# Impact Assessment of Urbanization and Land Use Change Using LID to Characterize Water Quality in the Boise River

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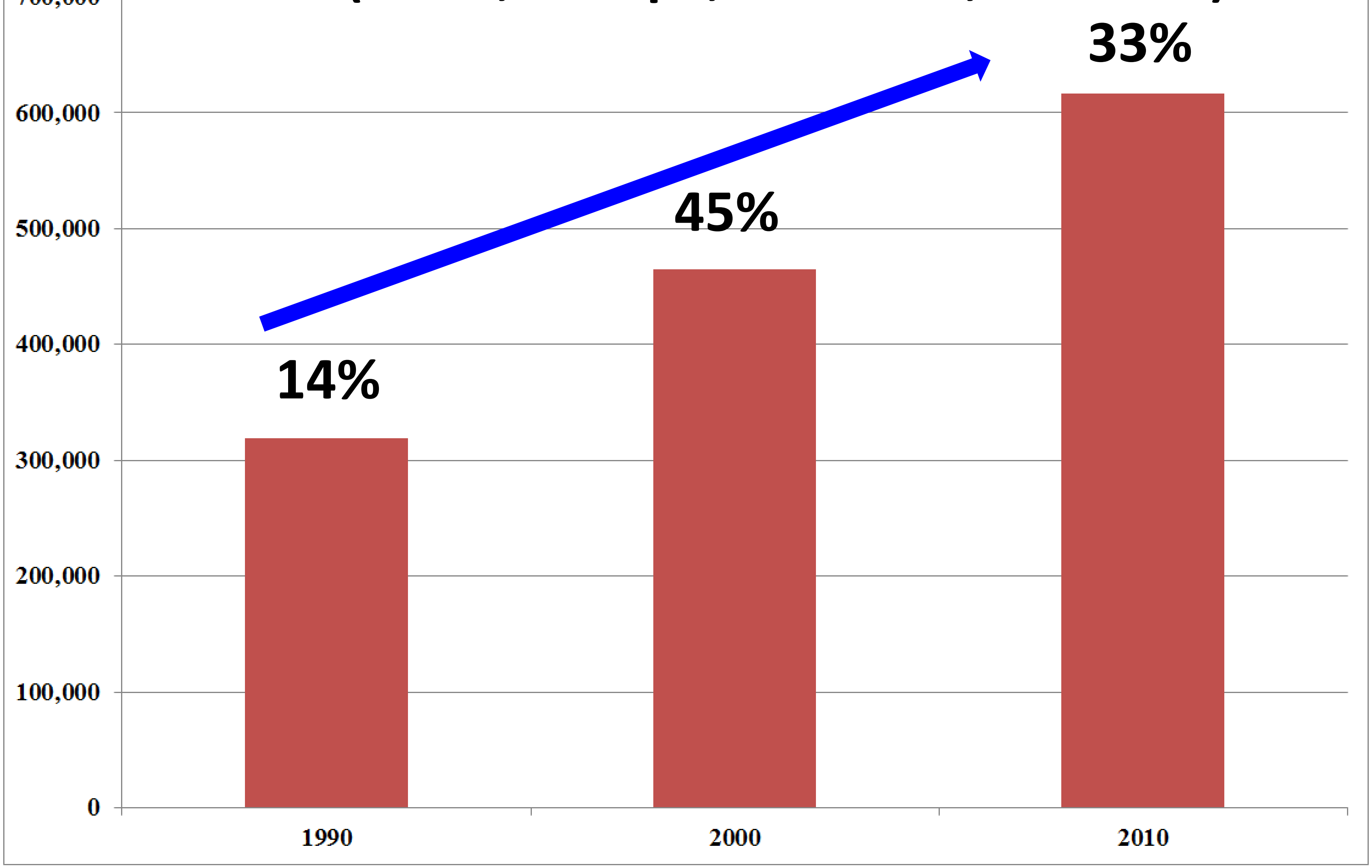
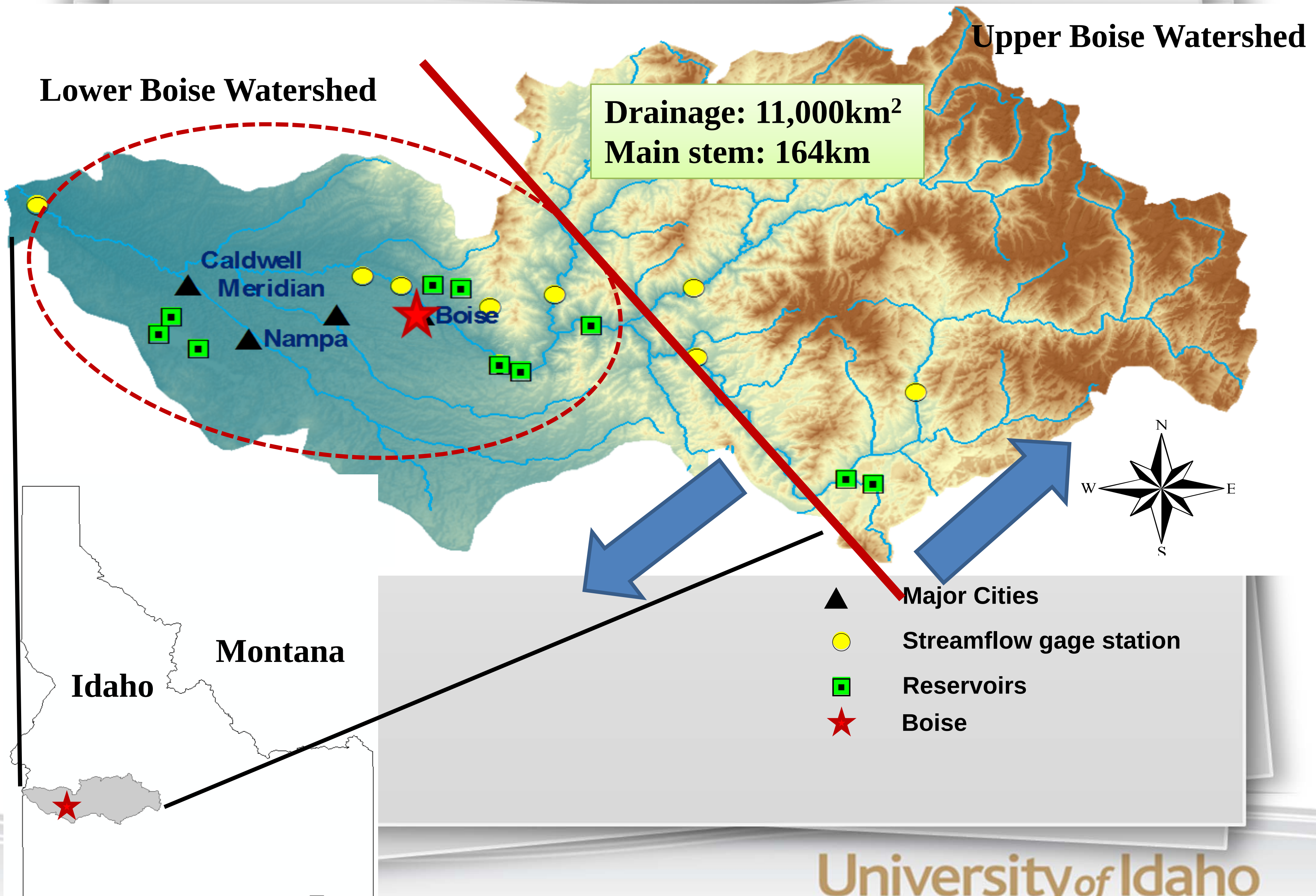
# Boise Metropolitan Population (Boise, Nampa, Meridian, Caldwell)



# Boise Watershed

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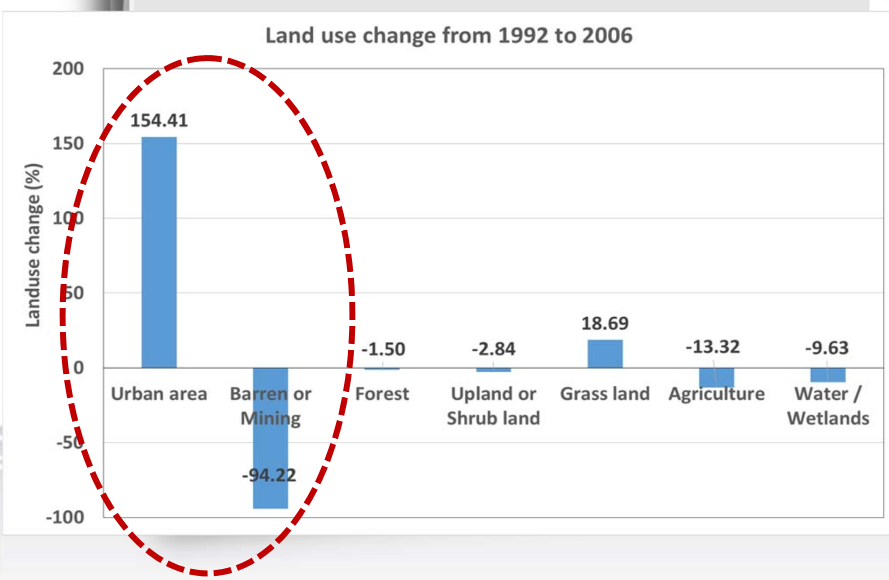
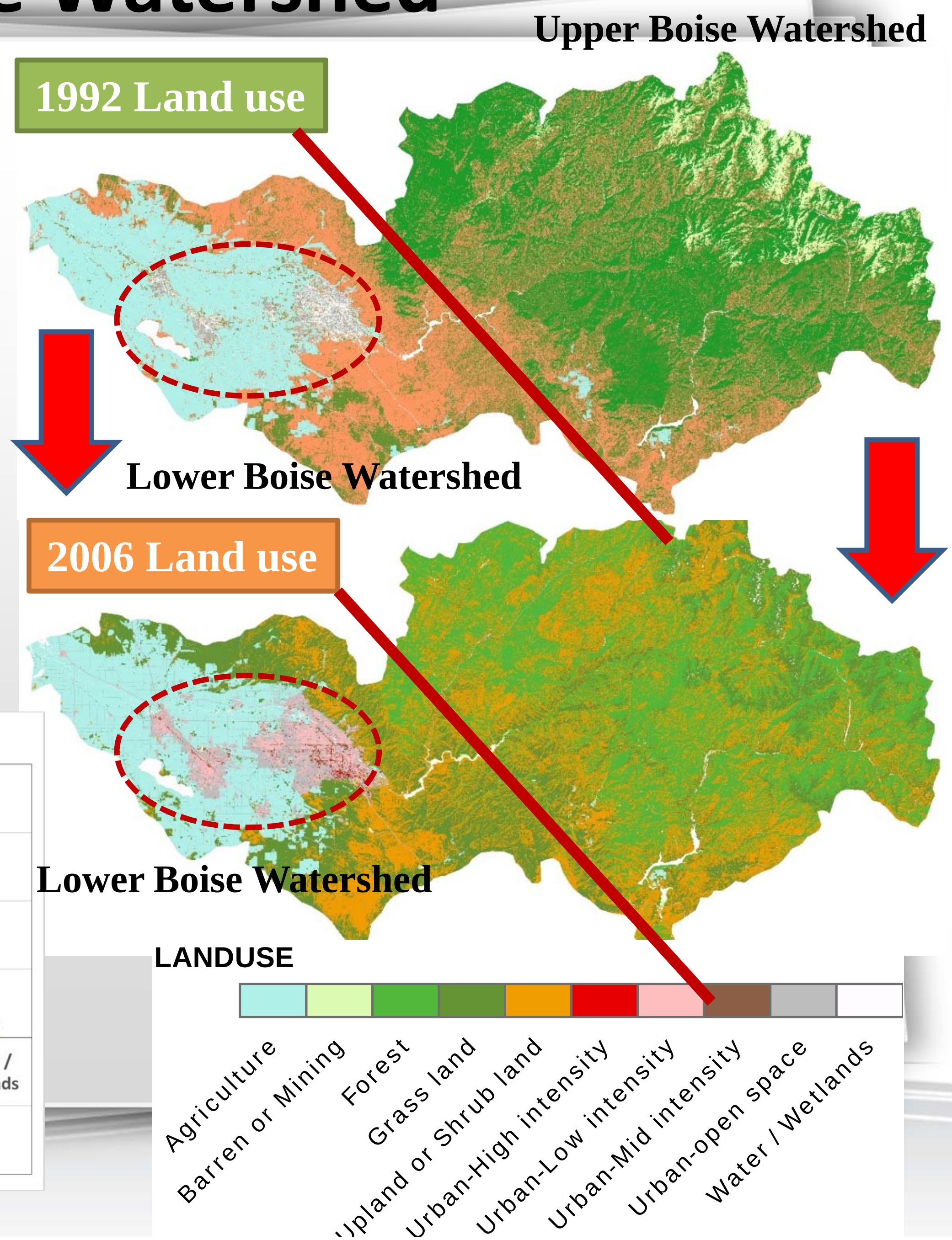
# Boise Watershed

