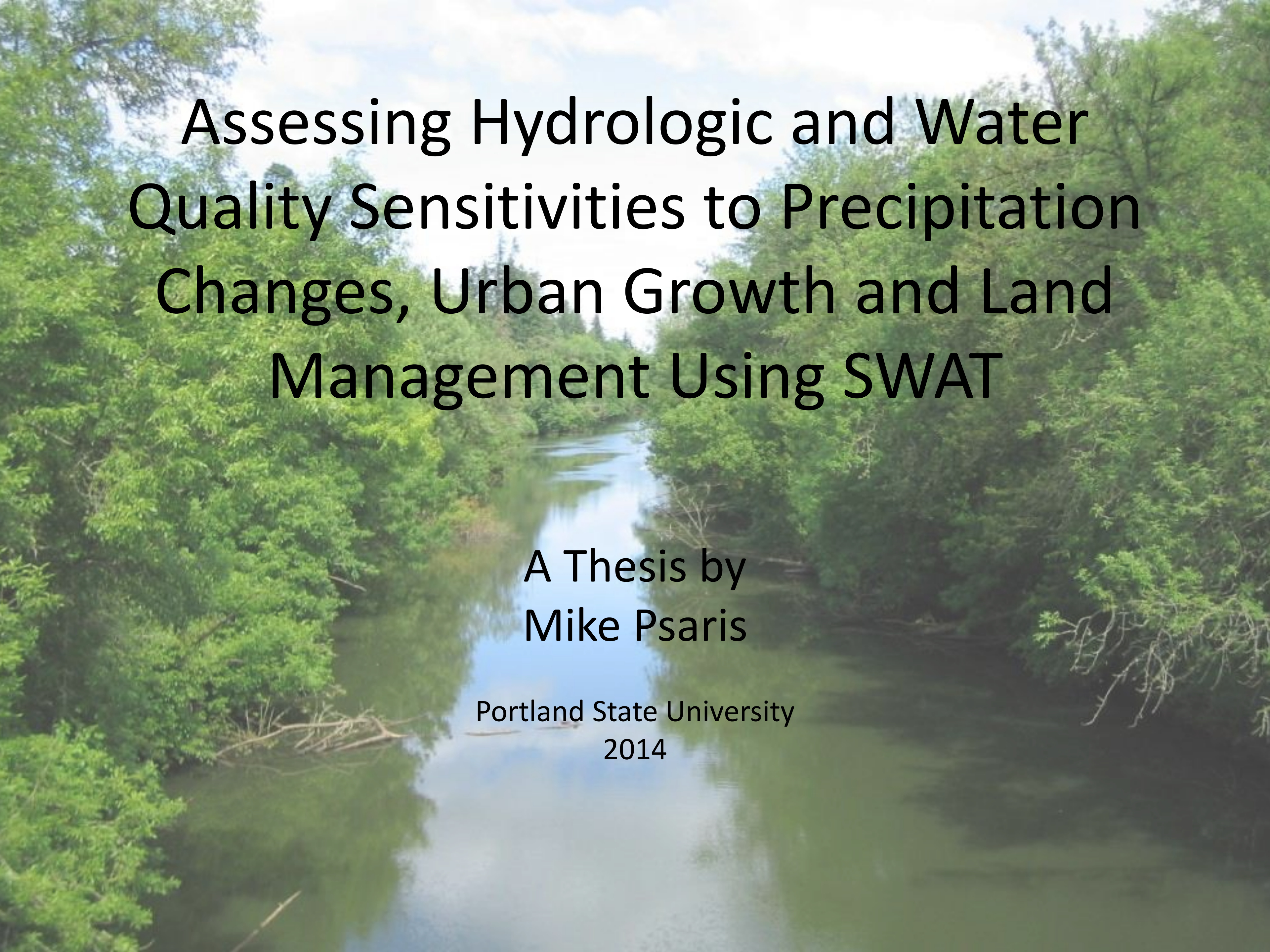

Assessing Hydrologic and Water Quality Sensitivities to Precipitation Changes, Urban Growth and Land Management Using SWAT

A Thesis by
Mike Psaris

Portland State University
2014

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- Study Site
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  - Scenario Runs
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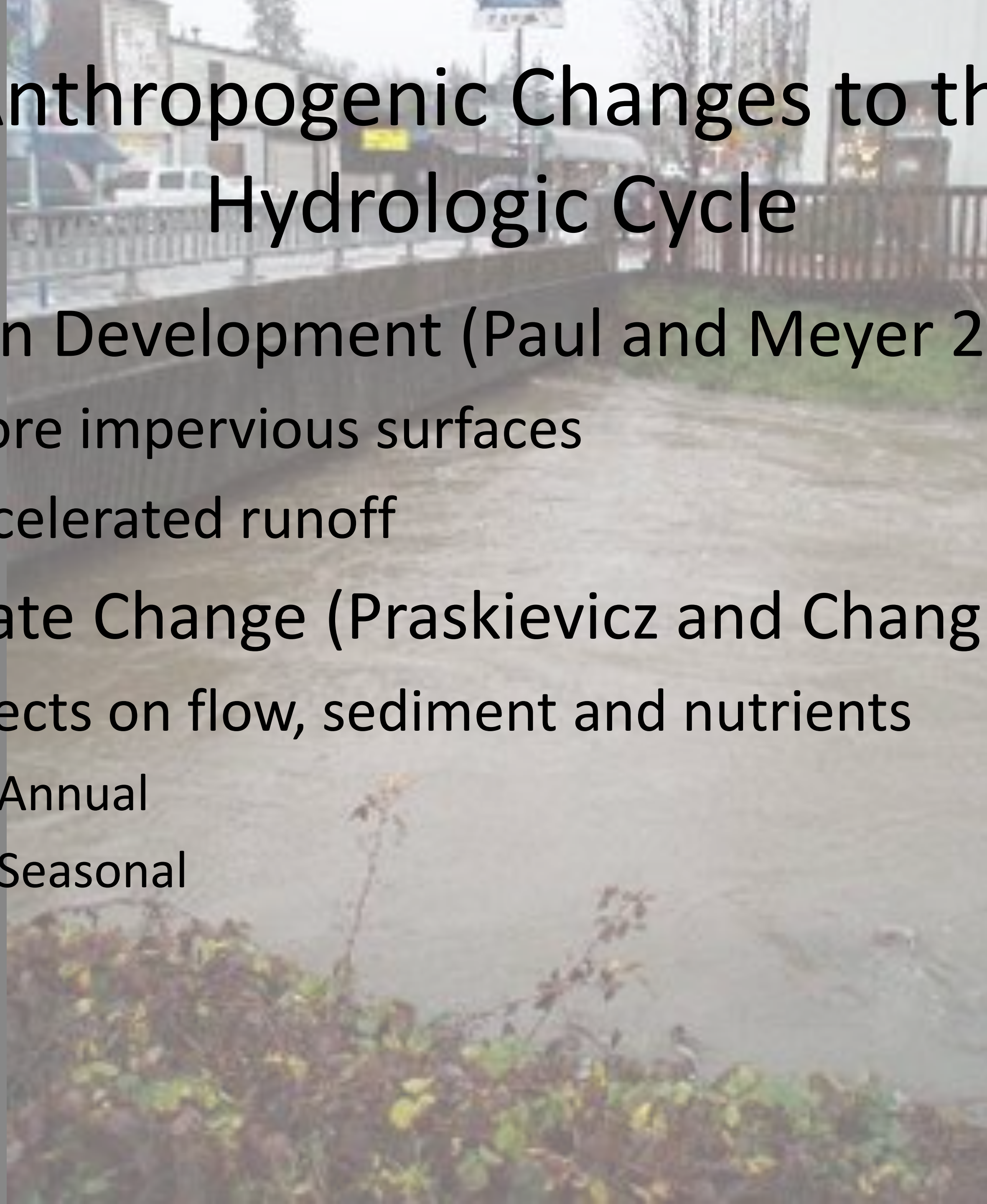
BACKGROUND



Anthropogenic Changes to the Hydrologic Cycle

- Urban Development (Paul and Meyer 2001)
  - More impervious surfaces
  - Accelerated runoff
- Climate Change (Praskievicz and Chang 2011)
  - Effects on flow, sediment and nutrients
    - Annual
    - Seasonal

