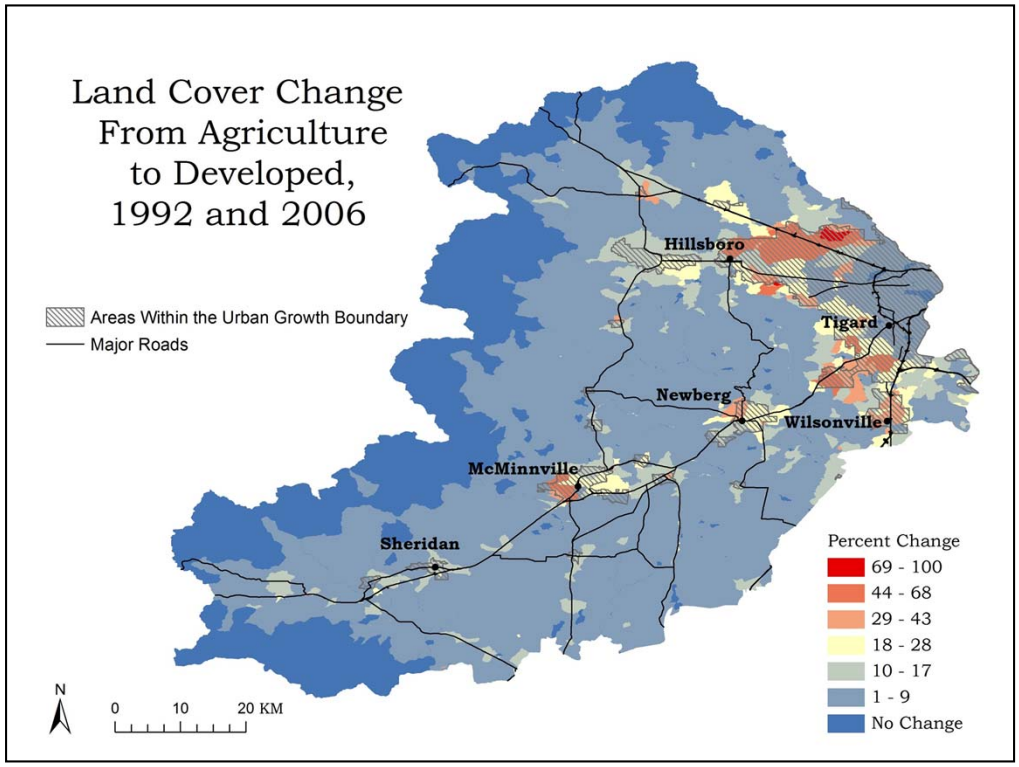
Tualatin River basin

Yamhill River basin

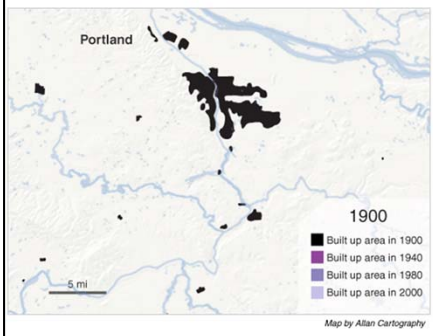


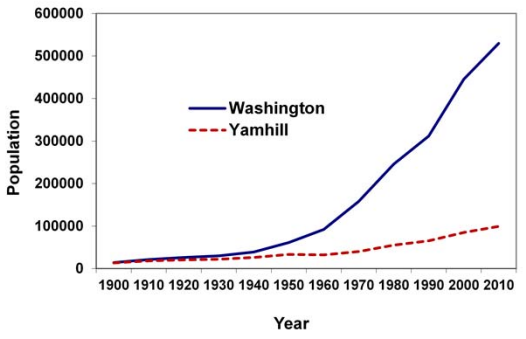
Lower Willamette and tributaries

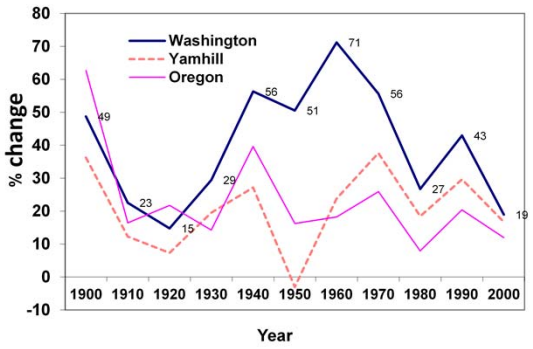

Land Cover Change
From Forest
to Agriculture,
1992 and 2006
Areas Within the Urban Growth Boundary
Major Roads
Hillsboro
Tigard
Newberg
Wilsonville
McMinnville
Sheridan
Percent Change
68 - 100
35 - 67
20 - 34
11 - 19
6 - 10
1 - 5
No Change
N
0
10
20 KM


Land Cover Change From Agriculture to Developed, 1992 and 2006
Areas Within the Urban Growth Boundary
Major Roads
Hillsboro
Tigard
Newberg
Wilsonville
McMinnville
Sheridan
N
0
10
20 KM
Percent Change
69 - 100
44 - 68
29 - 43
18 - 28
10 - 17
1 - 9
No Change