## ❑Land use changes

| land use | Land use ($km^2$) | | Land use change | |
|---|---|---|---|---|
| | 1992 | 2006 | ($km^2$) | (%) |
| Urban area | 215 | 547 | 332 | 154.41 |
| Barren | 391 | 22 | -368 | -94.22 |
| Forest | 3055 | 3009 | -48 | -1.50 |
| Upland/Shrub | 3121 | 3032 | -88 | -2.84 |
| Grass land | 2041 | 2423 | 381 | 18.69 |
| Agriculture | 1492 | 1293 | -198 | -13.22 |
| Water/Wetlands | 121 | 110 | -11 | -9.63 |



# Research Questions

- How much does urbanization affect local hydrology?
- How hydrological models can characterize urbanization effects in rainfall-runoff simulations?
- Land use change did contribute to water pollution in the river downstream?
- Low Impact Development (LID) can help non-point source (NPS) pollution control in waterways?
- How to evaluate alternatives if LID applicable for NPS control in the study area?

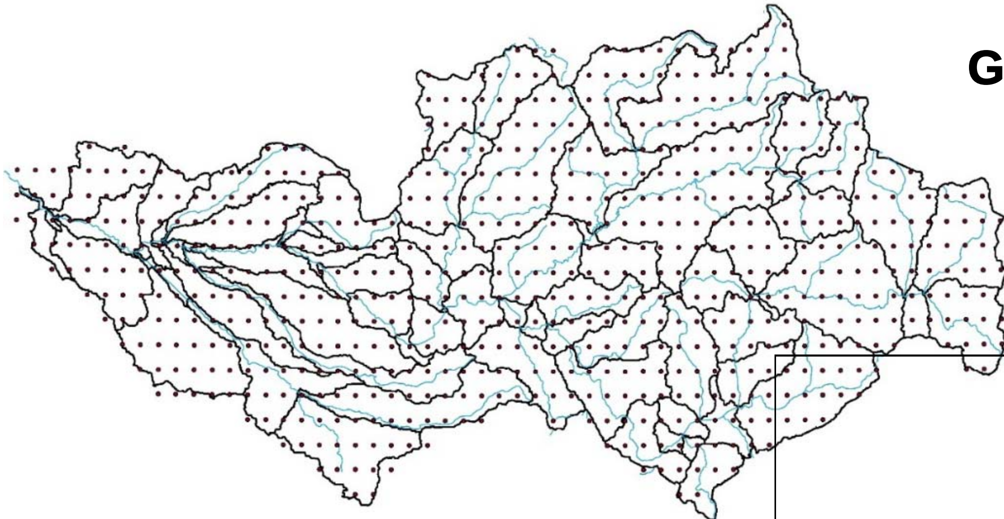
# HSPF

- Hydrological Simulation Program-Fortran (HSPF)-Stanford Watershed Model (Crawford and Linsley 1966)
- Lumped model-homogeneous land segments in each delineated sub-basins
- Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) – EPA 1996
- GIS capability- Semi-distributed model (hspf)

# Data Input

- Gridded Weather Data: 4km by 4km spatial resolution: North America Land Data Assimilation System (NLDAS)
- Daily time steps
- Data Periods: January 1979 – December 2013 (25 years)
- Data used: Precipitation, Minimum Temp, Maximum Temp, Mean Temp, Wind Speed, Humidity for Penmann-Monteith ET

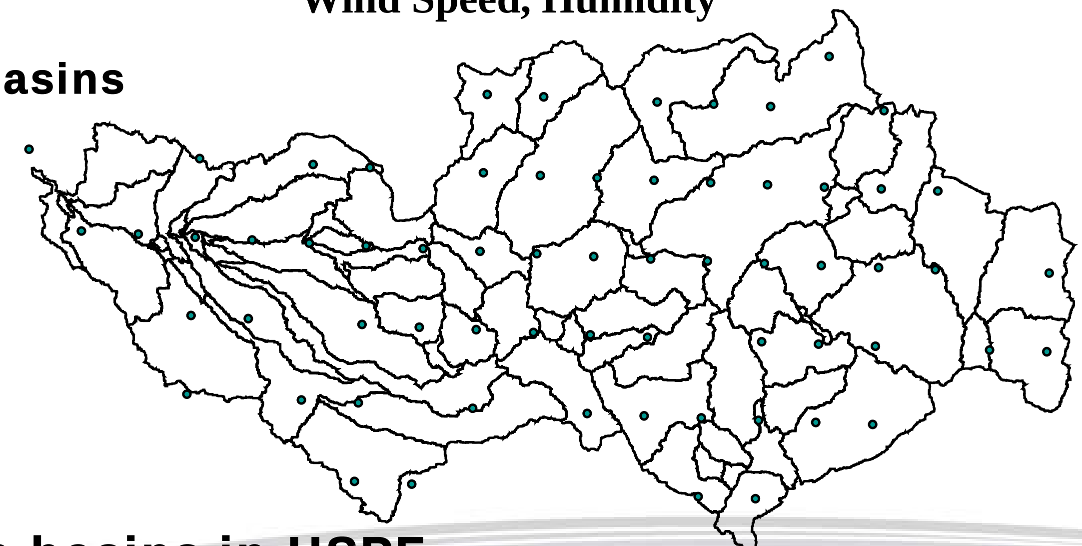
# Watershed Delineation



## Gridded Weather Data Locations

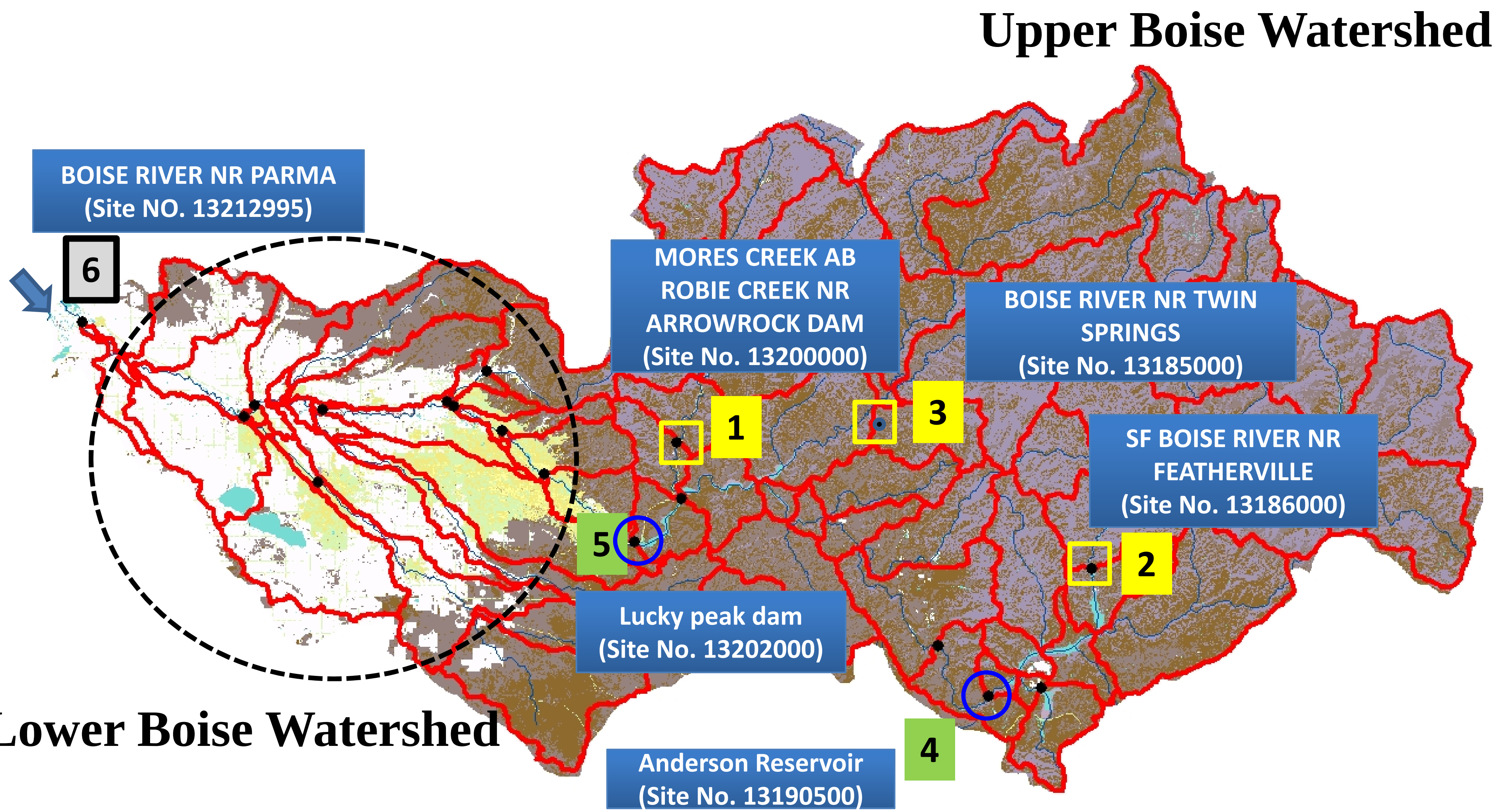
- **Gridded Weather Data: 4km by 4km spatial resolution**
- **Daily time steps**
- **Data Periods: 1979 – 2013 (25 years)**
- **Data used: Precipitation, Minimum Temp, Maximum Temp, Mean Temp, Wind Speed, Humidity**