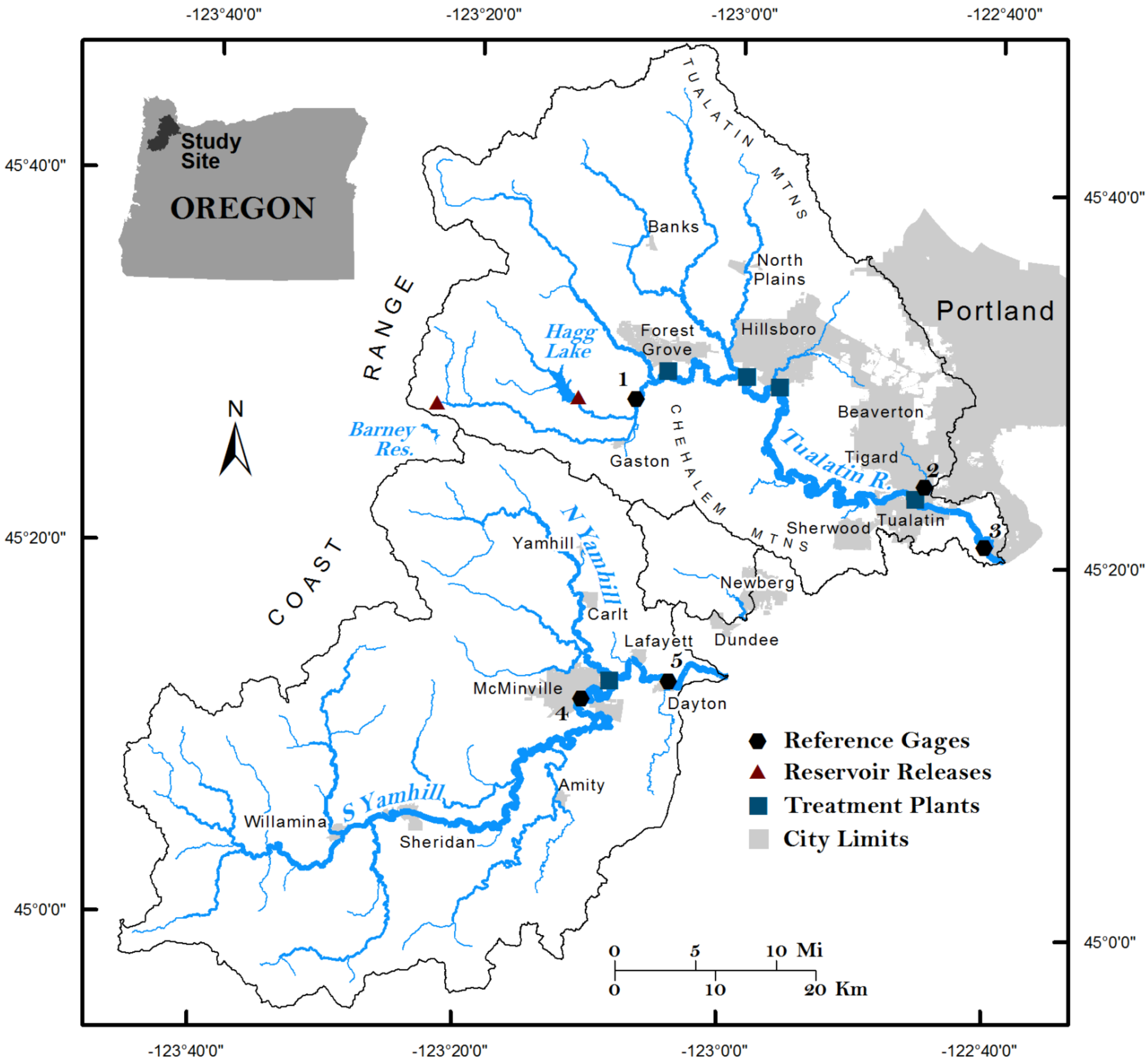
How We Respond

- Use models to
  - Better understand current and future conditions
    - Locate critical source areas (CSAs) of pollutants (Niraula et al 2013)
    - Project future changes
  - Explore management options
    - Vegetated Filter Strips (VFS) (Arnold et al 2012)

Research Questions

- How do water, sediment and nutrient yields change annually and seasonally under climate change and urban growth?
- What are the locations of CSAs, and will these locations shift in the future?
- What effect does the implementation of vegetated filter strips have on sediment and nutrient yields?