Population Change, 1900-2010

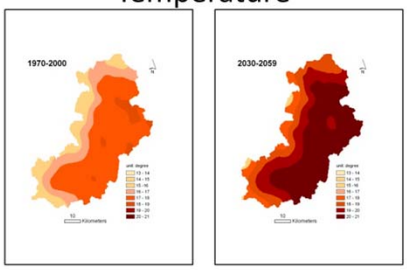




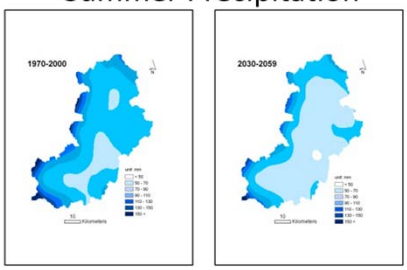


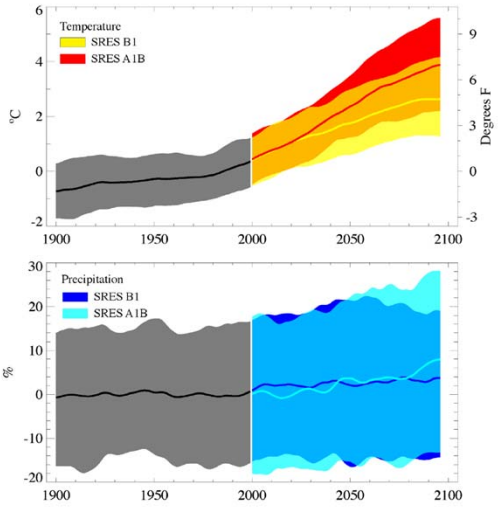
Climate Change, 1900-2100

Temperature



Summer Precipitation





Source: Mote and Salathe (2010) *Climatic Change*

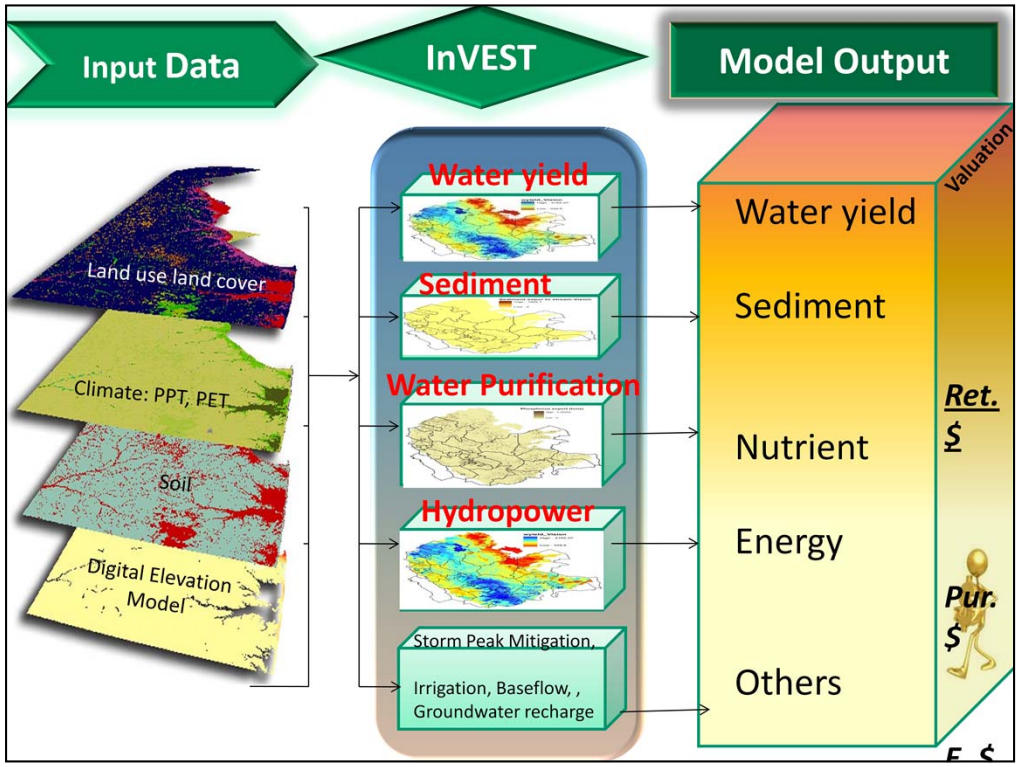
Research Questions

1. What is the effect of climate change on water-related ecosystem services (water yield, N, P, Sediment retention)?

2. Which parts of the basin provide the greatest water yield, sediment and nutrient retention?

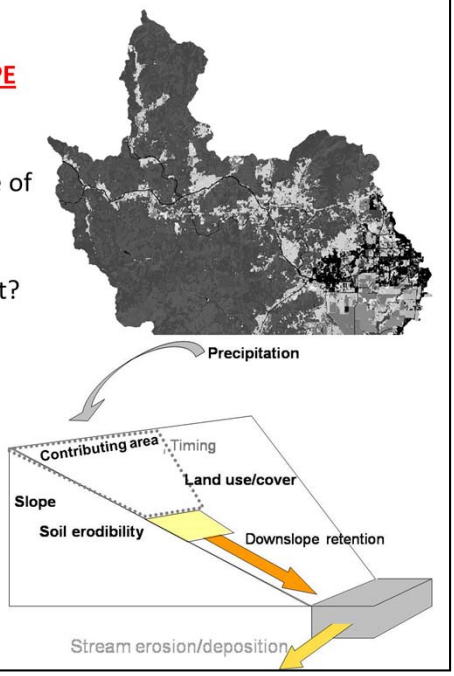
3. Do spatial patterns persist regardless of different climate regimes?

4. How do we bundle these multiple ecosystem services together?


Input Data
InVEST
Model Output
Land use land cover
Climate: PPT, PET
Soil
Digital Elevation Model
Water yield
Sediment
Water Purification
Hydropower
Storm Peak Mitigation,
Irrigation, Baseflow, ,
Groundwater recharge
Water yield
Sediment
Nutrient
Energy
Others
Valuation
Ret.
$
Pur.
$

InVEST Water Models' Objectives

- **VALUE OF EACH PARCEL ON THE LANDSCAPE**
- Need to determine contribution (production function) of each parcel in ecosystem service of interest
- Where are the sources of nutrients/sediment?
- Where are the nutrients/sediment retention areas?
- How much is retained?
- What is the value of this retention?