**About 70 subbasins**



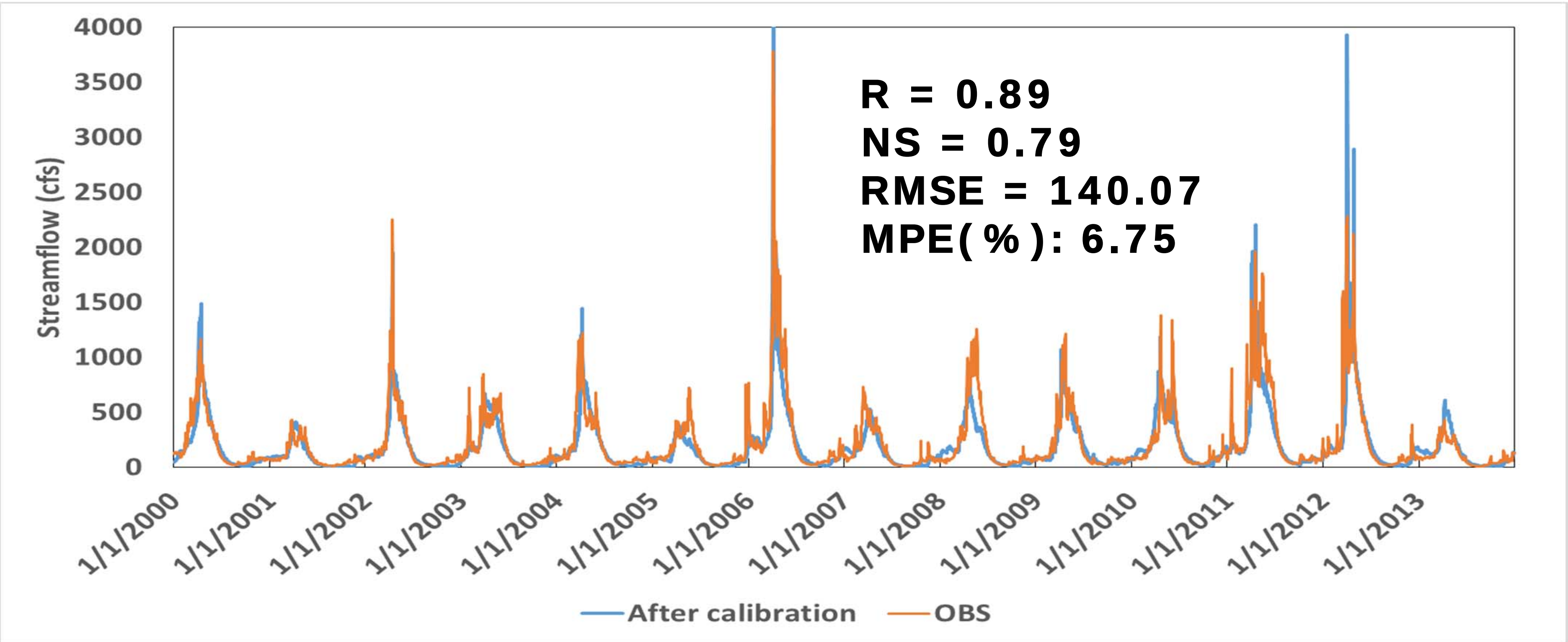
**Weather Data Used for Sub basins in HSPF**

# Hydrological Simulations



# Hydrological Simulations (Above Reservoir)

- Station 1: Mores Creek ABOVE Lucky Peak Dam, USGS#: 13200000

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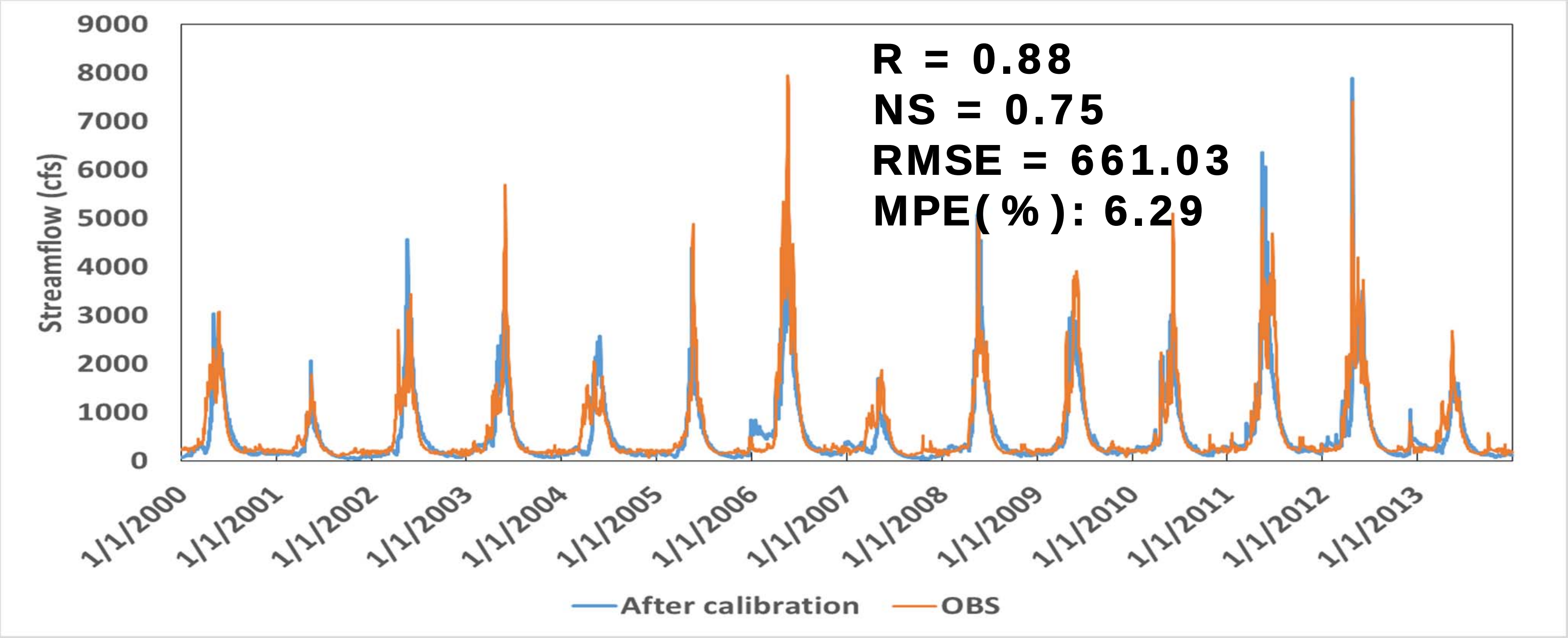
# Hydrological Simulations (Above Reservoir)

- Station 2: South Fork Boise River near Feathervilee, ABOVE Anderson Ranch Dam, USGS#: 13186000

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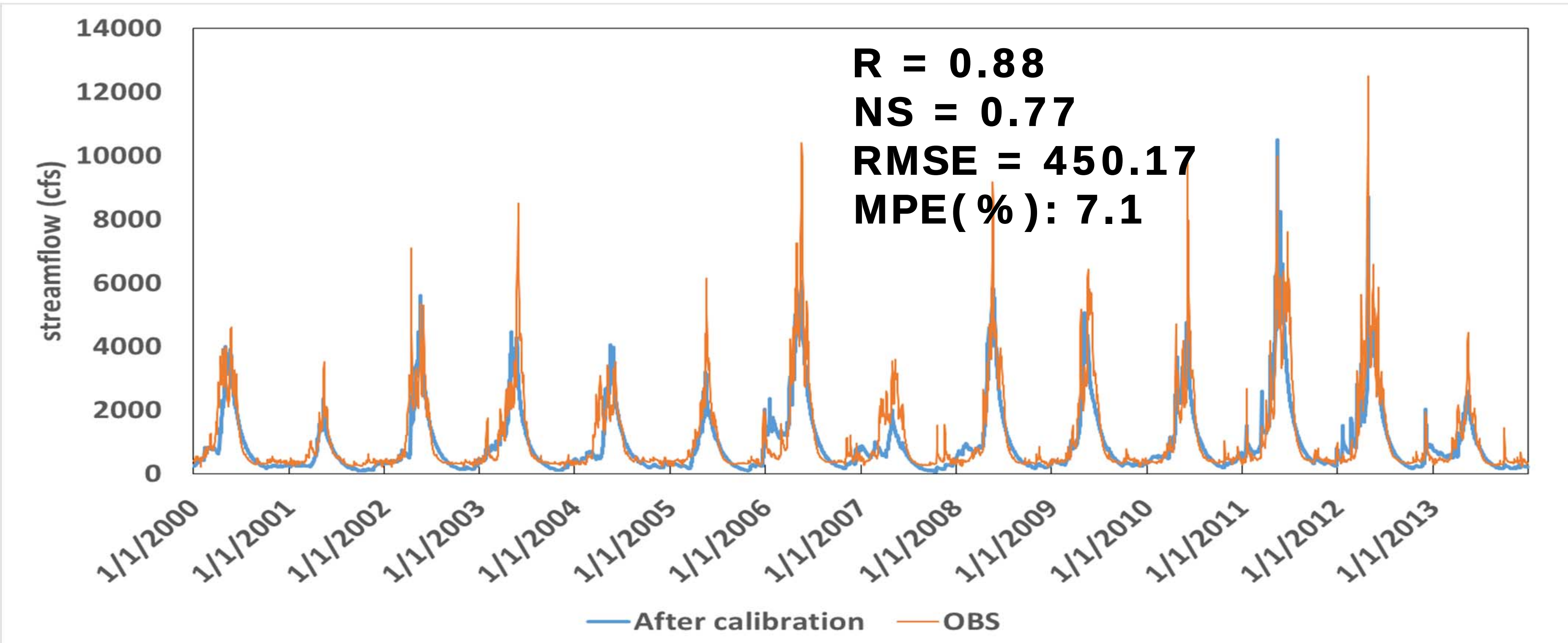
# Hydrological Simulations (Above Reservoir)

- Station 3: Boise River near Twin Springs ABOVE Arrow Rock Dam, USGS#: 13185000

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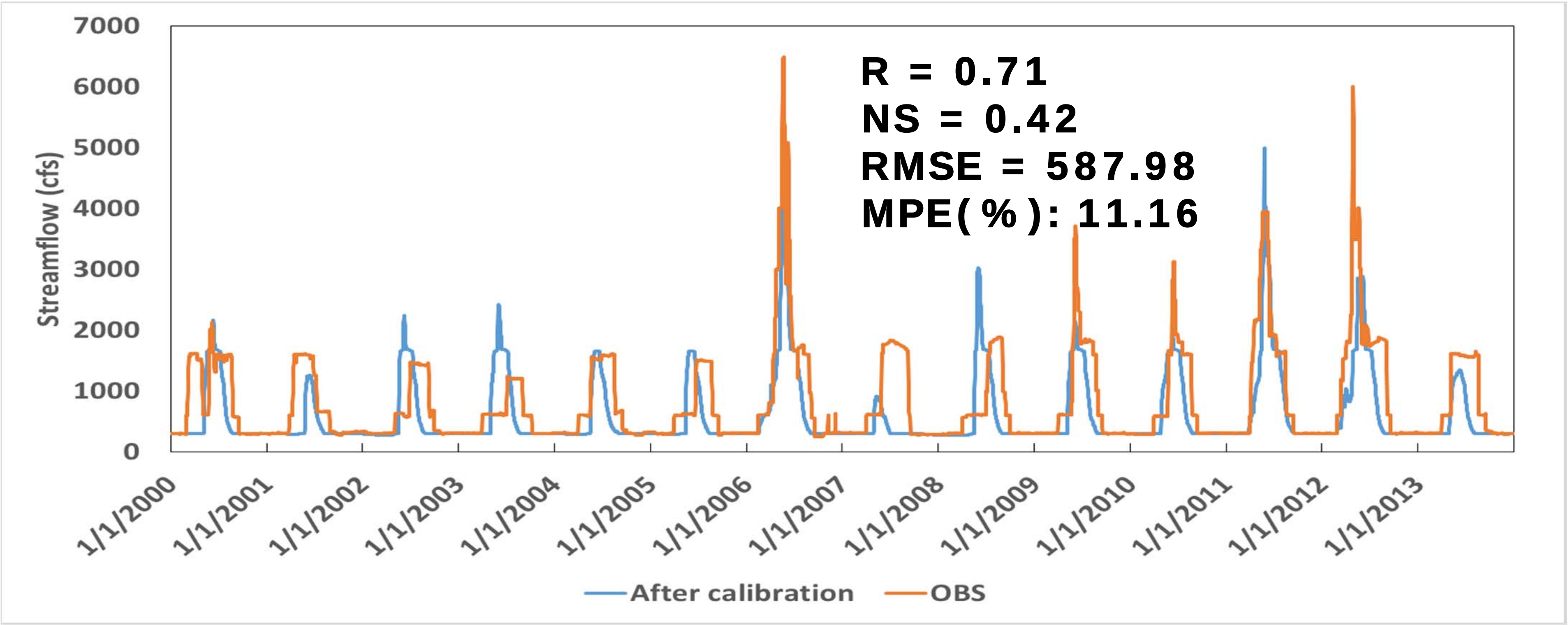
# Hydrological Simulations (Below Reservoir)