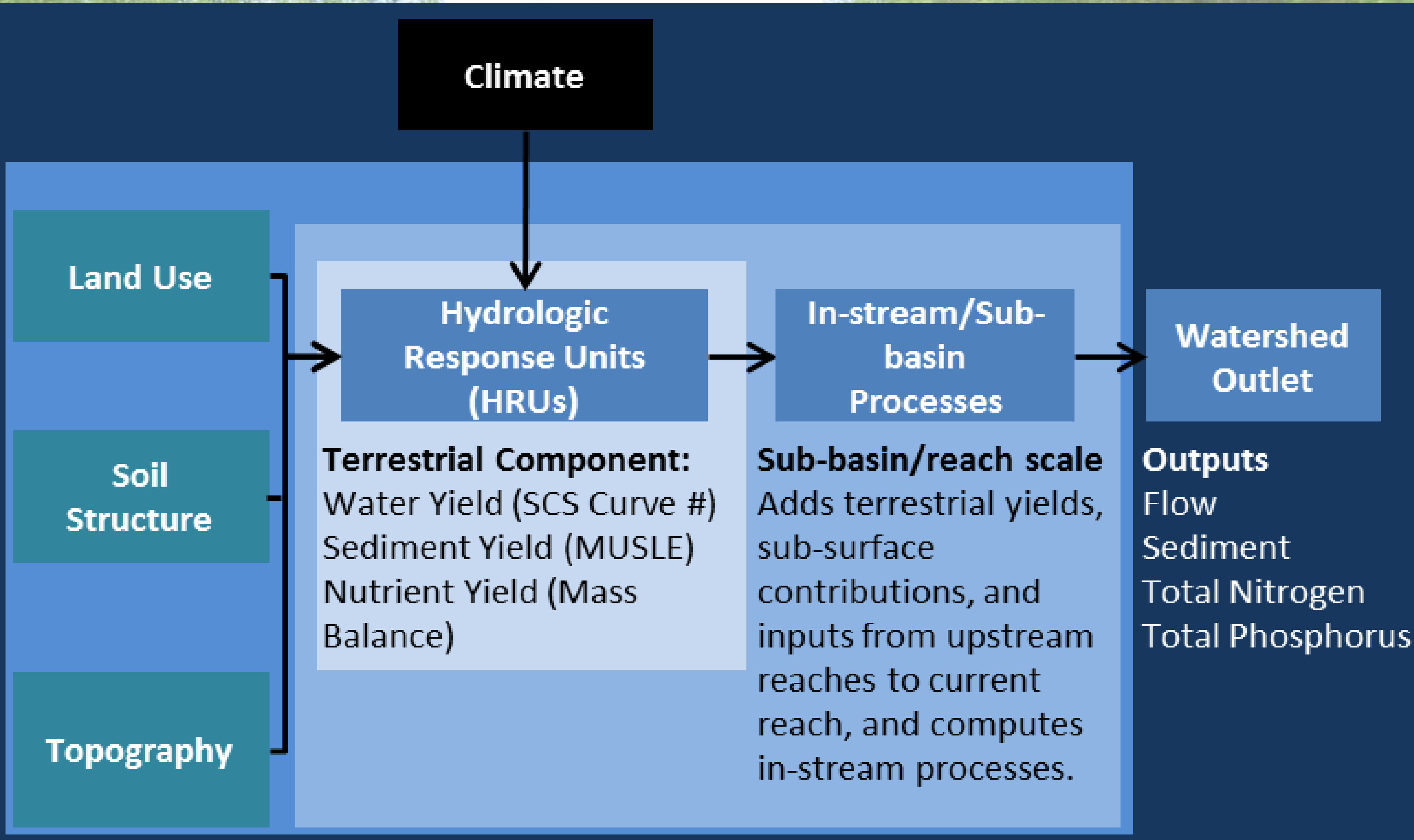
STUDY SITE



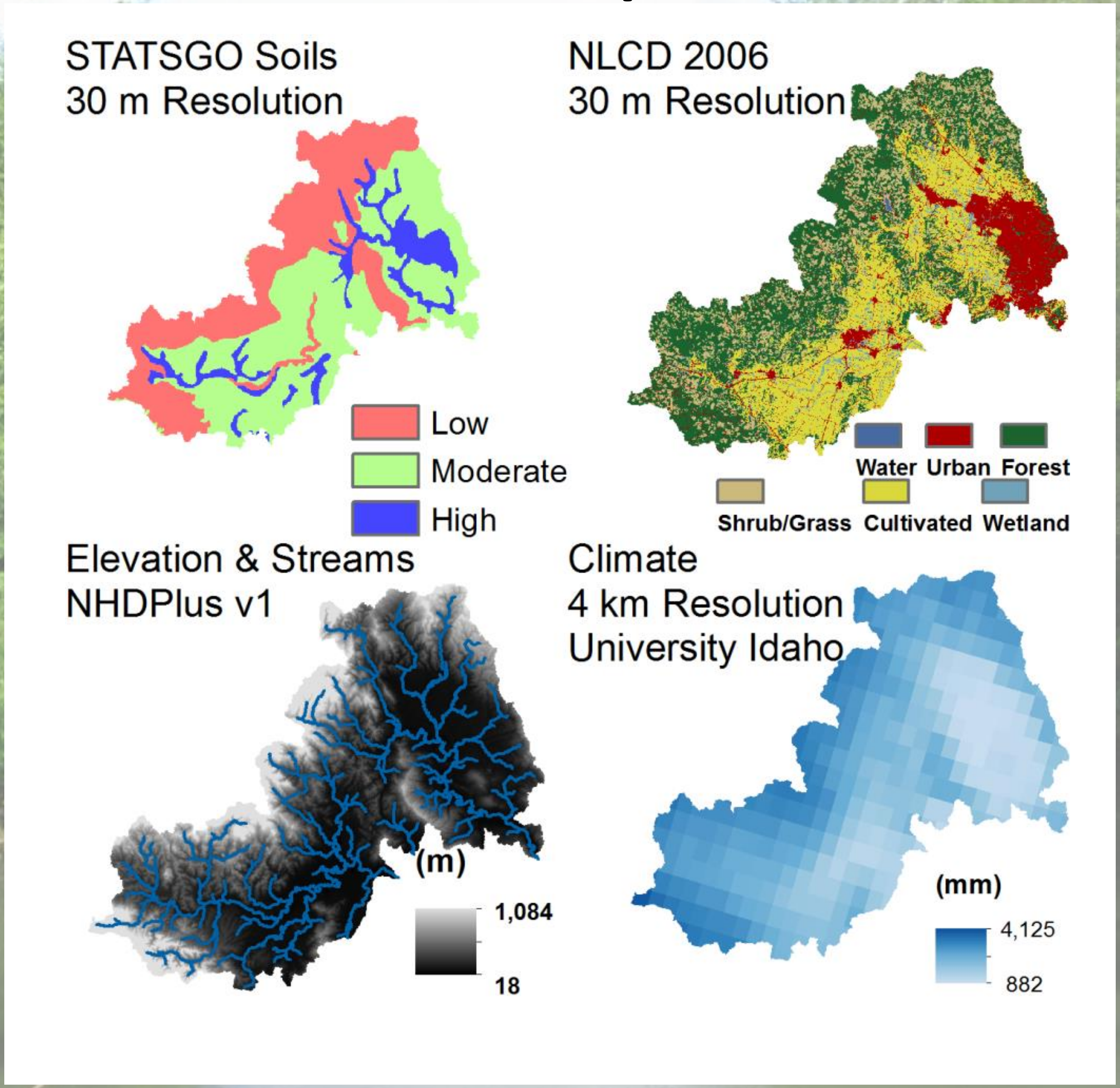
-123°40'0"
-123°20'0"
-123°0'0"
-122°40'0"
45°40'0"
45°20'0"
45°0'0"
Study Site
OREGON
TUALATIN MTNS
CHEHALEM MTNS
COAST RANGE
N
Banks
North Plains
Portland
Forest Grove
Hillsboro
Hagg Lake
Barney Res.
Gaston
Beaverton
Tigard
Tualatin R.
Tualatin
Sherwood
Yamhill
N Yamhill
Newberg
Carlt
Dundee
Lafayett
McMinville
Dayton
Amity
Willamina
S Yamhill
Sheridan
1
2
3
4
5
Reference Gages
Reservoir Releases
Treatment Plants
City Limits
0 5 10 Mi
0 10 20 Km

DATA AND METHODS

Soil and Water Assessment Tool (SWAT)



Data Inputs



STATSGO Soils
30 m Resolution
Low
Moderate
High
NLCD 2006
30 m Resolution
Water
Urban
Forest
Shrub/Grass
Cultivated
Wetland
Elevation & Streams
NHDPlus v1
(m)
1,084
18
Climate
4 km Resolution
University Idaho
(mm)
4,125
882

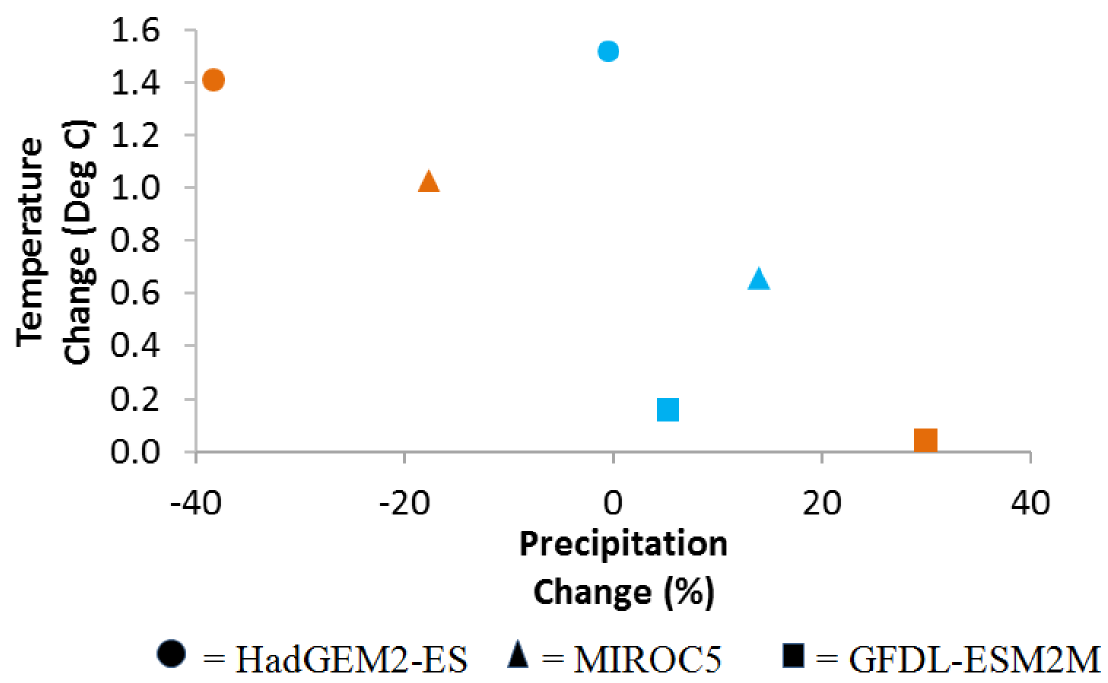
Model Calibration & Validation

- Manual Calibration (1981-2005)
  - Monthly
- Validation (2006-2010)
- Metrics
  - Nash-Sutcliffe Efficiency (NSE)
  - Percent Bias
  - RSR