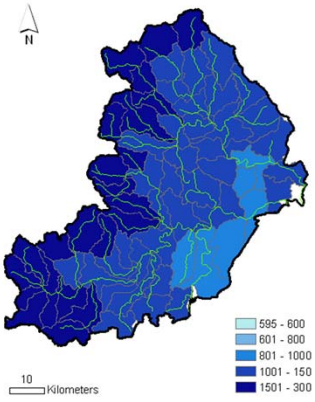


Datasets

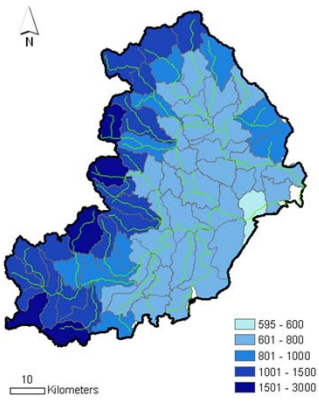
	Land Use/ Land Cover	Climate/ Weather	Streamflow
Current-Wet	USGS NLCD	NOAA 1995-1999	USGS/OWRD
Current-Norm	USGS NLCD	NOAA 2002-2006	USGS/OWRD
Current-Dry	USGS NLCD	NOAA 1988-1992	USGS/OWRD
Future – Dev (2050)	PNWERC or EPA ICLU	IPCC AR 5th	SWAT model output
Future – Cons (2050)	PNWERC or EPA ICLU + TNC Synthesis map	IPCCAR 5th	SWAT model output