- Station 4: Right BELOW Anderson Ranch Reservoir, USGS#: 13190500

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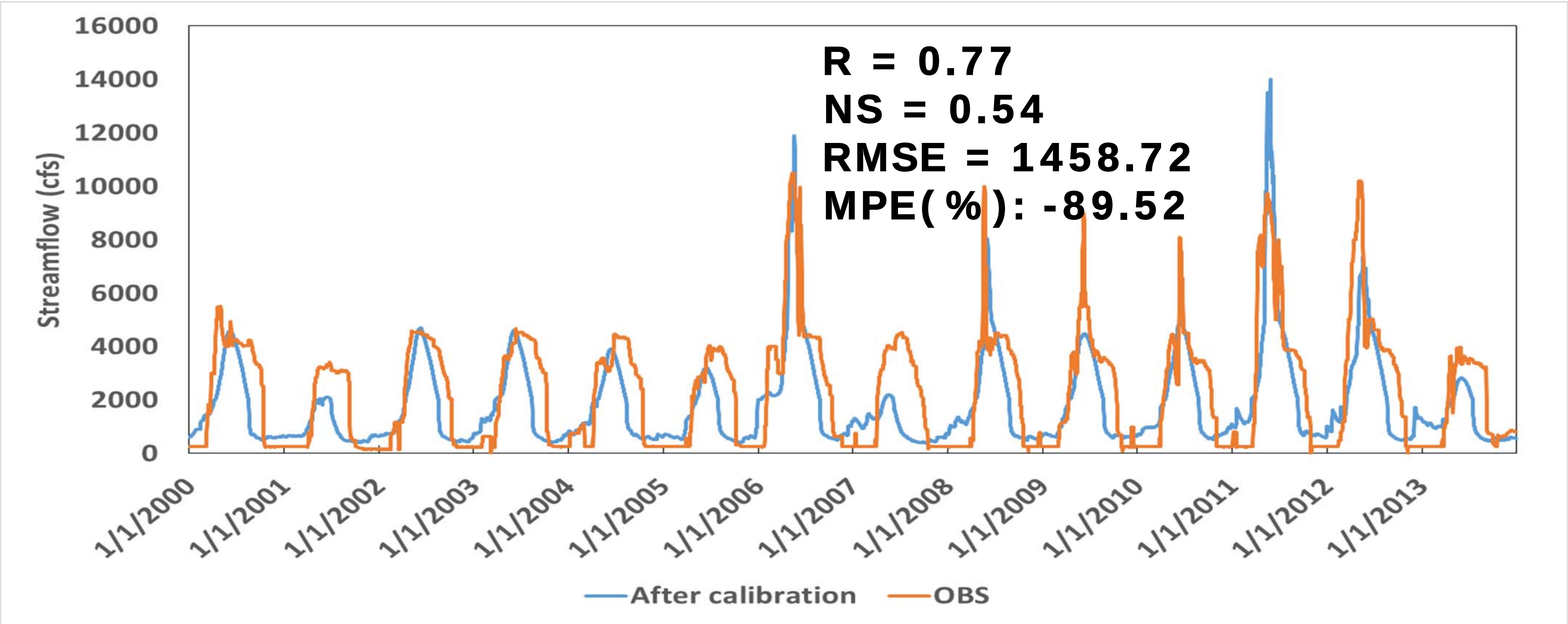
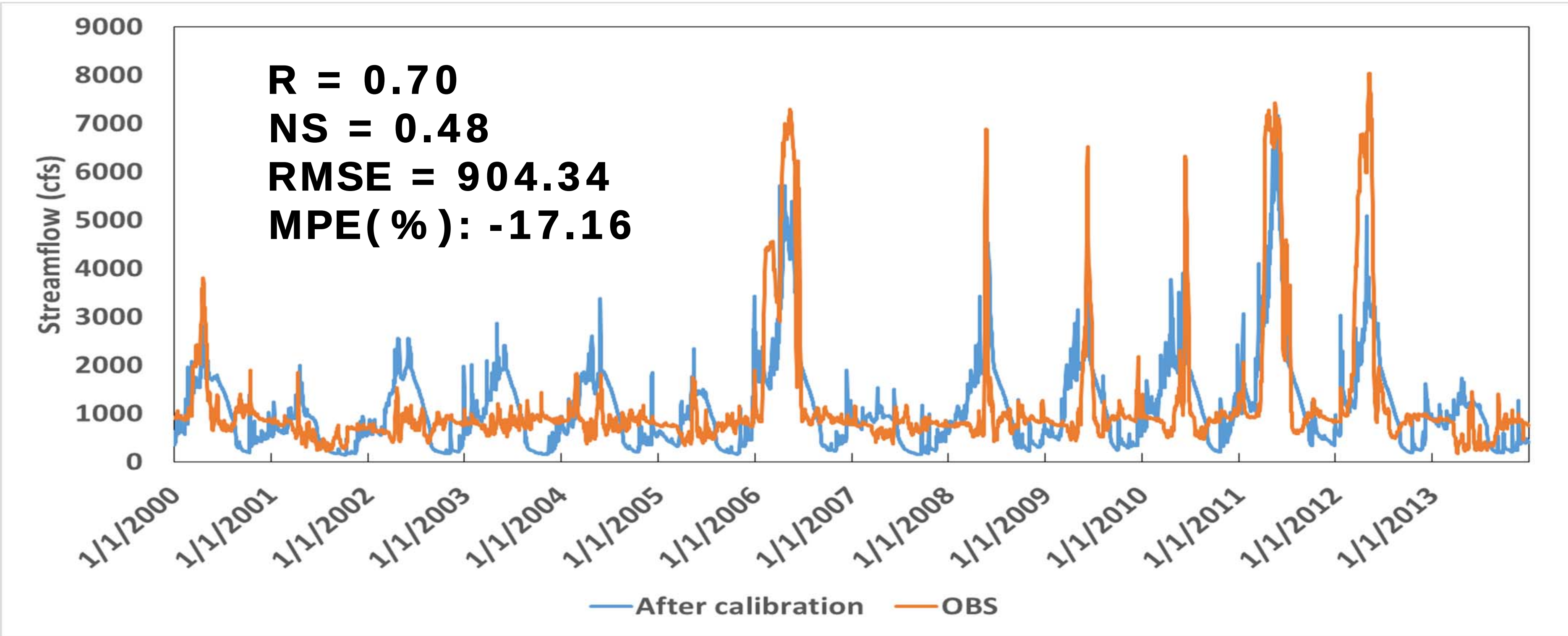
# Hydrological Simulations (Below Reservoir)