Calculating Changes

3 Climate scenarios
2 Urbanization scenarios

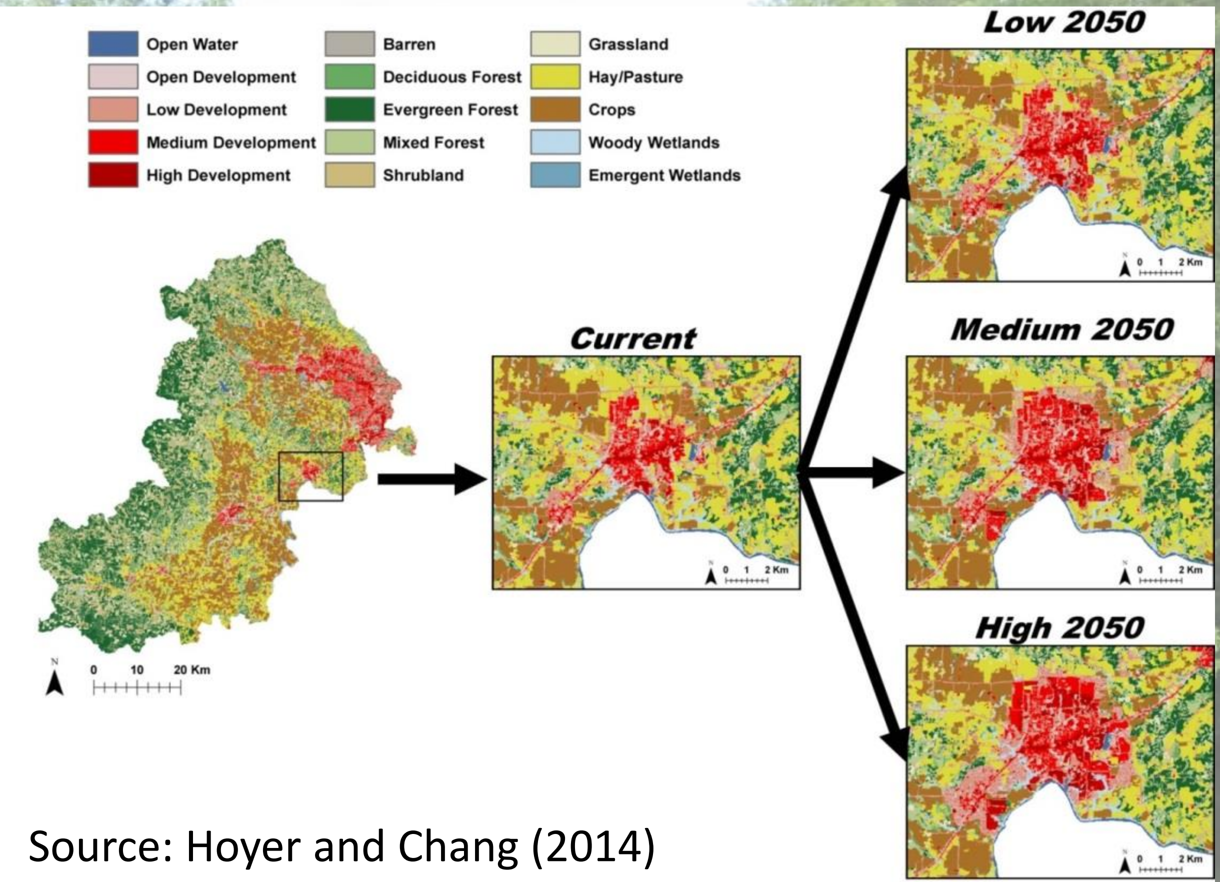
Climate Scenarios



Baseline: 1981-2010
Future: 2036-2065

Winter=DJF
Summer=JJA

Urbanization Scenarios



Source: Hoyer and Chang (2014)

Critical Source Areas

$$INDEX = 0.5S + 0.25N + 0.25P$$

Sediment

Total Nitrogen

Total Phosphorus

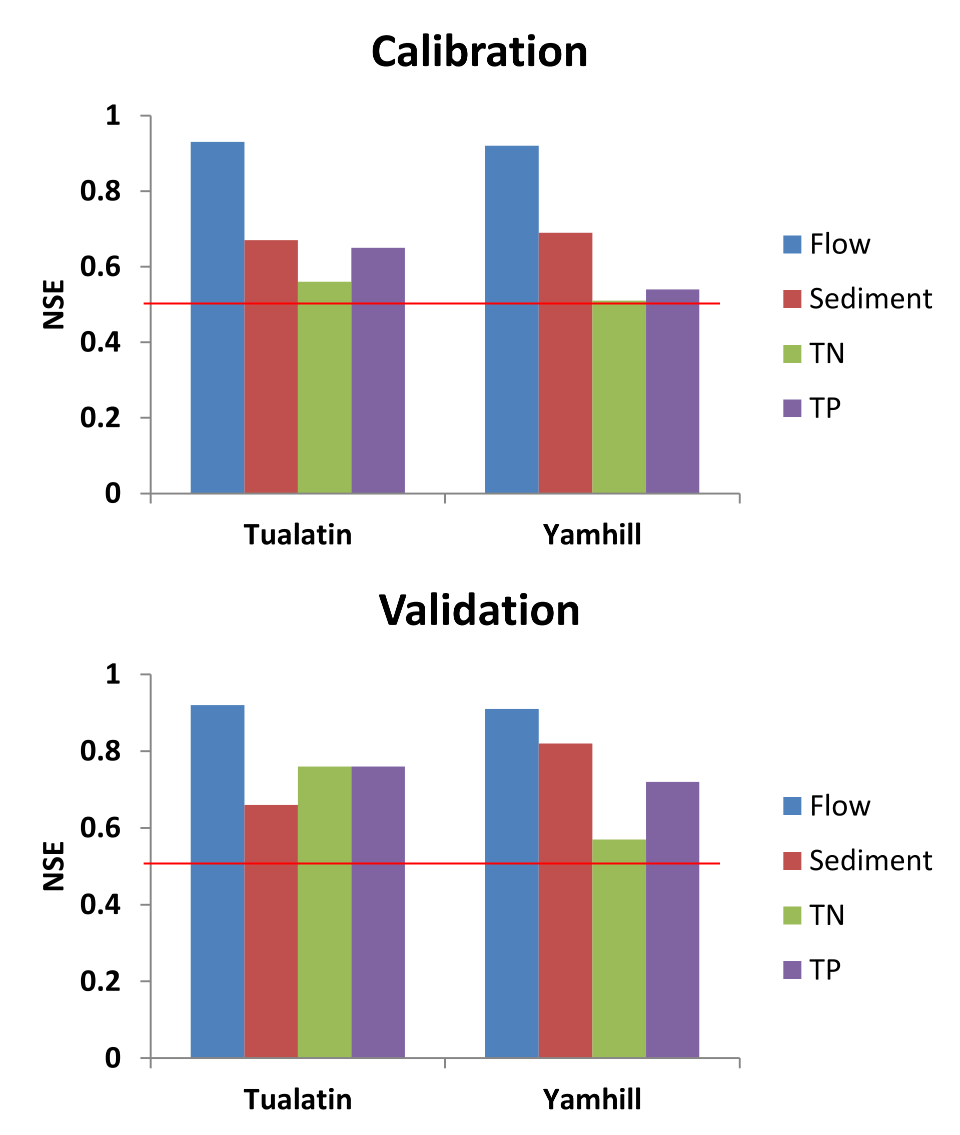
Vegetated Filter Strip (VFS) Model

- Top 5% most polluted sub-basins in Yamhill
- Two representative years: Water Year: 1994-95