Water Yield

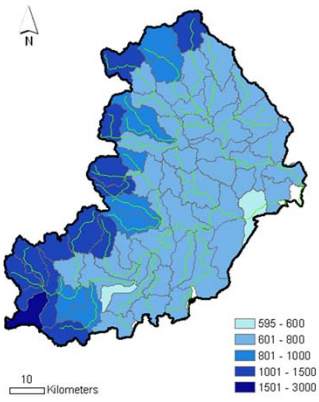
Wet year



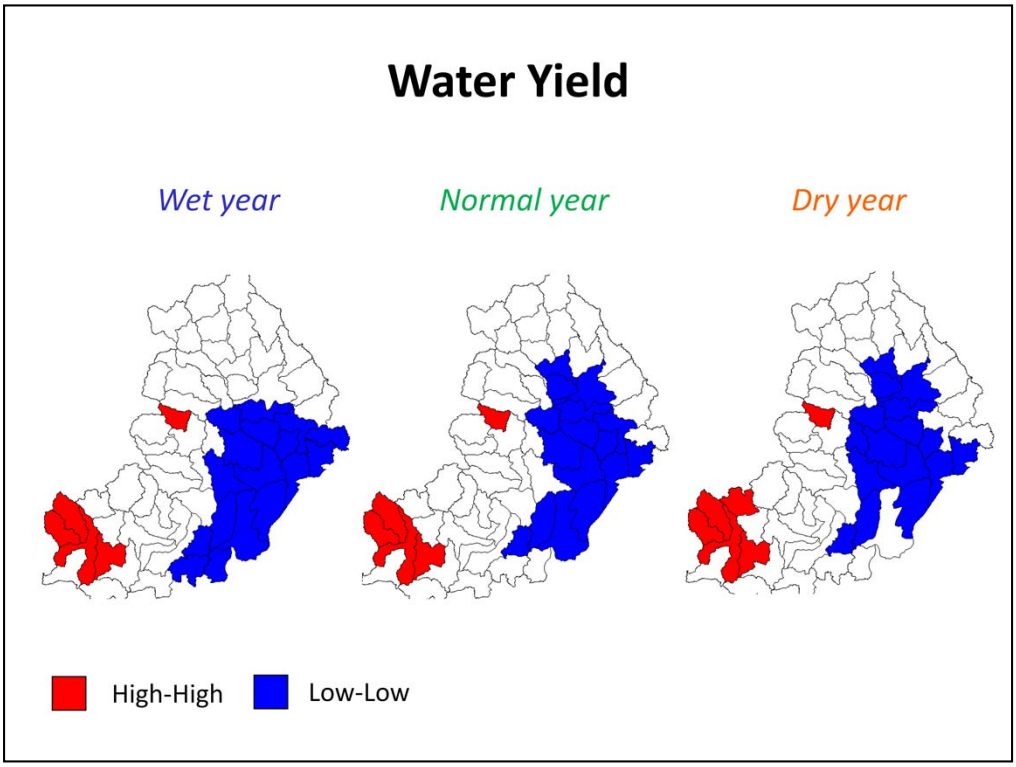
Normal year



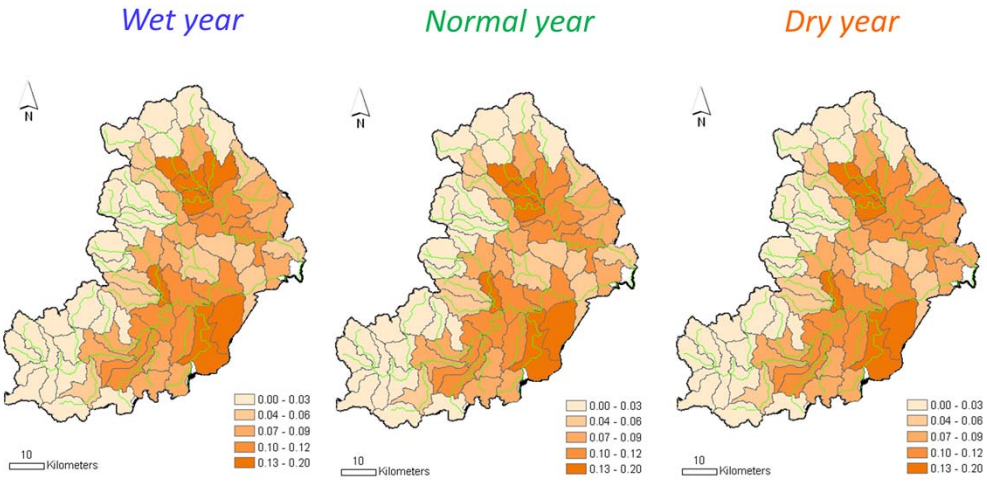
Dry year



(unit: m^3)

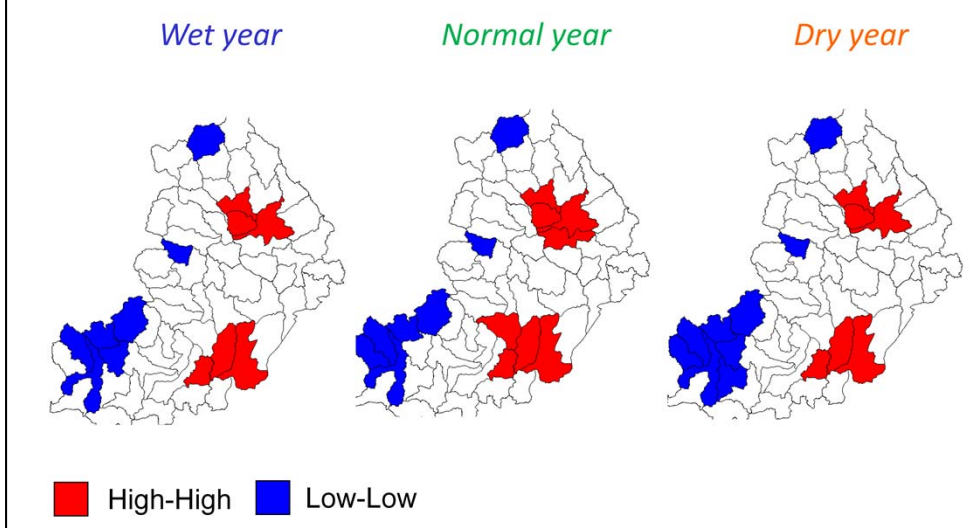

Water Yield