- Station 5: Right BELOW Lucky Peak Reservoir, USGS#: 13202000

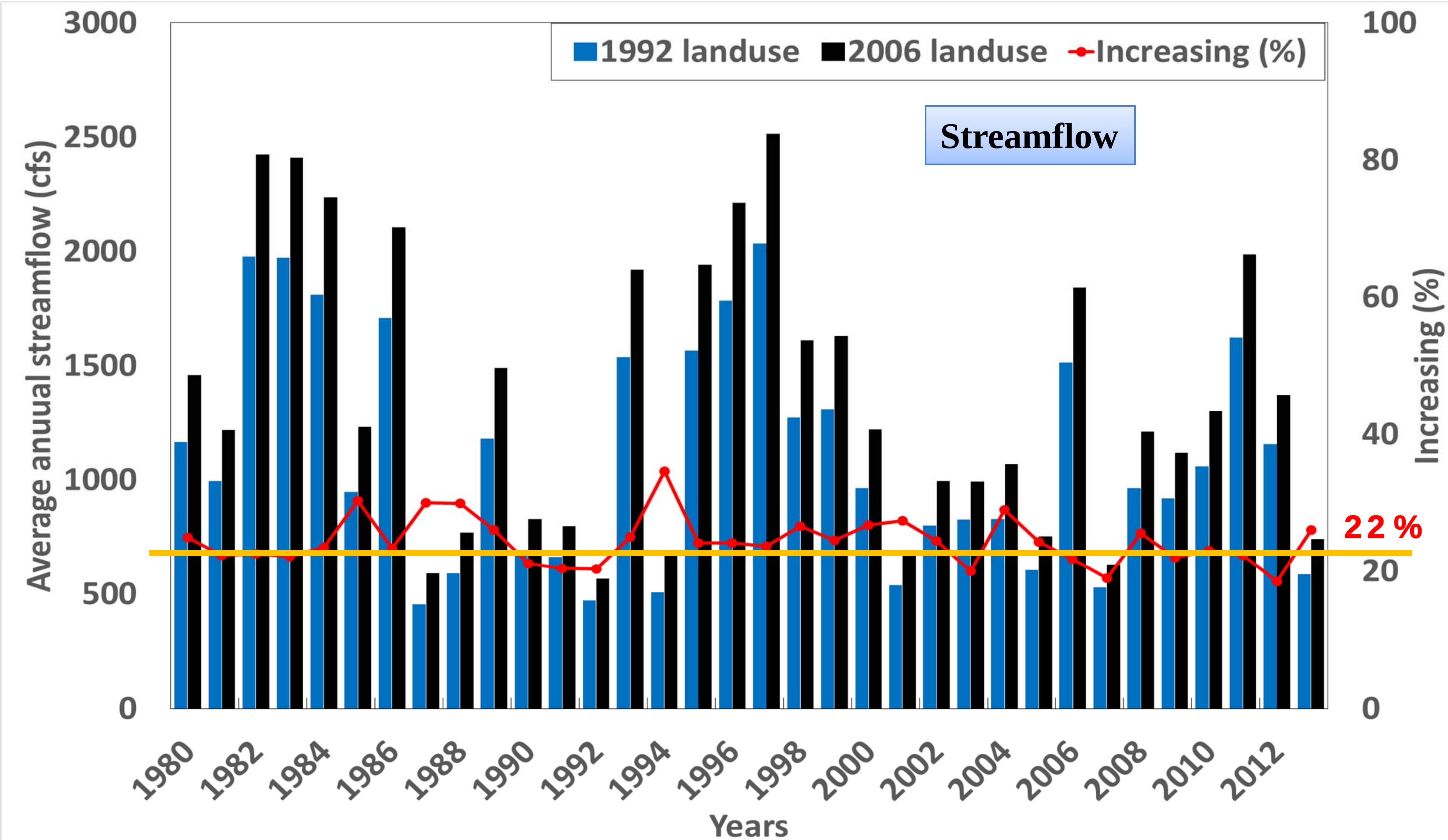


# Hydrological Simulations (Below Reservoir)

- Station 6: Boise River near Nampa, Mouth of Watershed, USGS#: 13212955



# Hydrological Responses to Land Use Change

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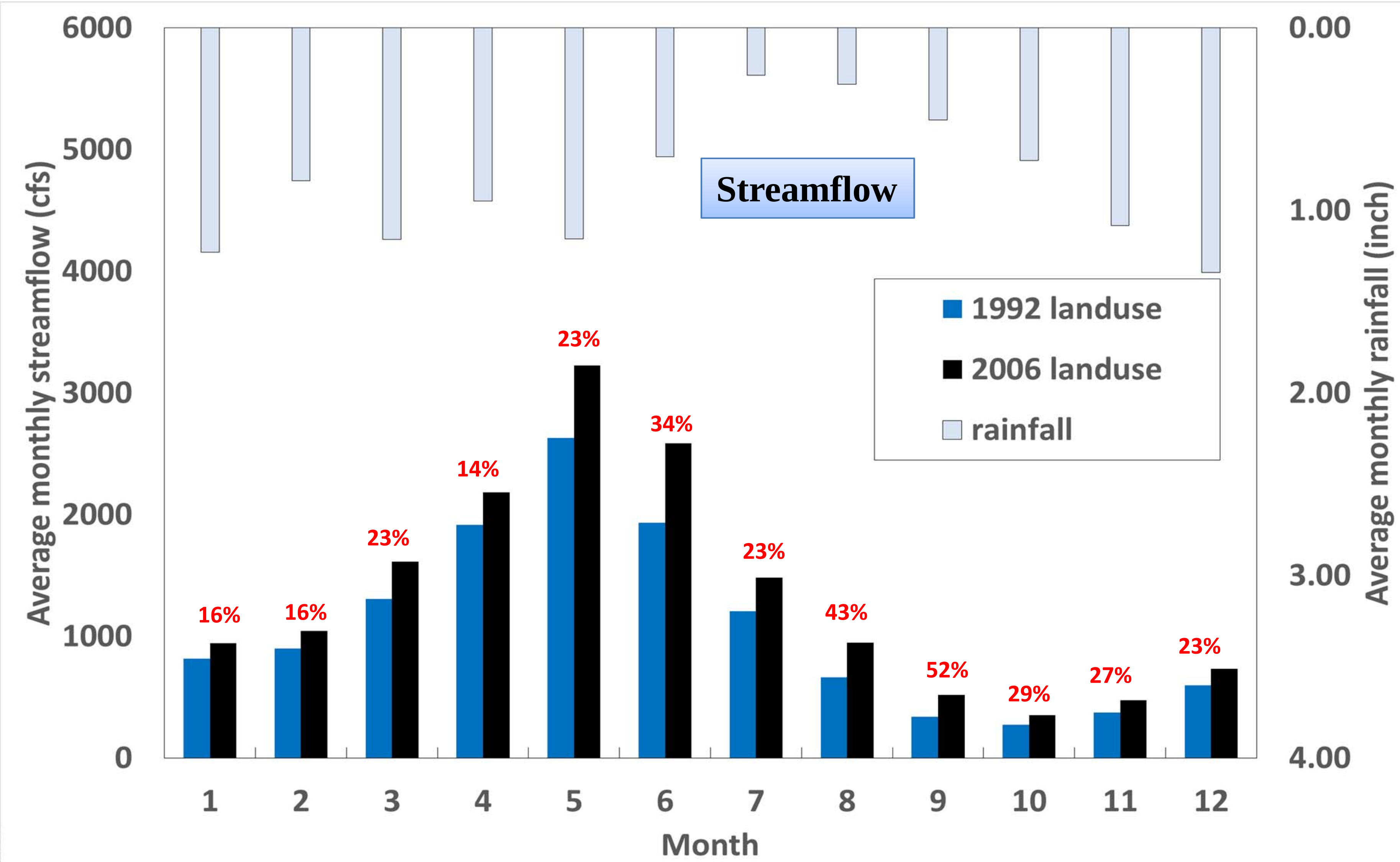
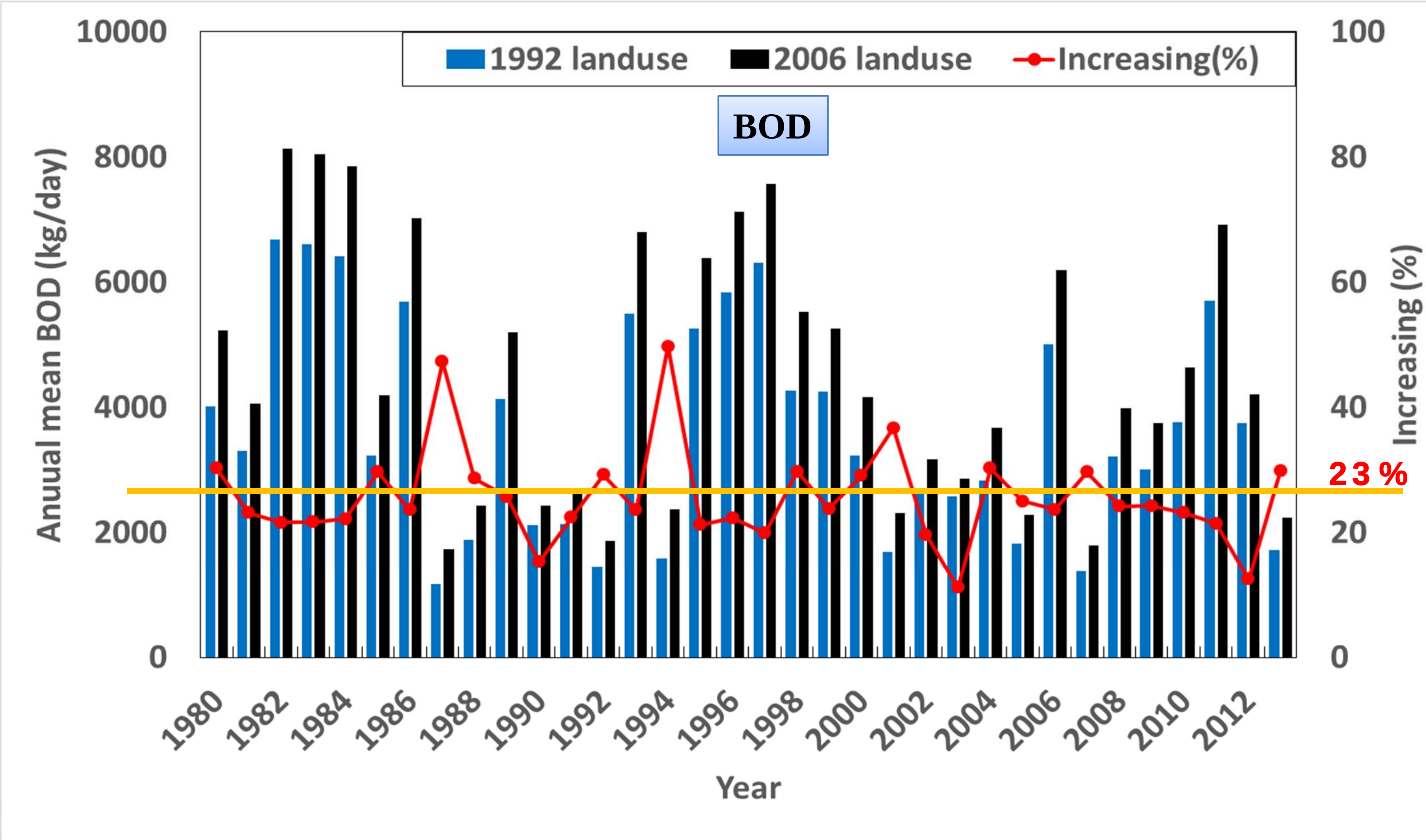


# Environmental Responses to Land Use Change

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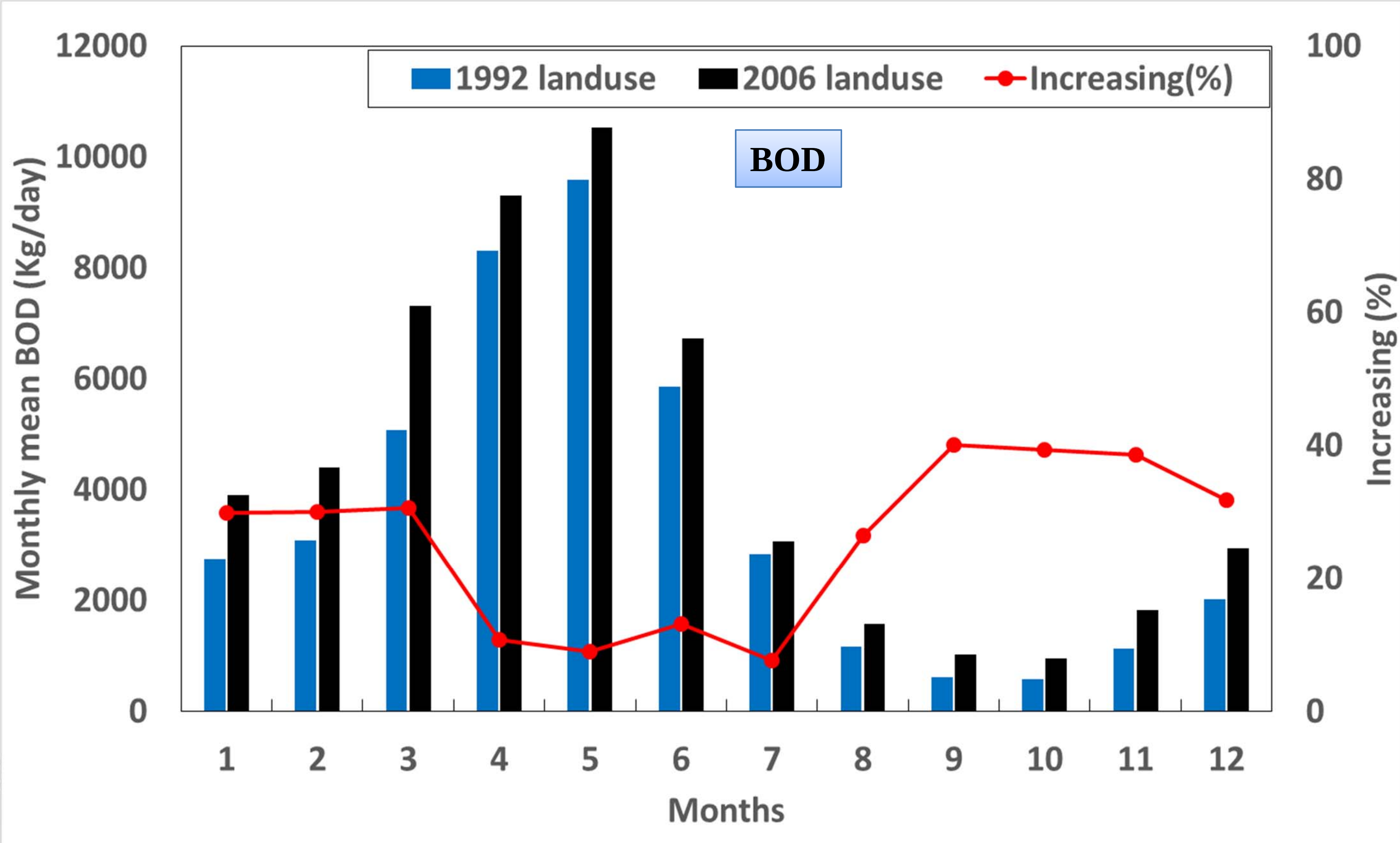
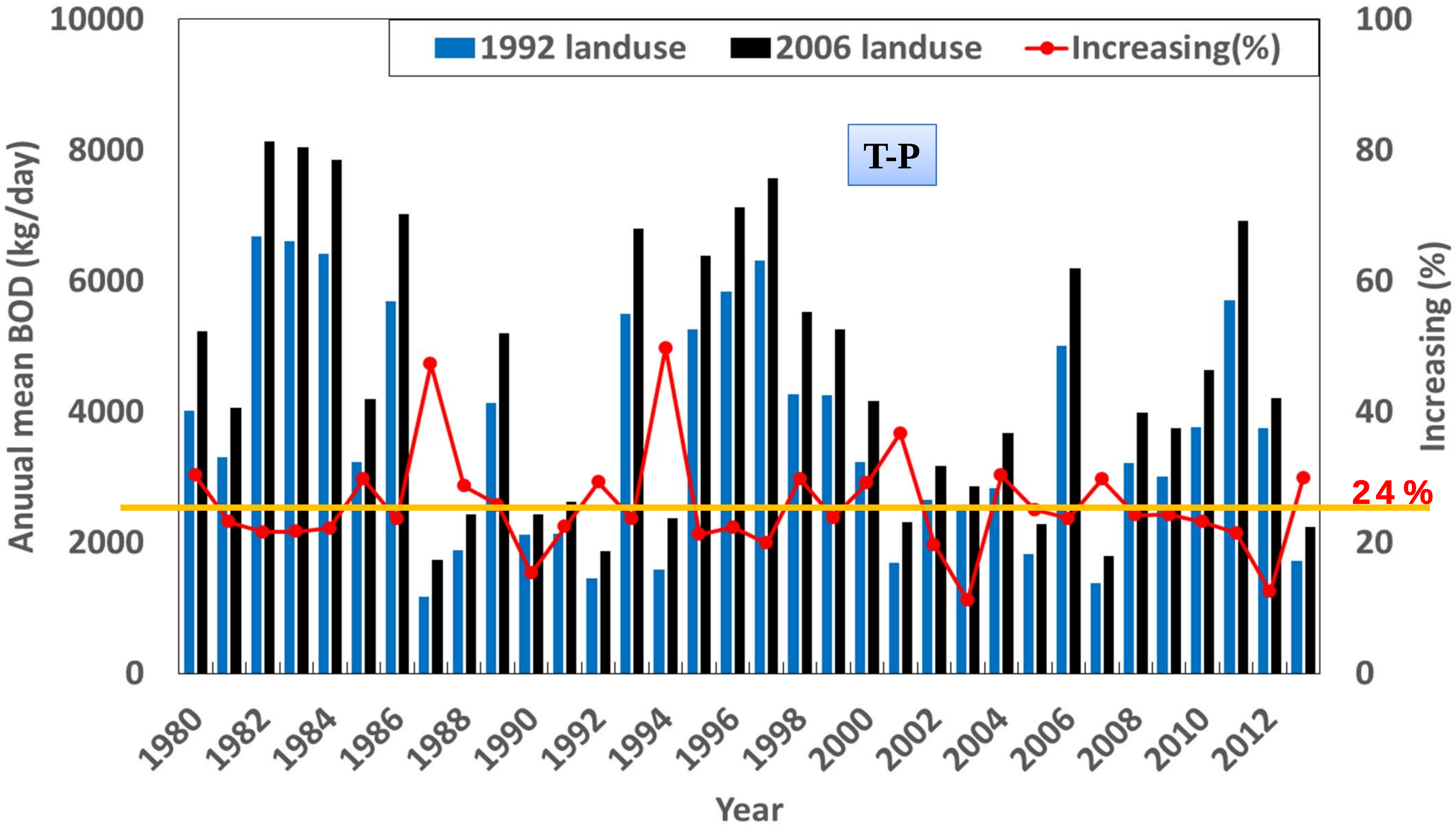