RESULTS

MODEL CALIBRATION

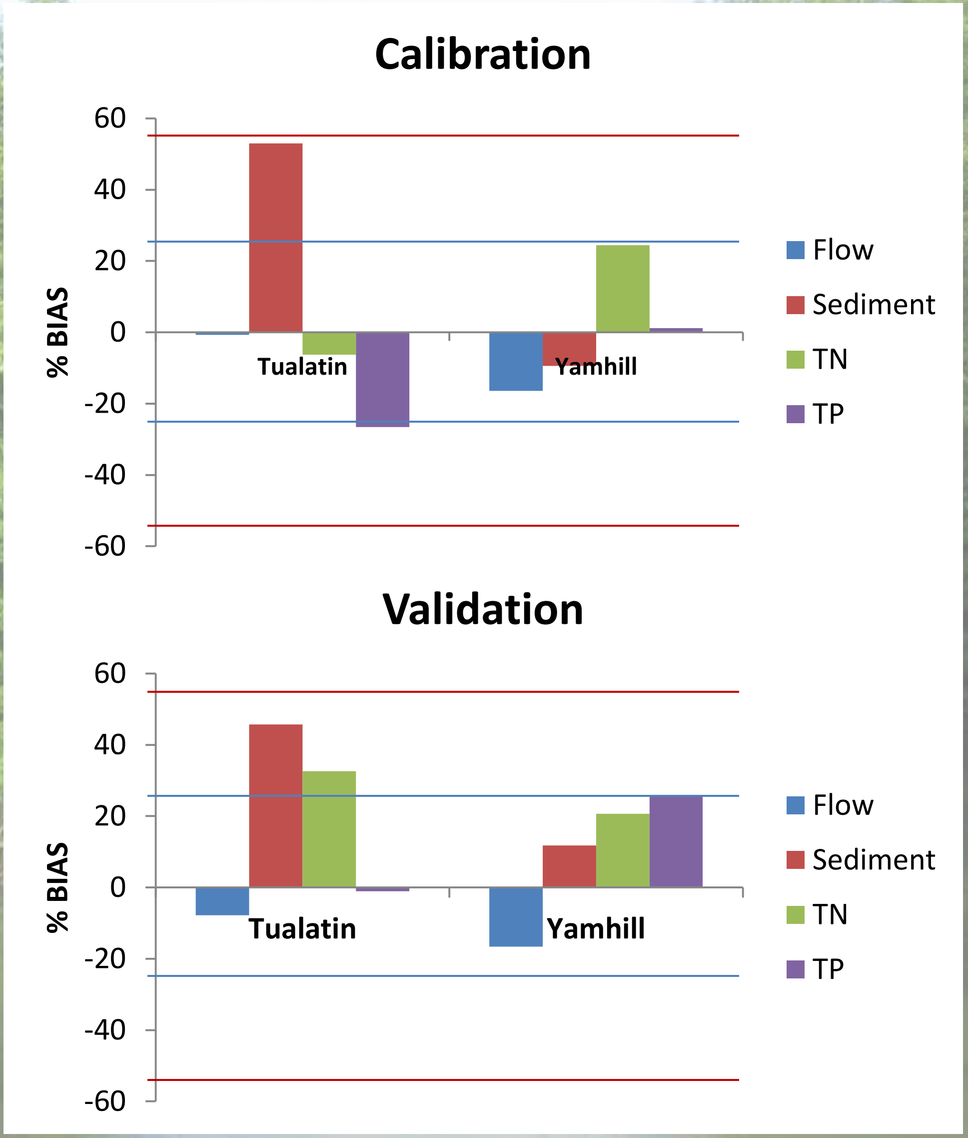
NSE



Goal

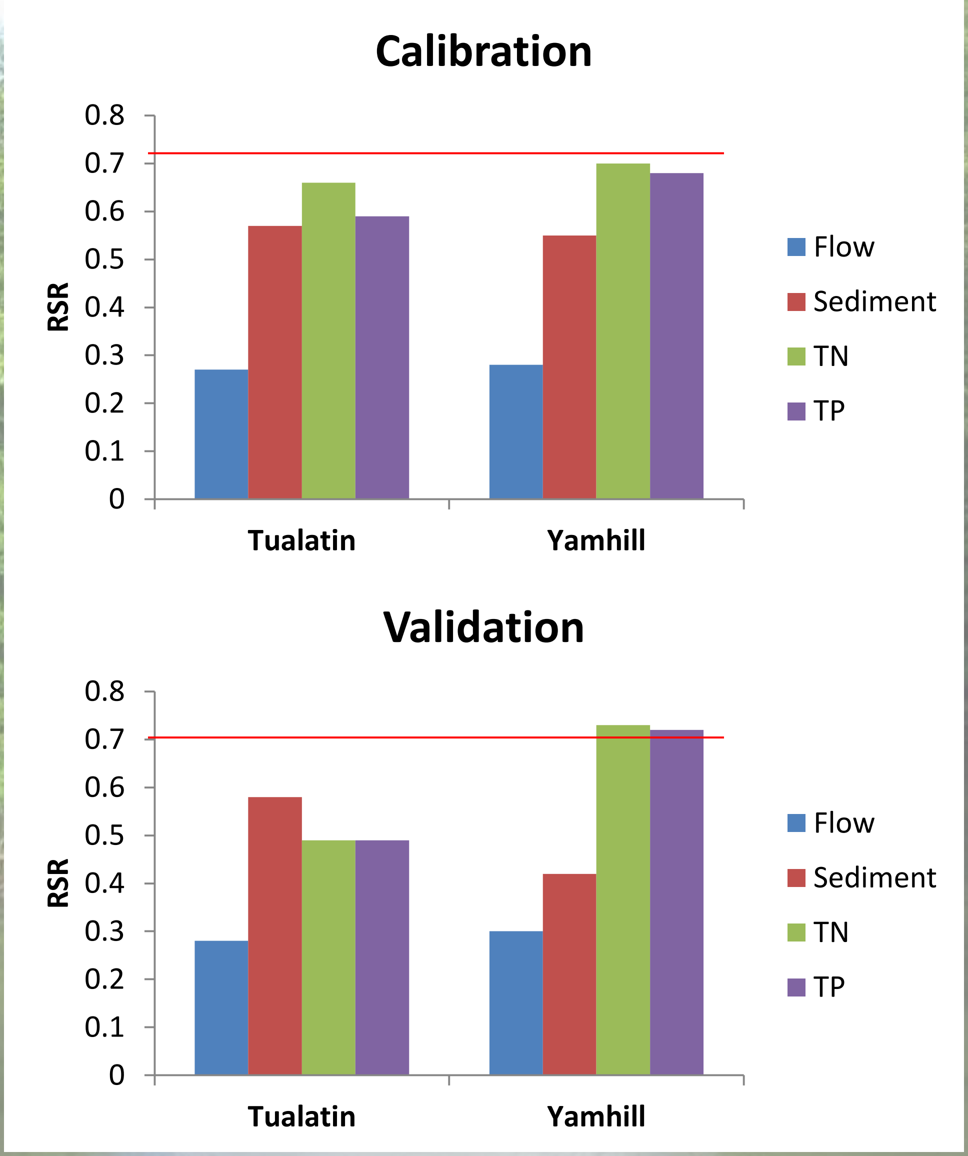
NSE > 0.5

%BIAS



<u>Goal</u>
Flow: %BIAS < 25%
Sediment: %BIAS < 55%
Nutrients: %BIAS < 70%

RSR

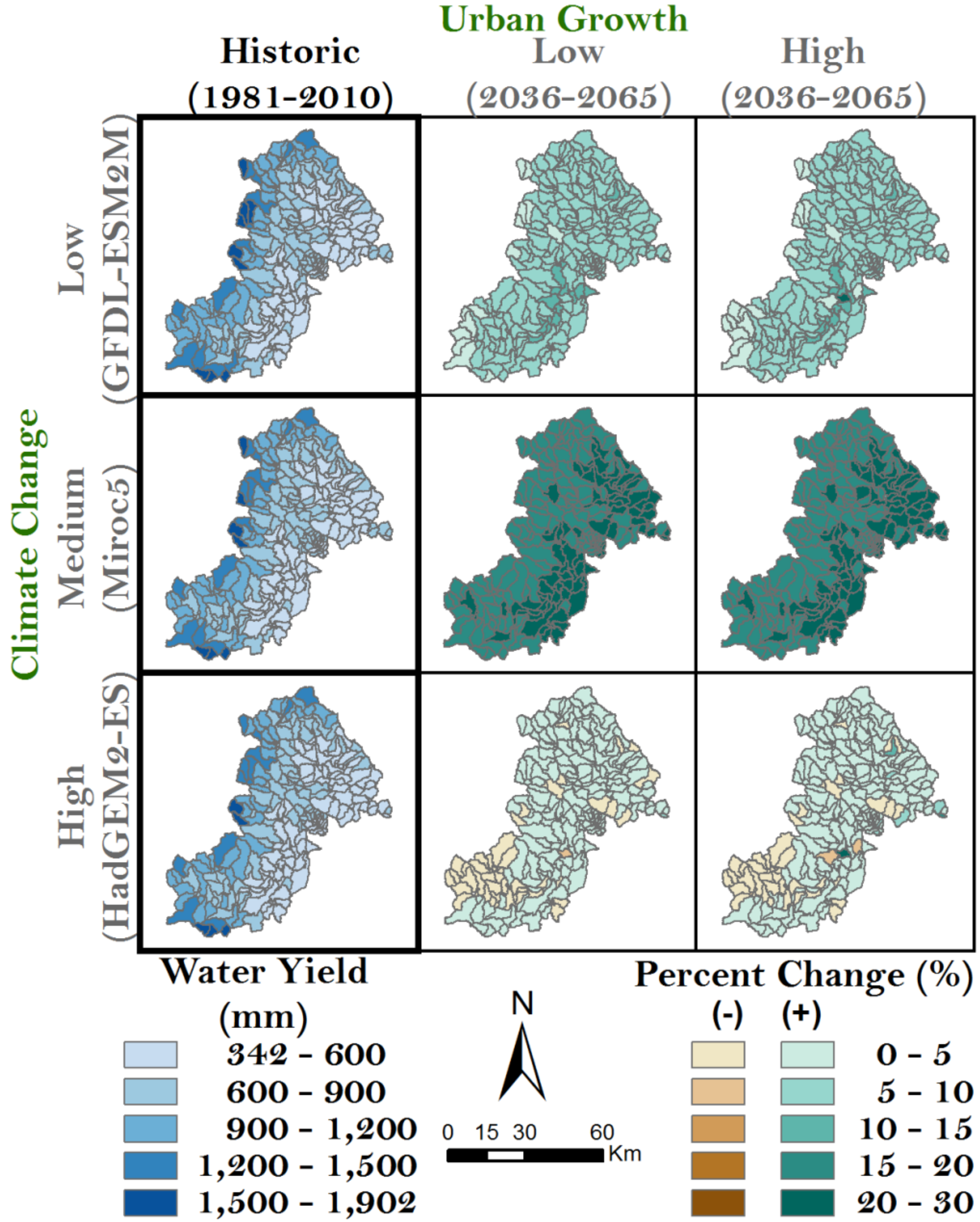


Goal

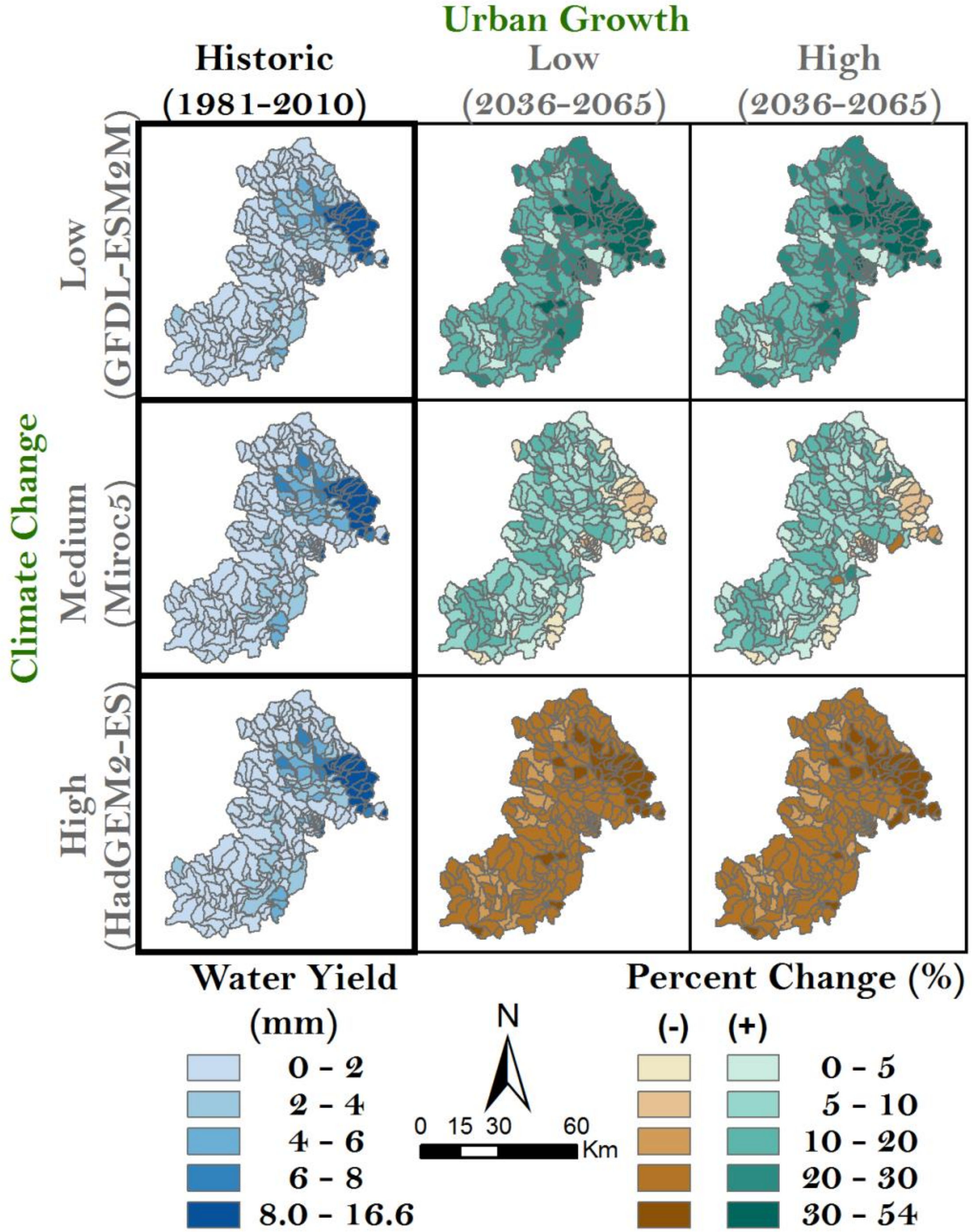
RSR <= 0.7

SCENARIO RESULTS

Annual Flow

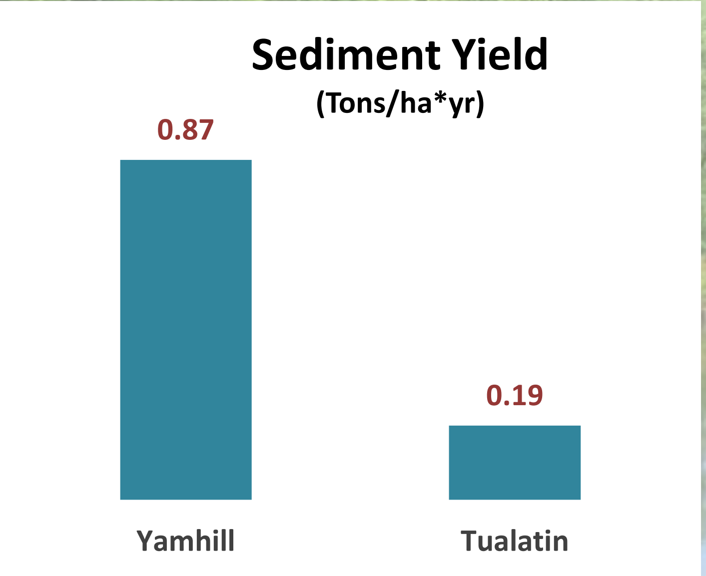

Urban Growth
Historic (1981-2010)
Low (2036-2065)
High (2036-2065)
Climate Change
Low (GFDL-ESM2M)