Wet year
Normal year
Dry year
High-High
Low-Low

Phosphorous retention



(unit: kg)

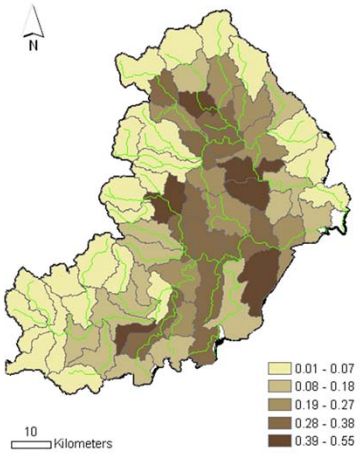
Phosphorous Retention



High-High Low-Low

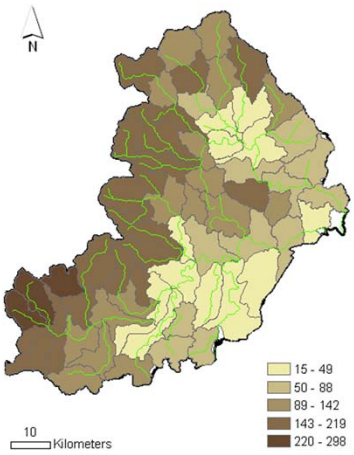
Sediment (Normal year)