# Hydrological and Environmental Responses to Land Use Change



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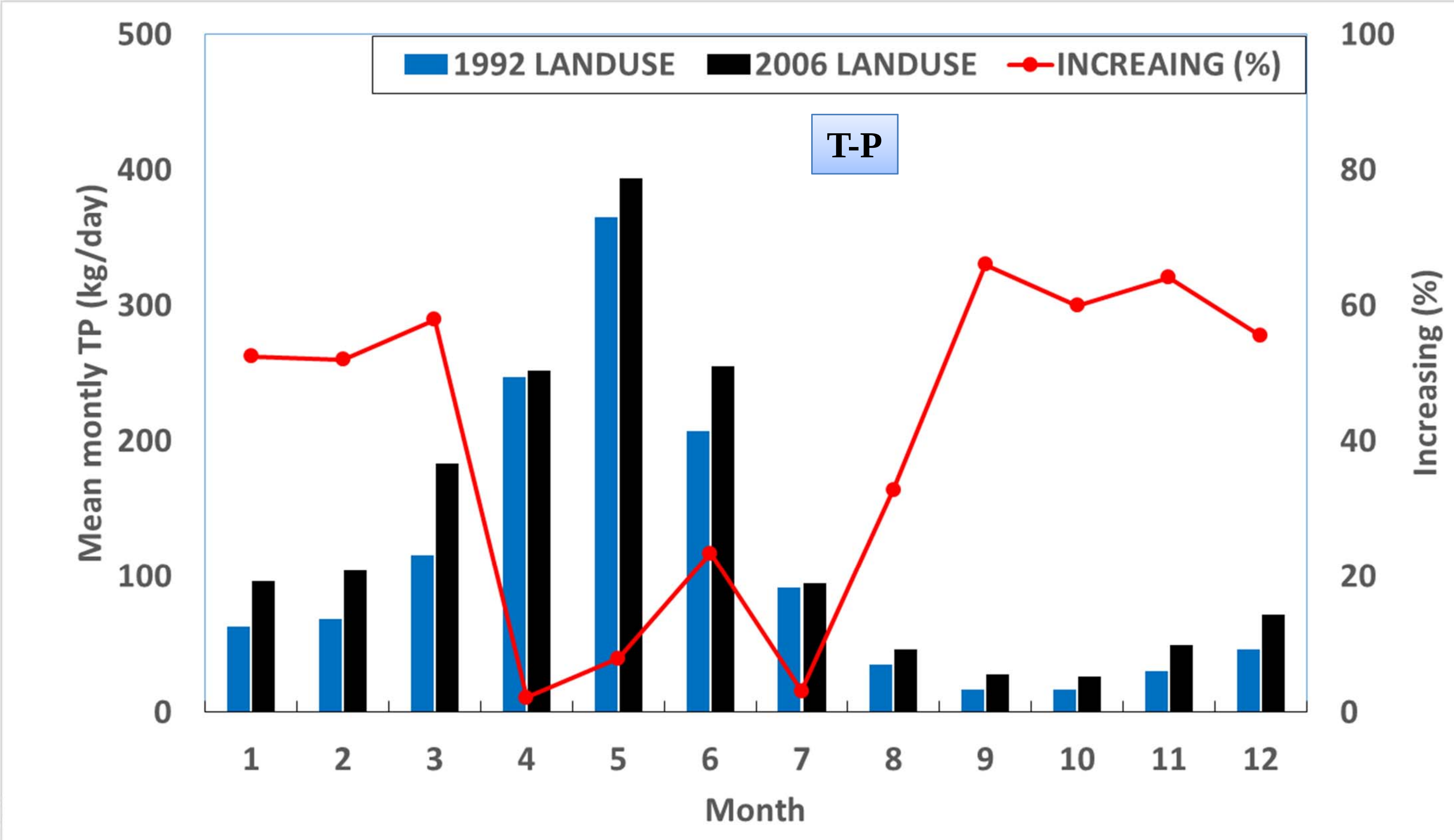


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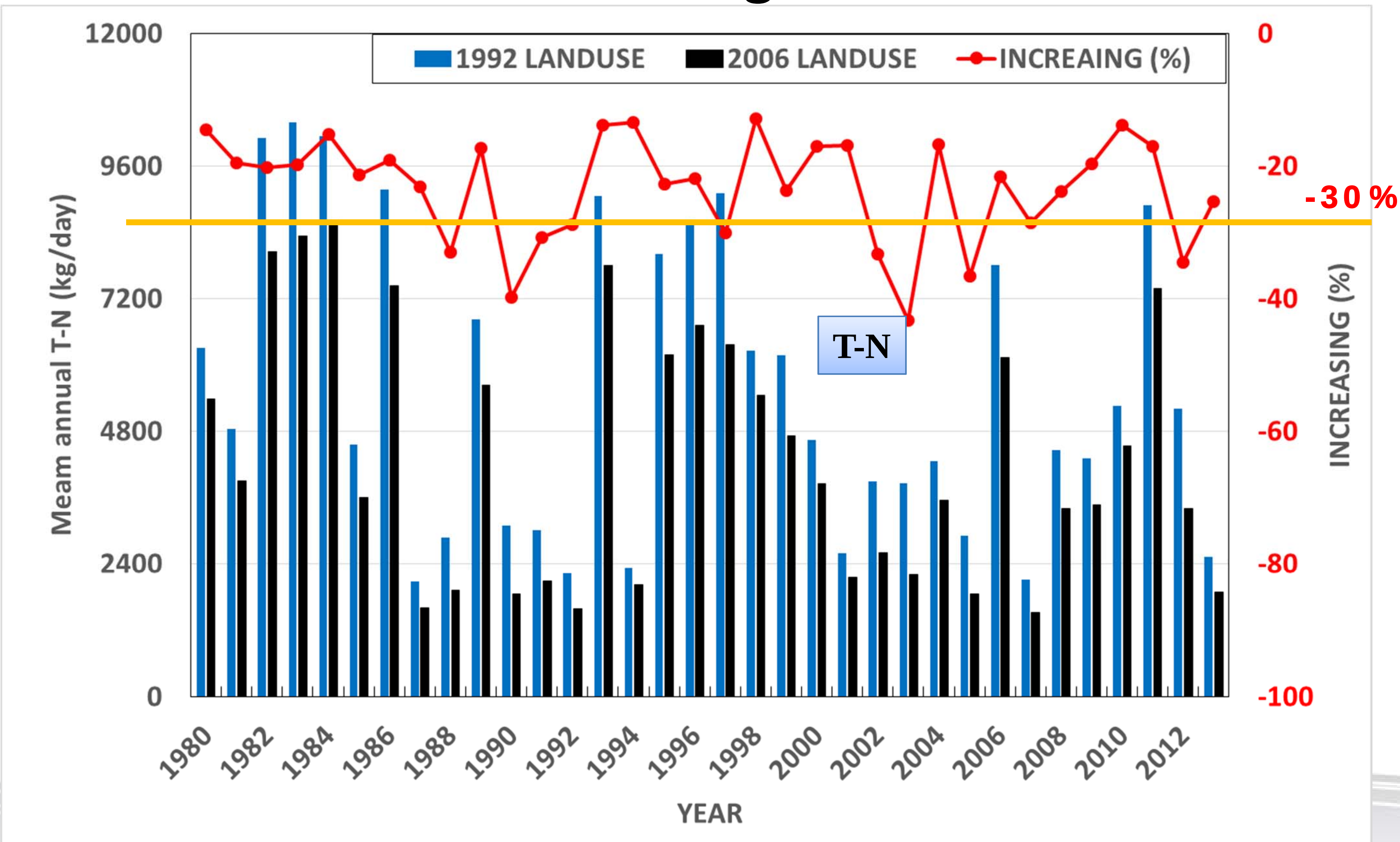
# Environmental Responses to Land Use Change



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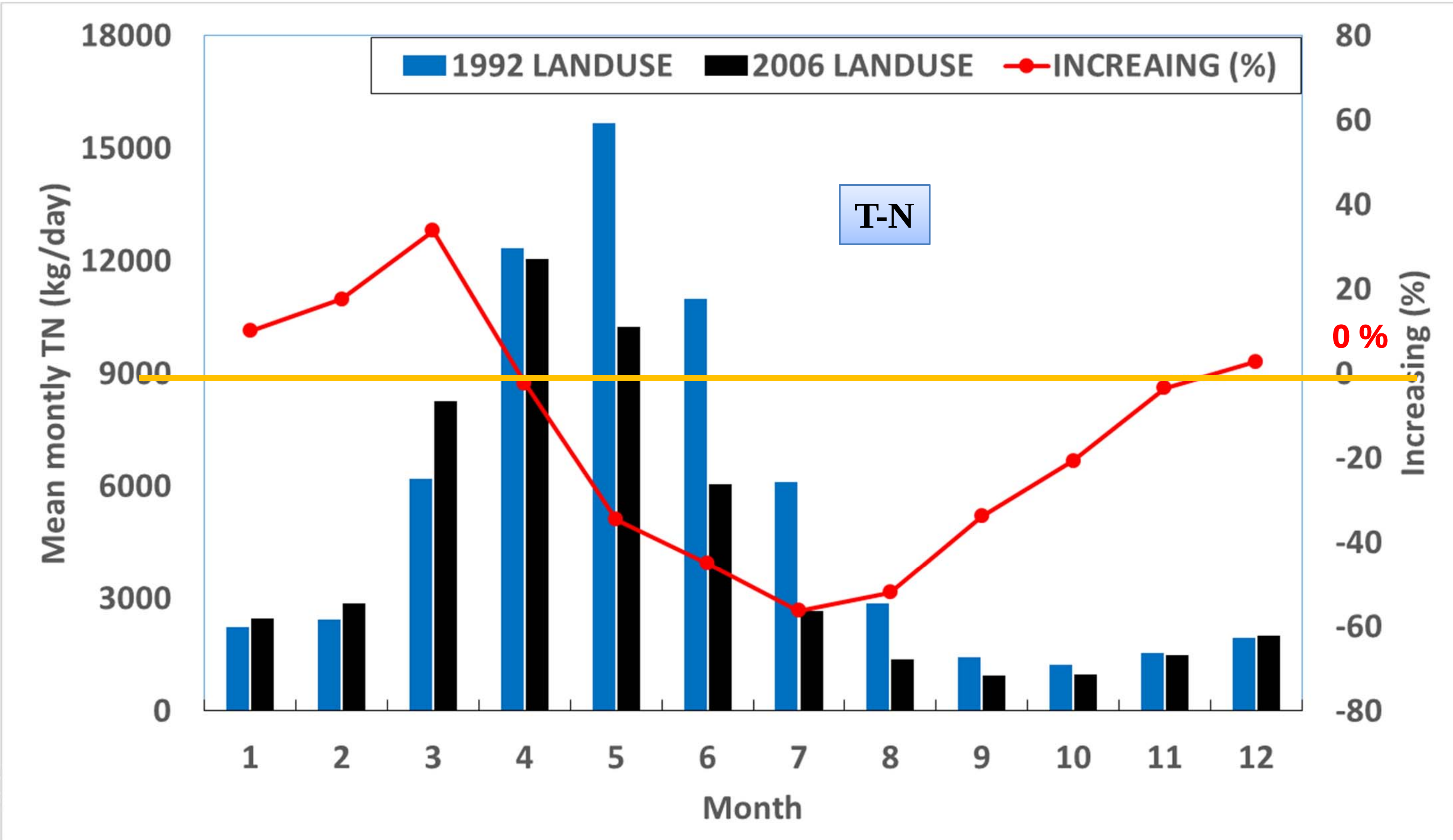