Medium (Miroc5)
High (HadGEM2-ES)
Water Yield (mm)
342 - 600
600 - 900
900 - 1,200
1,200 - 1,500
1,500 - 1,902
N
0 15 30 60 Km
Percent Change (%)
(-) (+)
0 - 5
5 - 10
10 - 15
15 - 20
20 - 30

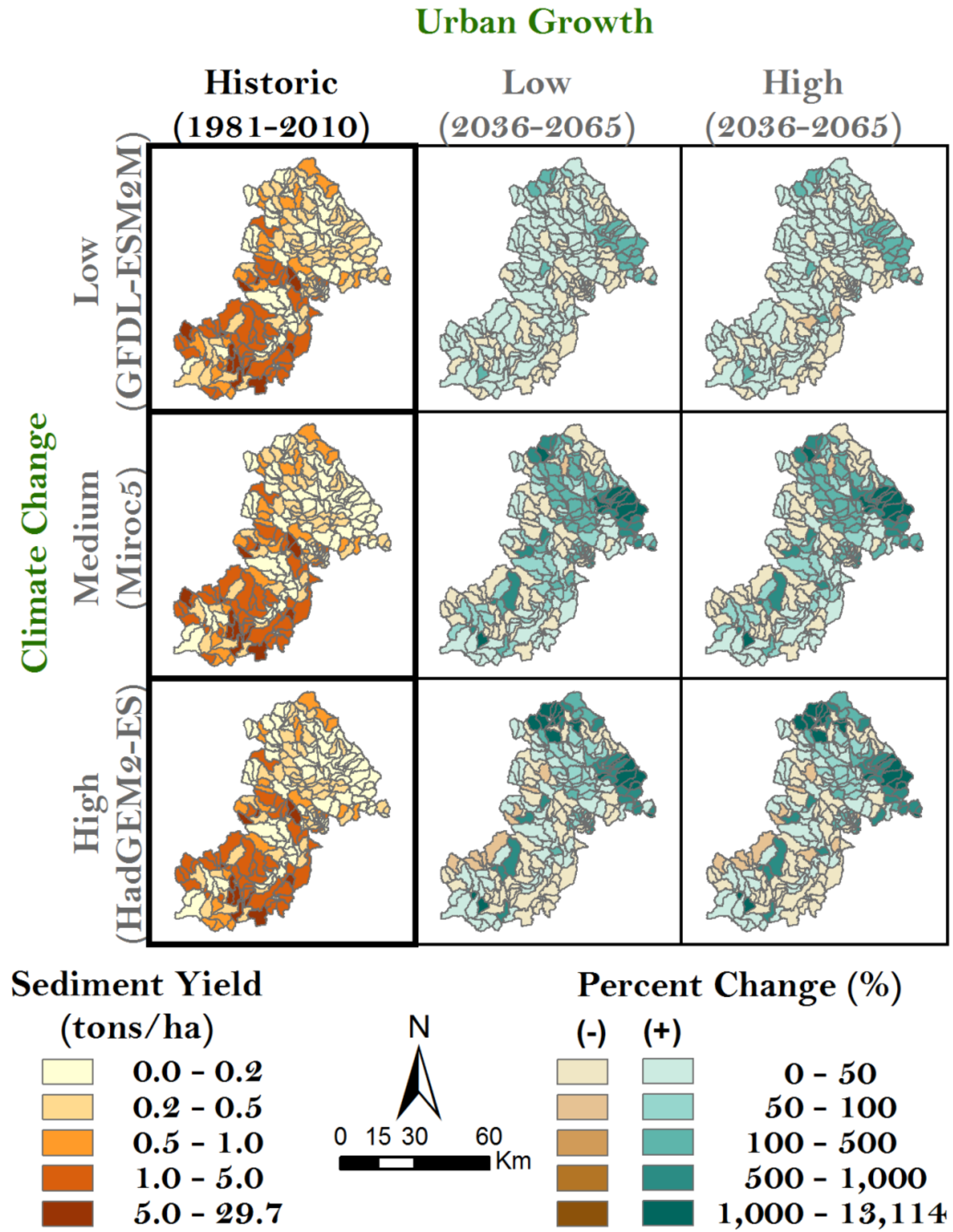
Summer Flow



Urban Growth
Historic (1981-2010)
Low (2036-2065)
High (2036-2065)
Climate Change
Low (GFDL-ESM2M)
Medium (Miroc5)
High (HadGEM2-ES)
Water Yield (mm)
0 - 2
2 - 4
4 - 6
6 - 8
8.0 - 16.6
N
0 15 30 60 Km
Percent Change (%)
(-)
(+)
0 - 5
5 - 10
10 - 20
20 - 30
30 - 54