Sediment (load)

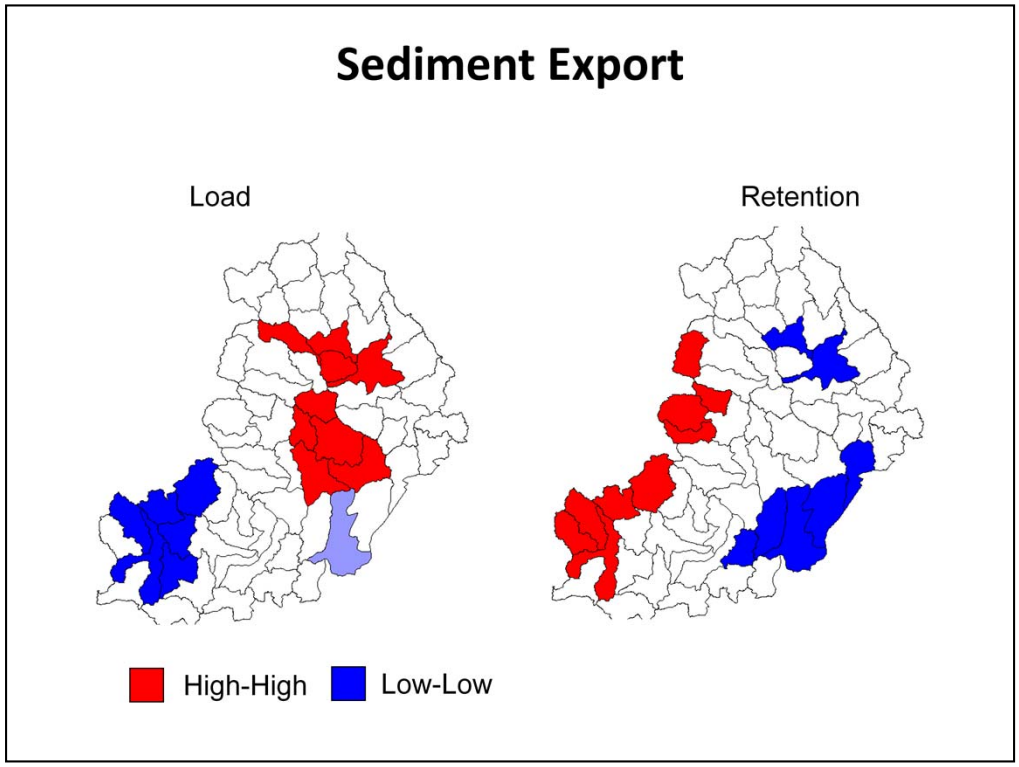


(unit: tons)

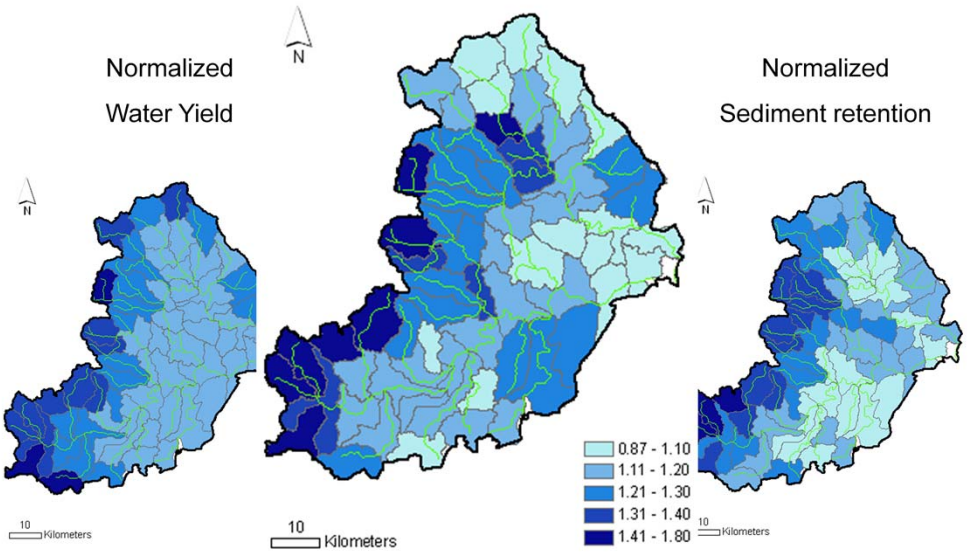
Sediment (retention)