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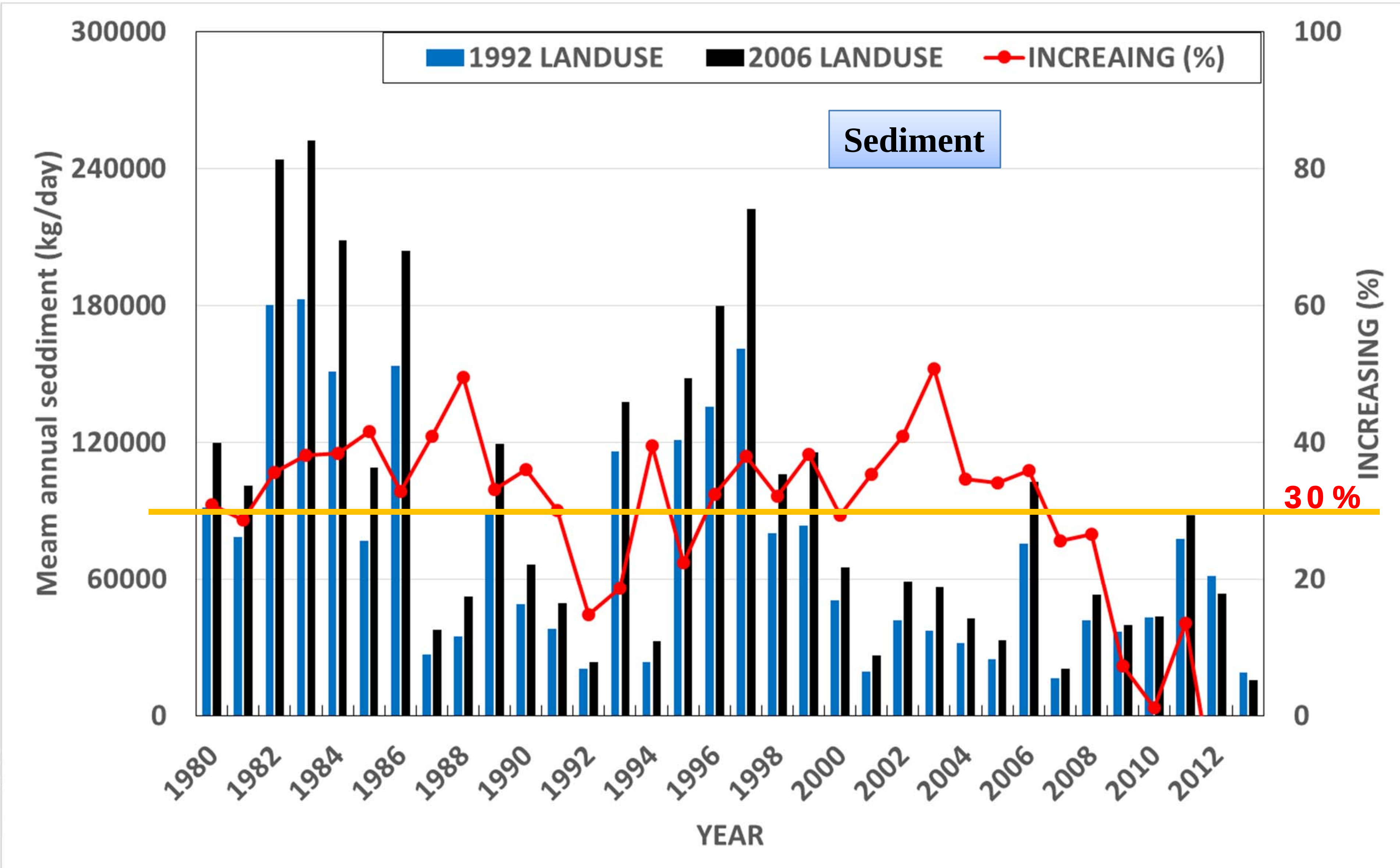

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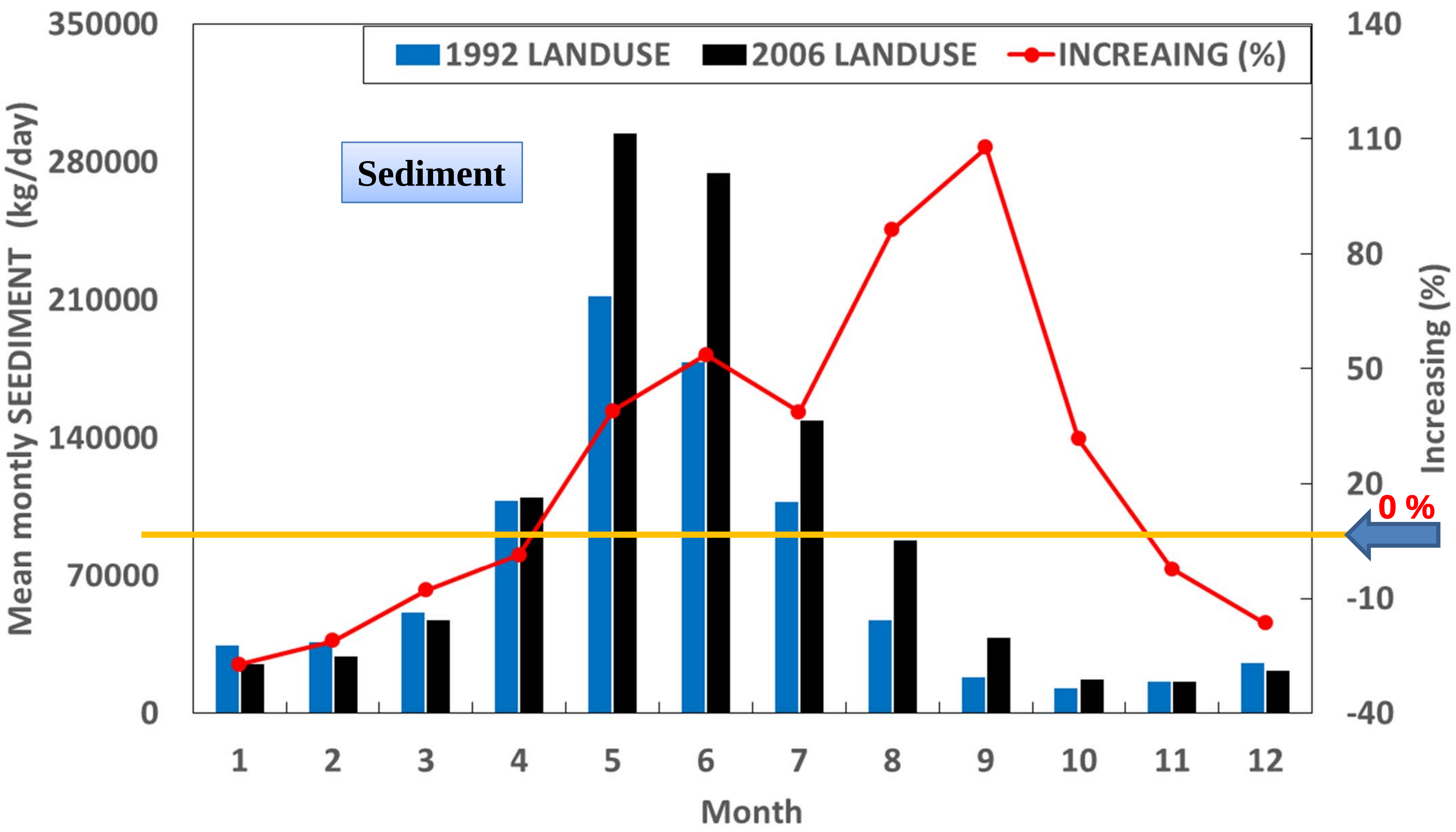


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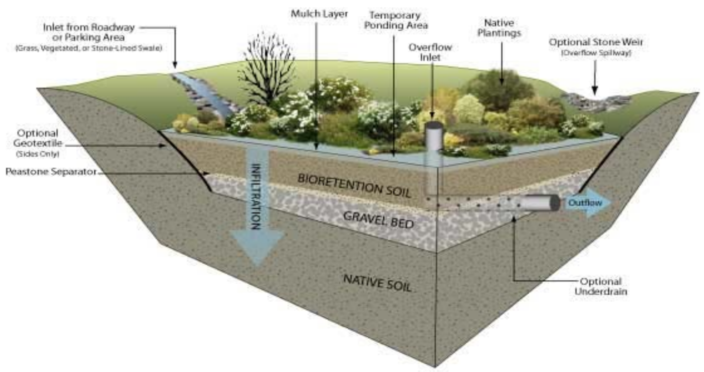
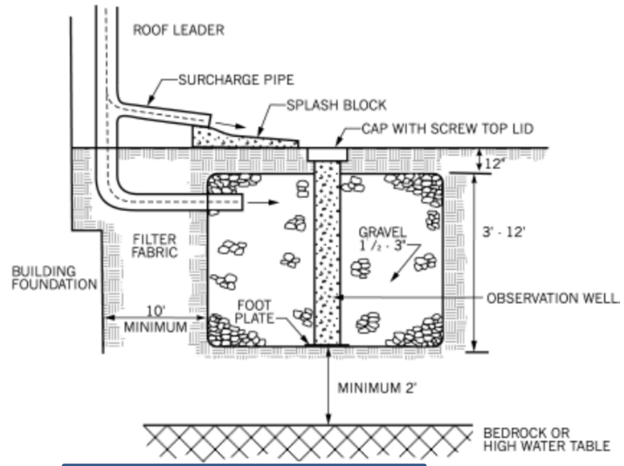
# Low Impact Development (LID)Techniques