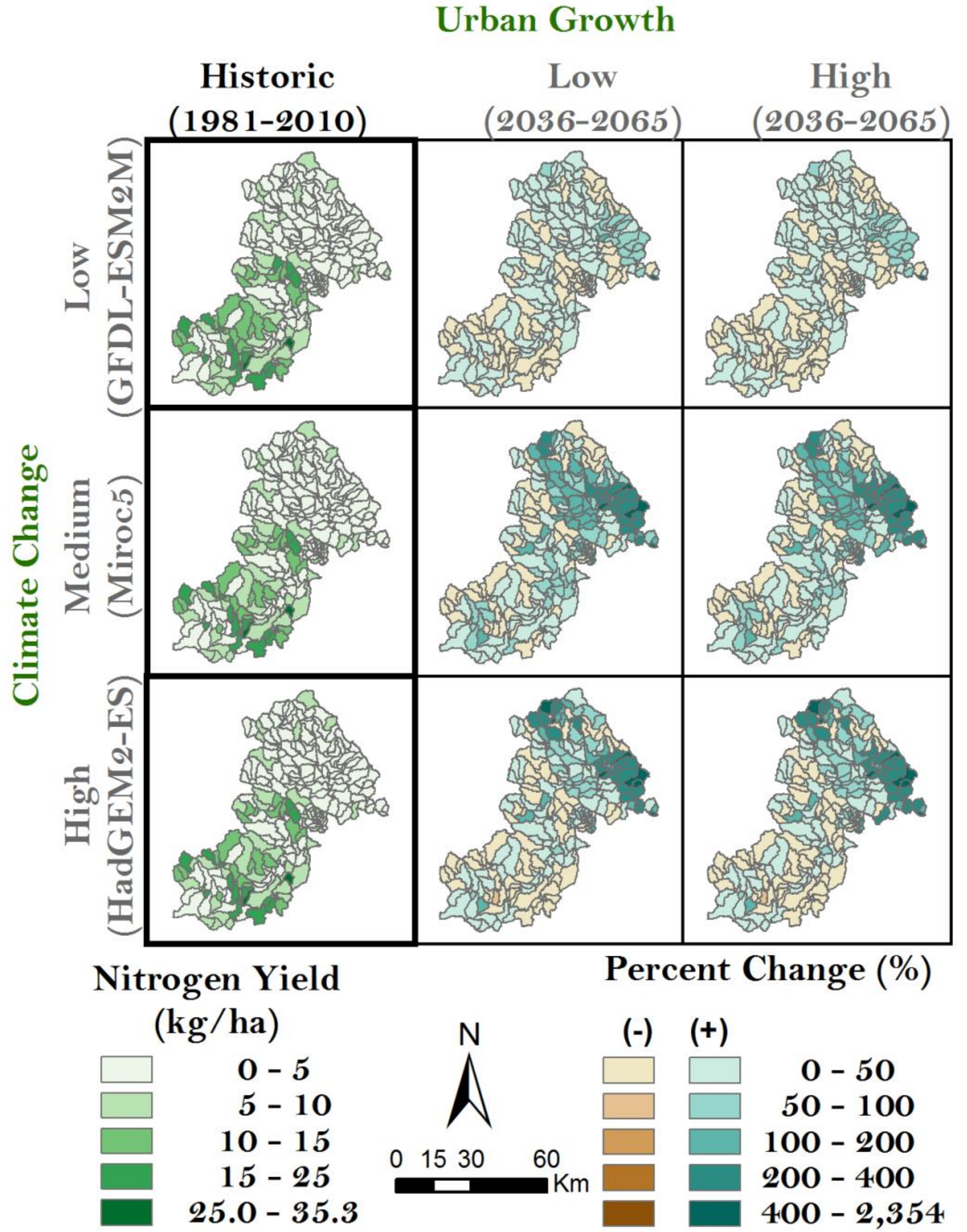
Sediment



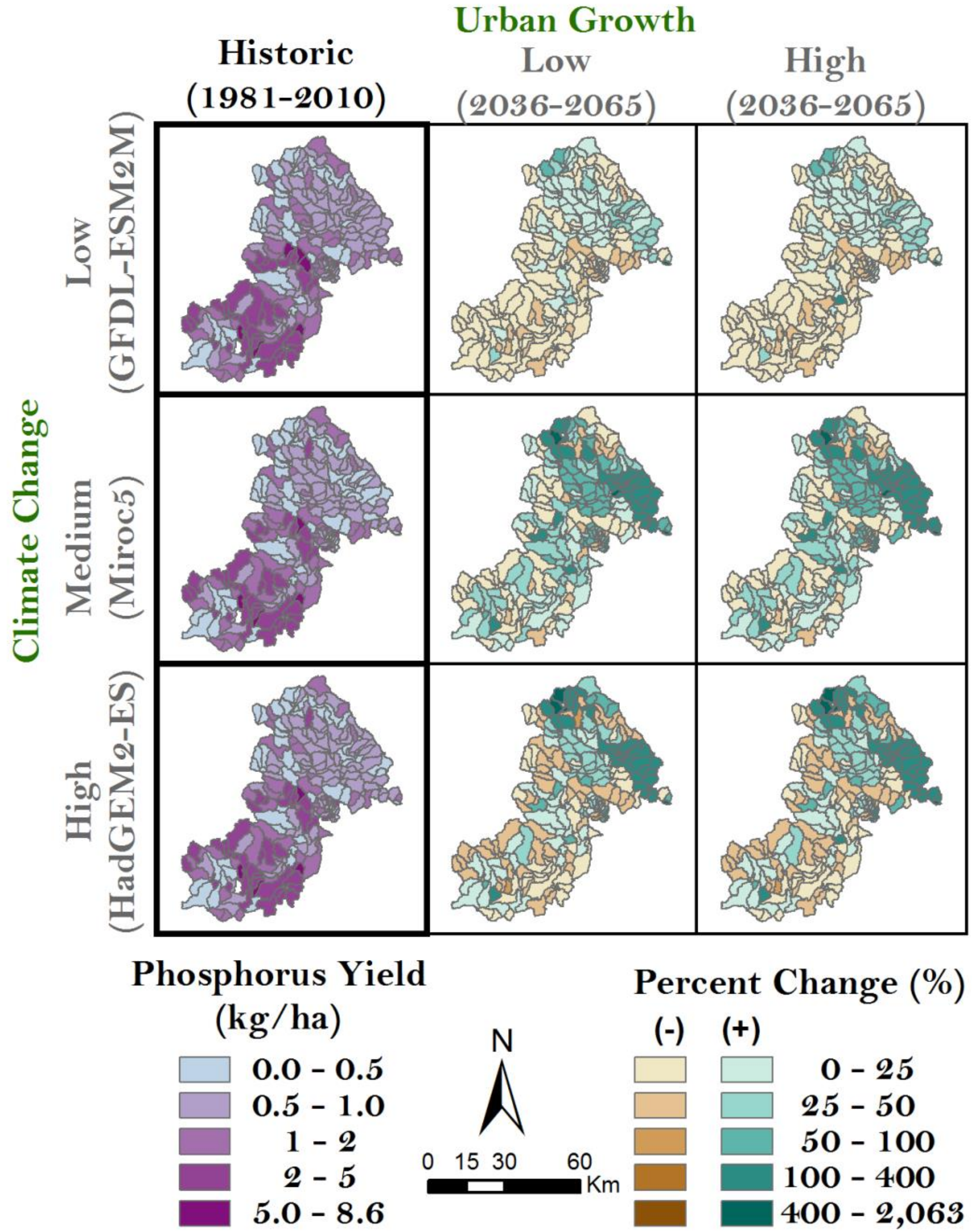


- No in-stream processes modeled

Nitrogen


Urban Growth
Historic (1981-2010)
Low (2036-2065)
High (2036-2065)
Climate Change
Low (GFDL-ESM2M)
Medium (Miroc5)
High (HadGEM2-ES)
Nitrogen Yield (kg/ha)
0 - 5
5 - 10
10 - 15
15 - 25
25.0 - 35.3
N
0 15 30 60 Km
Percent Change (%)
(-)
(+)
0 - 50
50 - 100
100 - 200
200 - 400
400 - 2,354