(unit: tons)


Sediment Export
Load
Retention
High-High
Low-Low

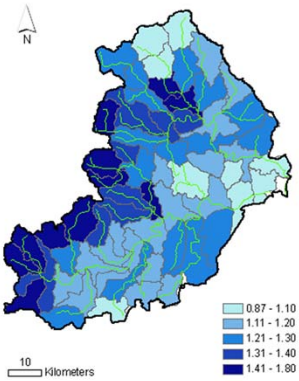
Bundled Process (Normal year)



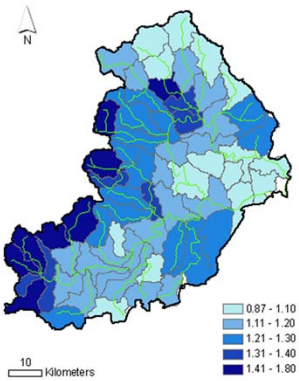
Bundled results

(water yield + P retention + Sediment retention)

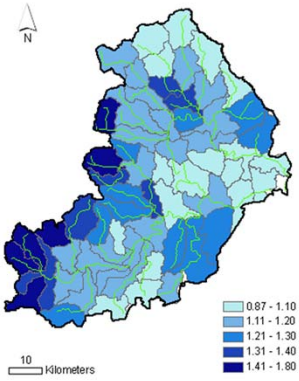
Wet year



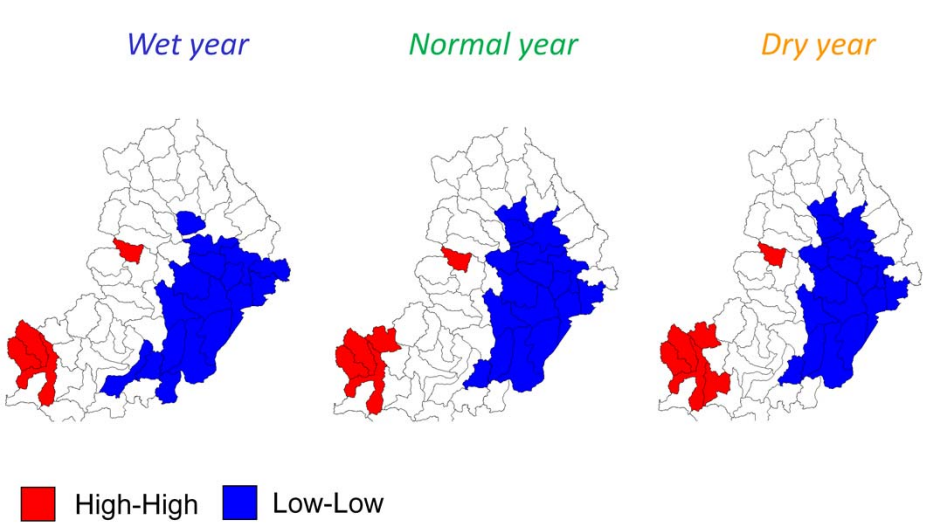
Normal year



Dry year



Bundled Services

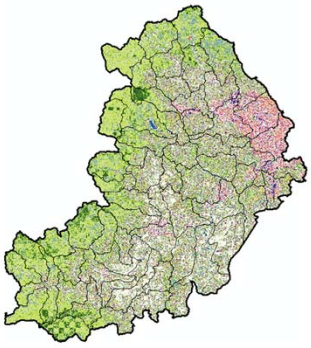


Stakeholder involvement

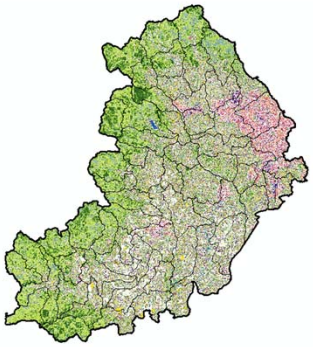

Stakeholder involvement

Future land cover scenarios (2040)