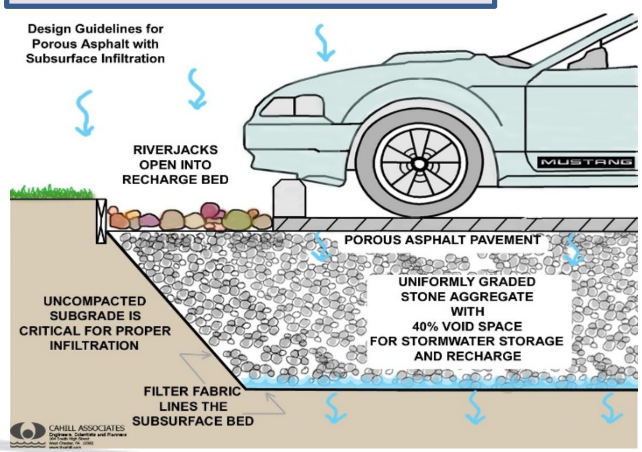
**Bioretention**



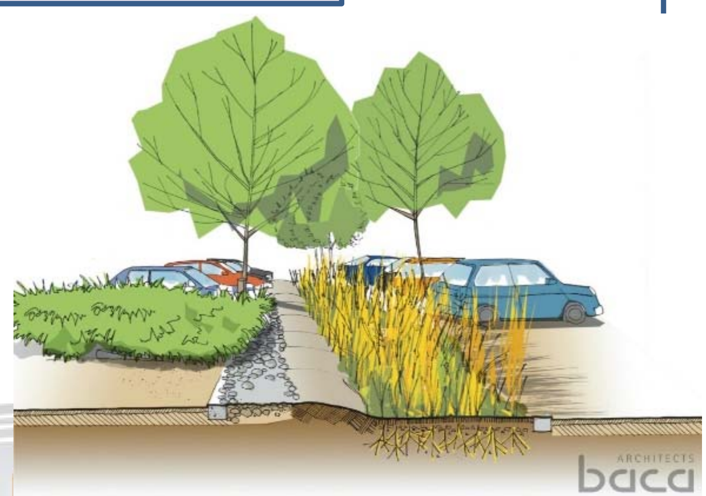

**Drywell**




**Permeable pavement**

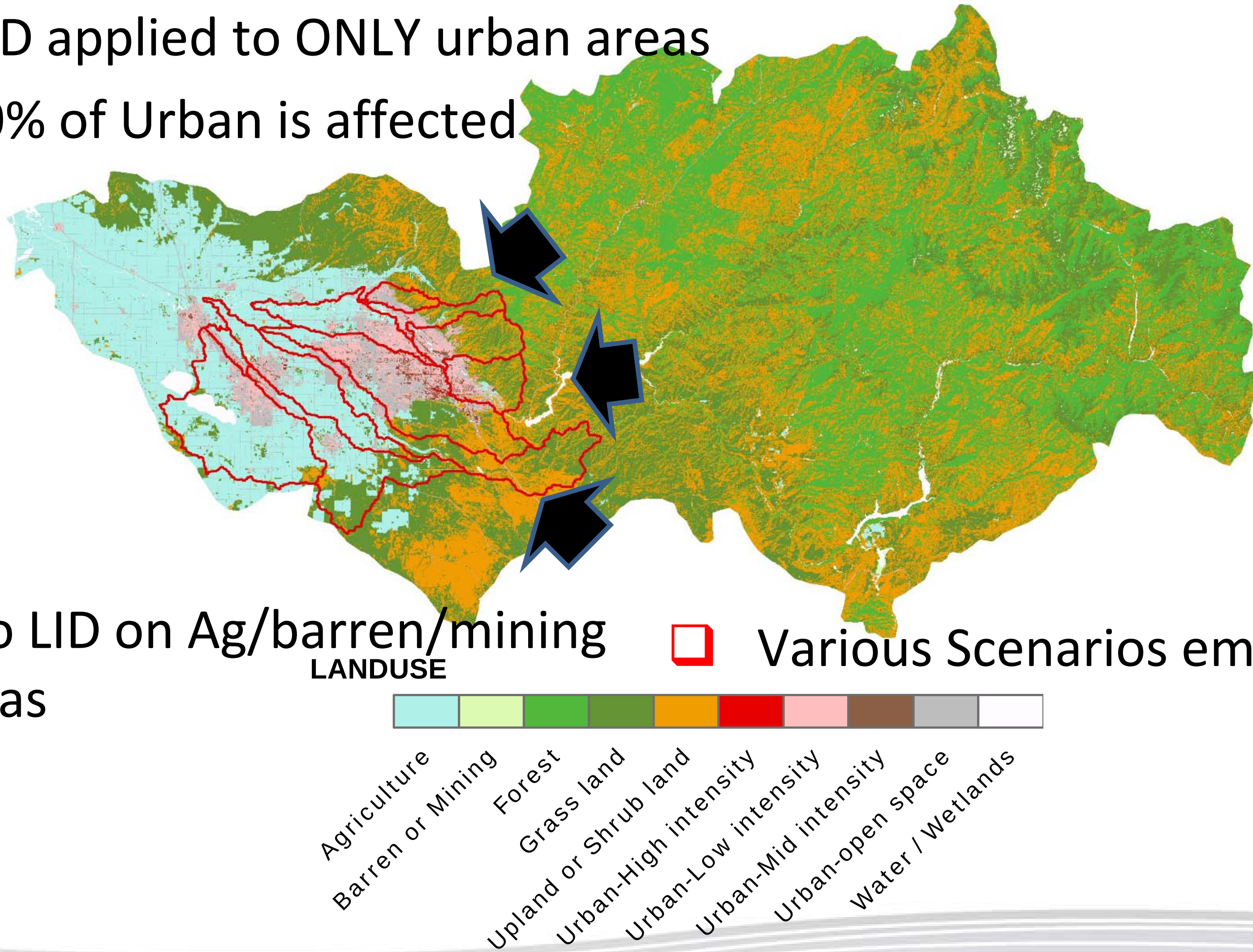



**Buffer strip**



# Low Impact Development (LID) Application

- LID applied to ONLY urban areas
- 50% of Urban is affected

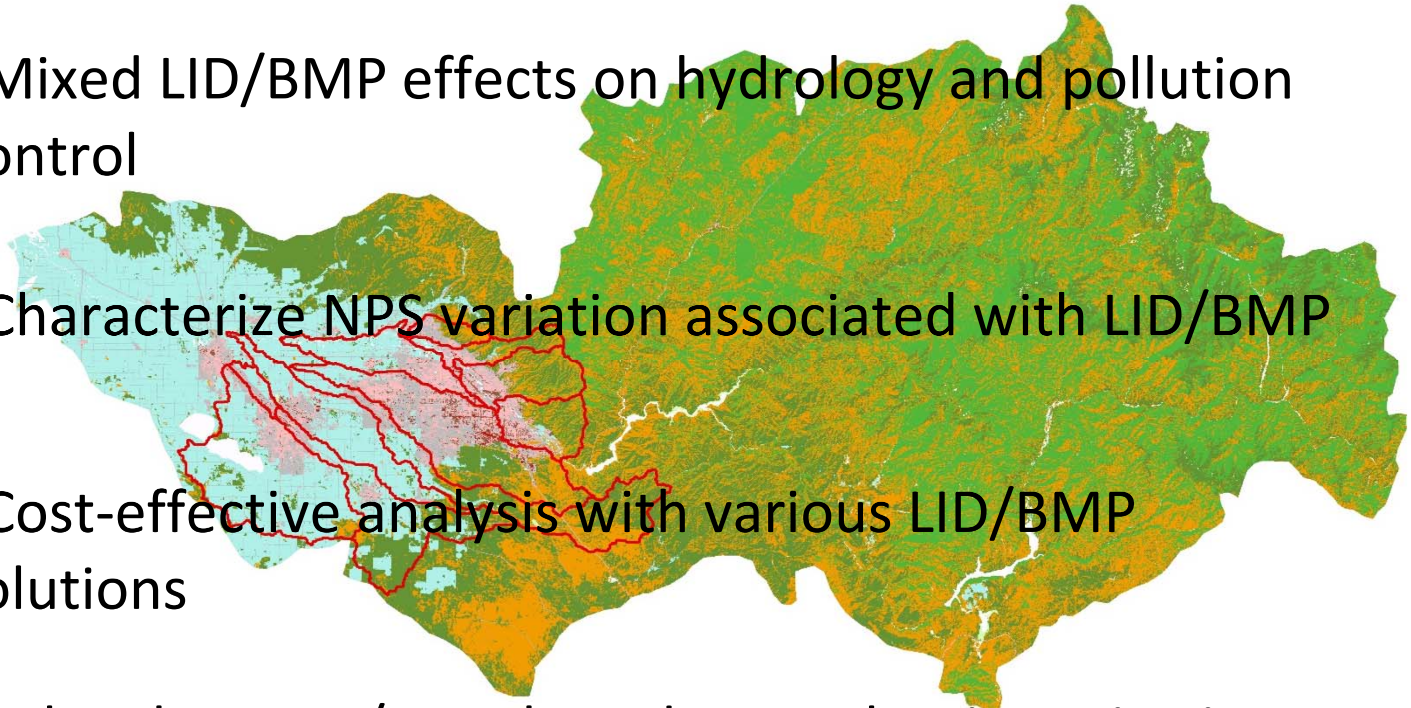



- No LID on Ag/barren/mining areas
- Various Scenarios employed

# Results/Bioretention

| Mon | Stream flow (cfs) | | BOD (Kg/day) | | T-N (Kg/day) | | T-P (Kg/day) | |
|---|---|---|---|---|---|---|---|---|
| | W/O LID | With LID | W/O LID | With LID | W/O LID | With LID | W/O LID | With LID |
| 1 | 952 | 859 (11 %) | 3,909 | 2,945 (33 %) | 2,466 | 2,064 (19 %) | 96 | 70 (38 %) |
| 2 | 1054 | 959 (10 %) | 4,396 | 3,372 (30 %) | 2,861 | 2,436 (17 %) | 104 | 79 (32 %) |
| 3 | 1624 | 1,430 (14 %) | 7,309 | 5,713 (28 %) | 8,271 | 7,079 (17 %) | 183 | 139 (32 %) |
| 4 | 2,200 | 2,088 (5 %) | 9,305 | 8,005 (16 %) | 12,053 | 10,686 (13 %) | 252 | 223 (13 %) |
| 5 | 3,281 | 3,199 (3 %) | 10,521 | 9,597 (10 %) | 10,244 | 9,400 (9 %) | 394 | 373 (6 %) |
| 6 | 2,613 | 2,579 (1 %) | 6,734 | 6,355 (6 %) | 6,047 | 5,659 (7 %) | 255 | 247 (3 %) |
| 7 | 1,494 | 1,481 (1 %) | 3,074 | 2,891 (6 %) | 2,676 | 2,514 (6 %) | 94 | 91 (4 %) |
| 8 | 958 | 951 (1 %) | 1,580 | 1,464 (8 %) | 1,381 | 1,302 (6 %) | 46 | 44 (5 %) |
| 9 | 526 | 512 (3 %) | 1,017 | 842 (21 %) | 949 | 848 (12 %) | 28 | 24 (17 %) |
| 10 | 355 | 334 (6 %) | 945 | 699 (35 %) | 965 | 829 (16 %) | 26 | 20 (33 %) |
| 11 | 479 | 429 (12 %) | 1,831 | 1,275 (44 %) | 1,487 | 1,227 (21 %) | 49 | 35 (42 %) |
| 12 | 737 | 658 (12 %) | 2,949 | 2,156 (37 %) | 1,996 | 1,668 (20 %) | 71 | 51 (39 %) |

# Future Work



- Mixed LID/BMP effects on hydrology and pollution control
- Characterize NPS variation associated with LID/BMP
- Cost-effective analysis with various LID/BMP solutions
- Select best LID/BMP based on evaluation criteria using MCDM approach

# Thank You

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# Key Hydrologic Parameters

- AGWETP: Fraction of remaining potential evapotranspiration from active groundwater
- AGWRC: Base groundwater recession rate
- BASETP: The fraction of potential evapotranspiration from baseflow
- CEPSC: Interception storage capacity
- DEEPFR: Fraction of groundwater inflow to deep recharge
- INFILT: Infiltration rate
- IRC: Interflow recession parameter
- KVARY: Variable groundwater recession flow
- LZETP: Lower zone evapotranspiration parameter
- LSUR: Length of the assumed overland flow
- LZSN: Lower zone nominal soil moisture storage
- NSUR: Manning's roughness for overland flow
- UZSN: Upper zone nominal soil moisture storage

# Calibration Procedure (Cont'd)

- **Annual Water Balance – Adjust Evaporation by multiplying factors to minimize the differences between observed and simulated flow**
- **Seasonal Water Balance (interflow and groundwater)– Adjust physical hydrologic parameters as well as monthly parameters (e.g. monthly intercept storage capacity parameter (inches), monthly lower zone evaporation parameters at start in each month**
- **Peak and low flows – Adjust physical hydrologic parameters (e.g. infiltration and percolation rate)**

# Auto Calibration

- **Parameter Estimation (PEST) Software – a module built in HSPF**

- **Model Independent Parameter Estimator– Minimize the bias between observed and simulated flows by many runs**

- **Enhancements and improvement of PEST – Difficulty of hourly calibration, non-physical based parameter estimator, but still promising in terms of saving time and efforts**