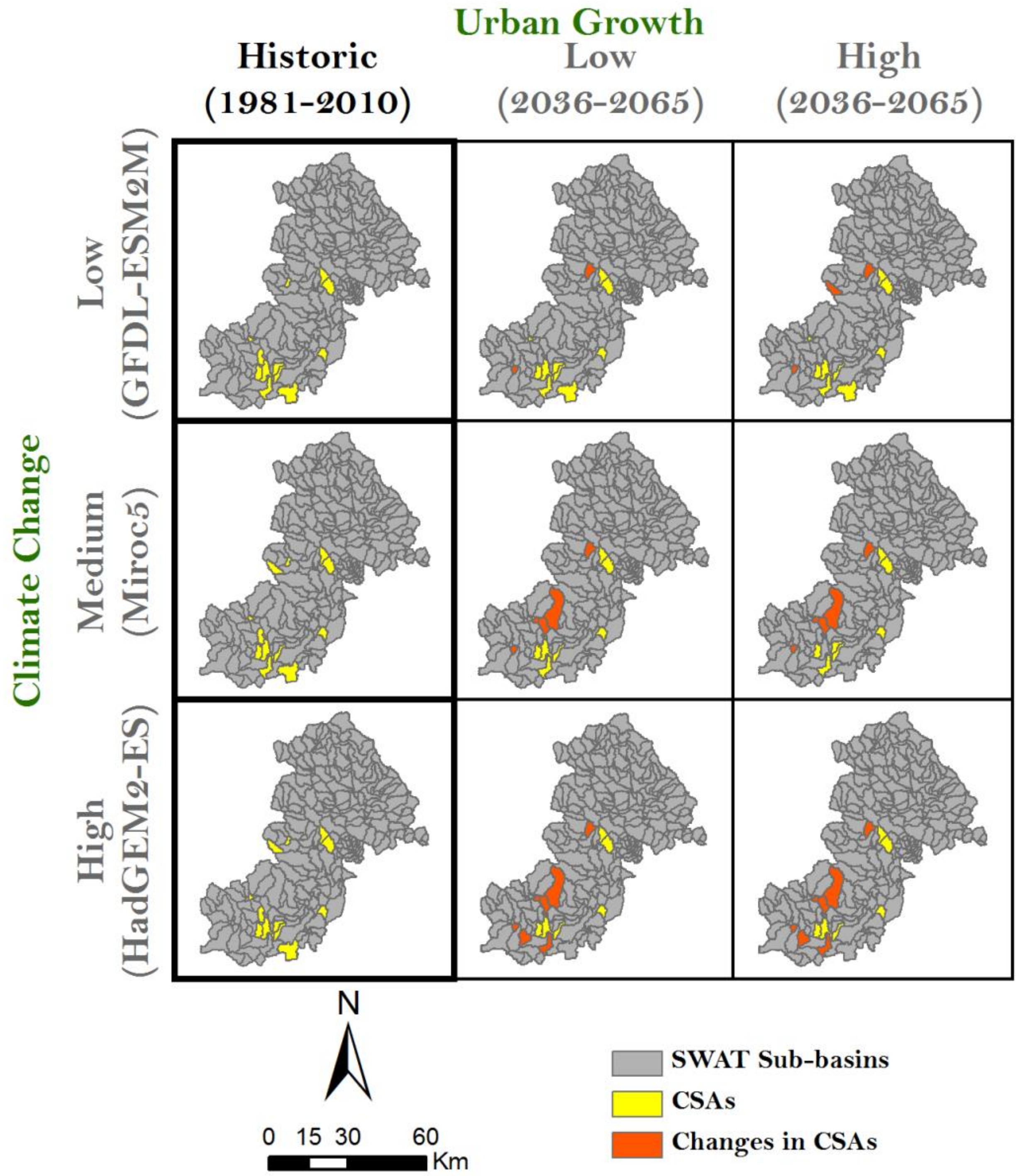
Phosphorus



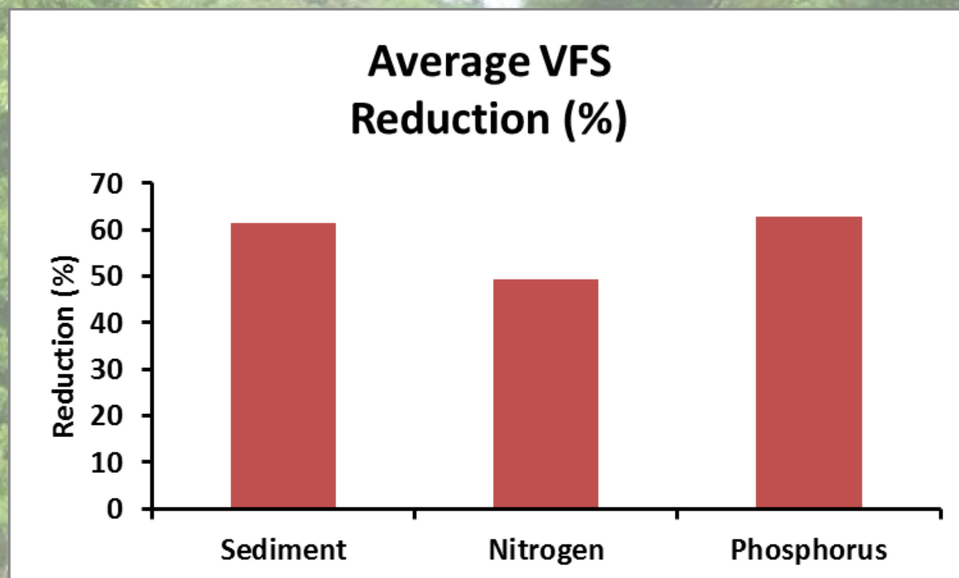
Urban Growth
Historic (1981-2010)
Low (2036-2065)
High (2036-2065)
Climate Change
Low (GFDL-ESM2M)
Medium (Miroc5)
High (HadGEM2-ES)
Phosphorus Yield (kg/ha)
0.0 - 0.5
0.5 - 1.0
1 - 2
2 - 5
5.0 - 8.6
N
0 15 30 60 Km
Percent Change (%)
(-) (+)
0 - 25
25 - 50
50 - 100
100 - 400
400 - 2,063

CSAs

Indices in top 5%



Vegetative Filter Strips



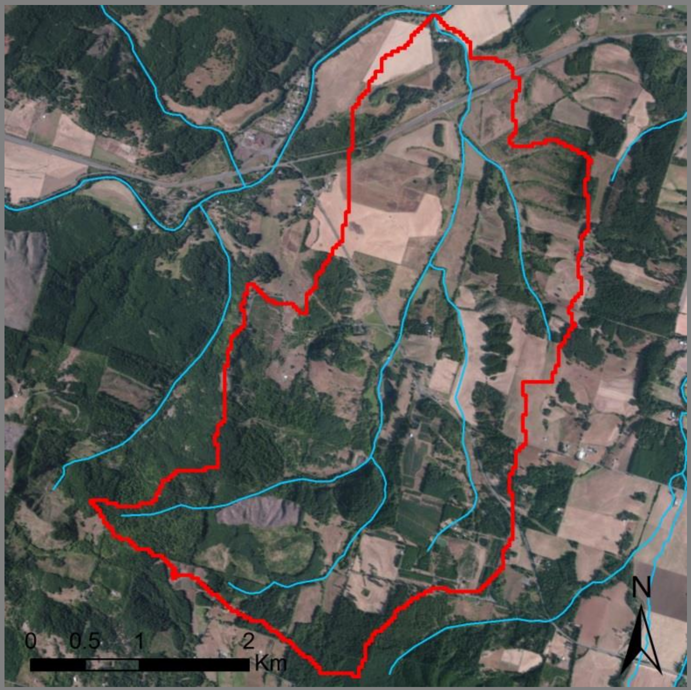
Effects on CSAs

Dominant Land Use: Hay

Dominant Soil: Moderate hydraulic conductivity

Dominant Slope: >12%

Rank	
No management	VFS
1	**1**
2	16
3	19
4	25
6	33



Discussion

- Uncertainty
  - GCM Structure
  - Sediment calibrations
    - In-stream sources and sinks of sediment
    - “Second-storm” effect
- Land cover thresholds
  - Clearly outline project goals
- Validation of CSA Identification
  - Field studies verifying SWAT accuracy

Conclusions

1. Basin wide effects are more sensitive to climate change than urbanization
2. Flows exhibit some seasonal lag in non-urban areas
3. Urban areas respond more immediately to precipitation patterns due to increased impervious surfaces
4. The largest increases in sediment and nutrients occur in urban and high sloping agricultural areas
5. CSAs show moderate changes in response to climate change and urban growth
6. VFS reduce sediment and nutrient yields by 58%, suggesting they are an effective method of pollutant reduction

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Questions/Comments?