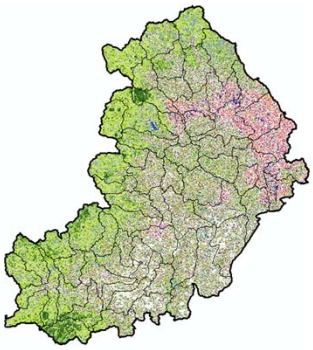
Plan trend

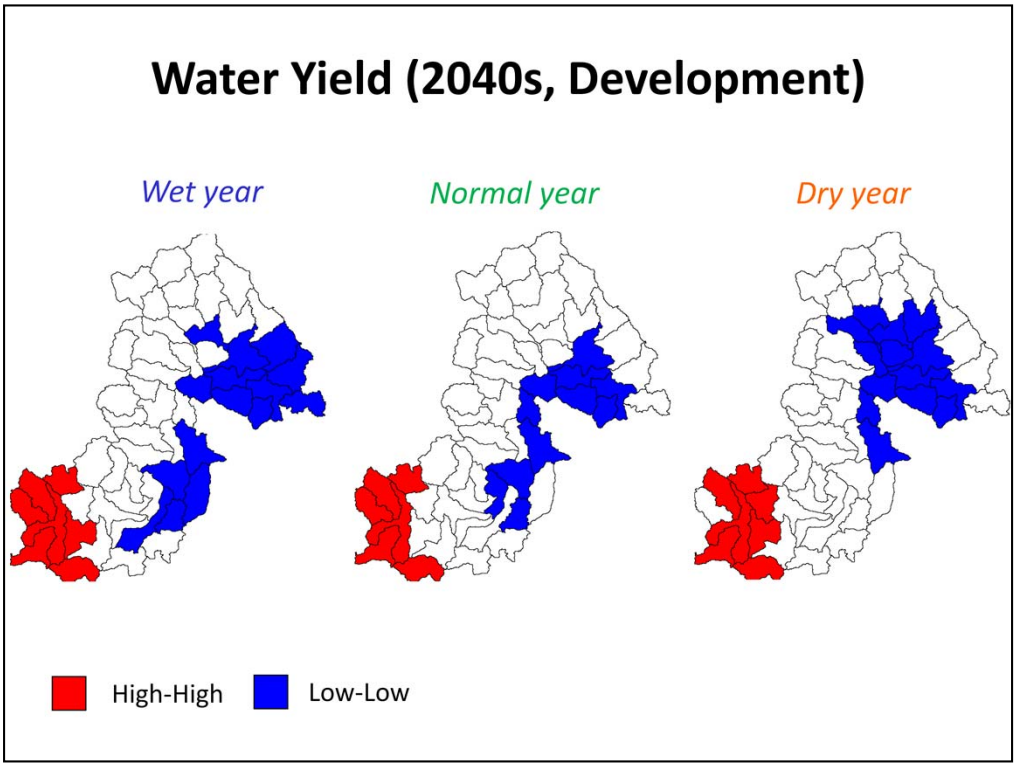


Conservation



Development




Water Yield (2040s, Development)
Wet year
Normal year
Dry year
High-High
Low-Low

Conclusions

1. Upper Yamhill sub-basins provide the most water yield and sediment retention, while lower valley areas have the highest phosphorus retention.

2. Climate change has either reduce or increase water yield and phosphorus retention depending on the direction of precipitation change.

3. Spatial patterns generally persist regardless of different climate regimes.

4. Bundling is a complex sociopolitical process and may not necessarily in line with biophysical modeling results.


Acknowledgements
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Questions or comments: contact Heejun Chang at changh@pdx.edu
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OSU
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