Regional hydrology and public health: A feasibility study

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Decision Making Activities

1. States need a low cost, quick method for estimating water quality.
   - A number of states are unable to quickly test for harmful bacteria in coastal waters.
   - States are unable to warn their citizens of harmful water quality.

2. Accurate long term predictions of water capacity for wastewater treatment plants are necessary.
   - All states are faced with rising costs for wastewater treatment plants.
   - Construction of these plants is extremely costly and resisted by municipalities.
   - But inadequate facilities result in degraded water quality.

Project Hypotheses

1. Coastal water quality is driven by precipitation, land use, and discharge from watersheds.

   NASA products for land use and precipitation can be used to accurately predict water quality.

2. Projected climate and land use changes will lead to robust variations in precipitation and river discharge.
3. Changes in discharge will lead to decreased water quality in the coastal environment.

   Output from NASA climate models and land use prediction models will allow for accurate predictions of discharge and water quality.

Research Questions

1. Can we accurately predict reduced water quality events in coastal waters?
2. Can we estimate future land use changes in watersheds?
3. Can we forecast wastewater treatment needs over a 10-20 year time period?
4. Can we adapt this method to large scale forecasts?

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Earth Science Research Results

Land Cover Data

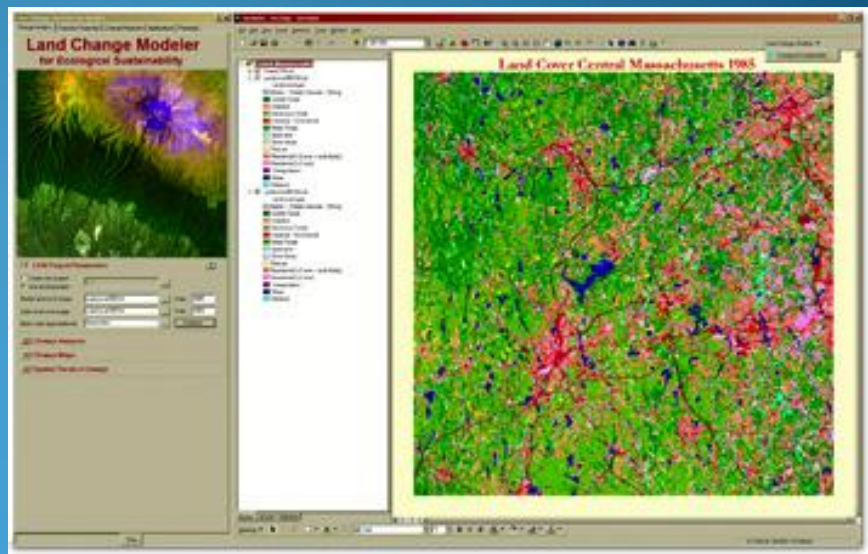
- Landsat Multi-Spectral Scanner, Thematic Mapper, and Enhanced Thematic Mapper
- Time Range – 1972 – Present
- Spatial Resolution – 30 – 240 m

Precipitation Data

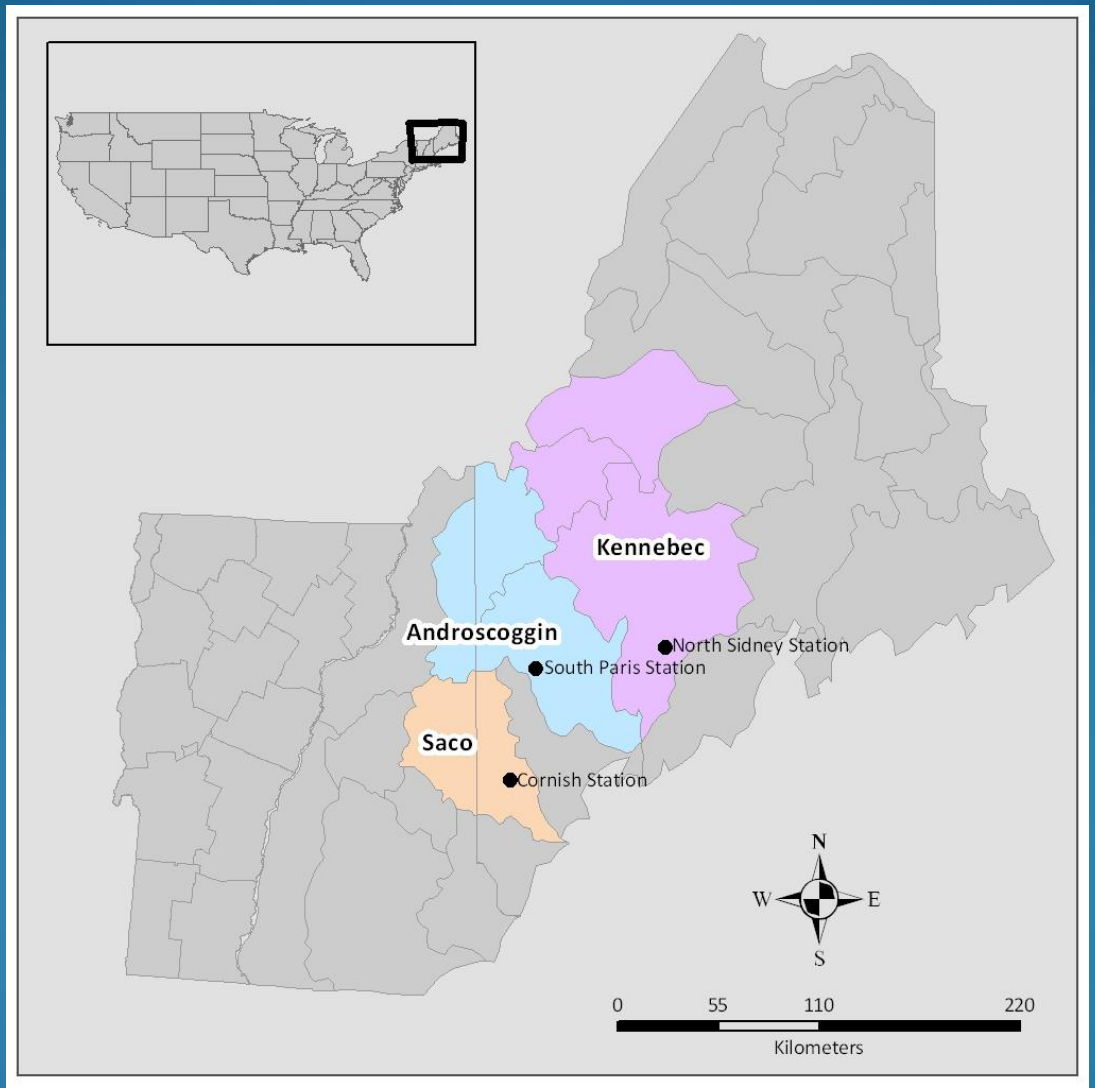
- Tropical Rainfall Measurement Mission Microwave Imager
- Time Range – 1998 – present
- Spatial Resolution – 0.25° × 0.25°

Land Use/Land Cover Prediction

- IDRISI Land Change Modeler
  - Multi-layer Perceptron Neural Network
    - 1992 – 2001 – 2010 – 2030
  - Variables
    - Likelihood of class transformation
    - Distance to developed areas
    - Distance to roads



Test Case: Three watersheds in Maine



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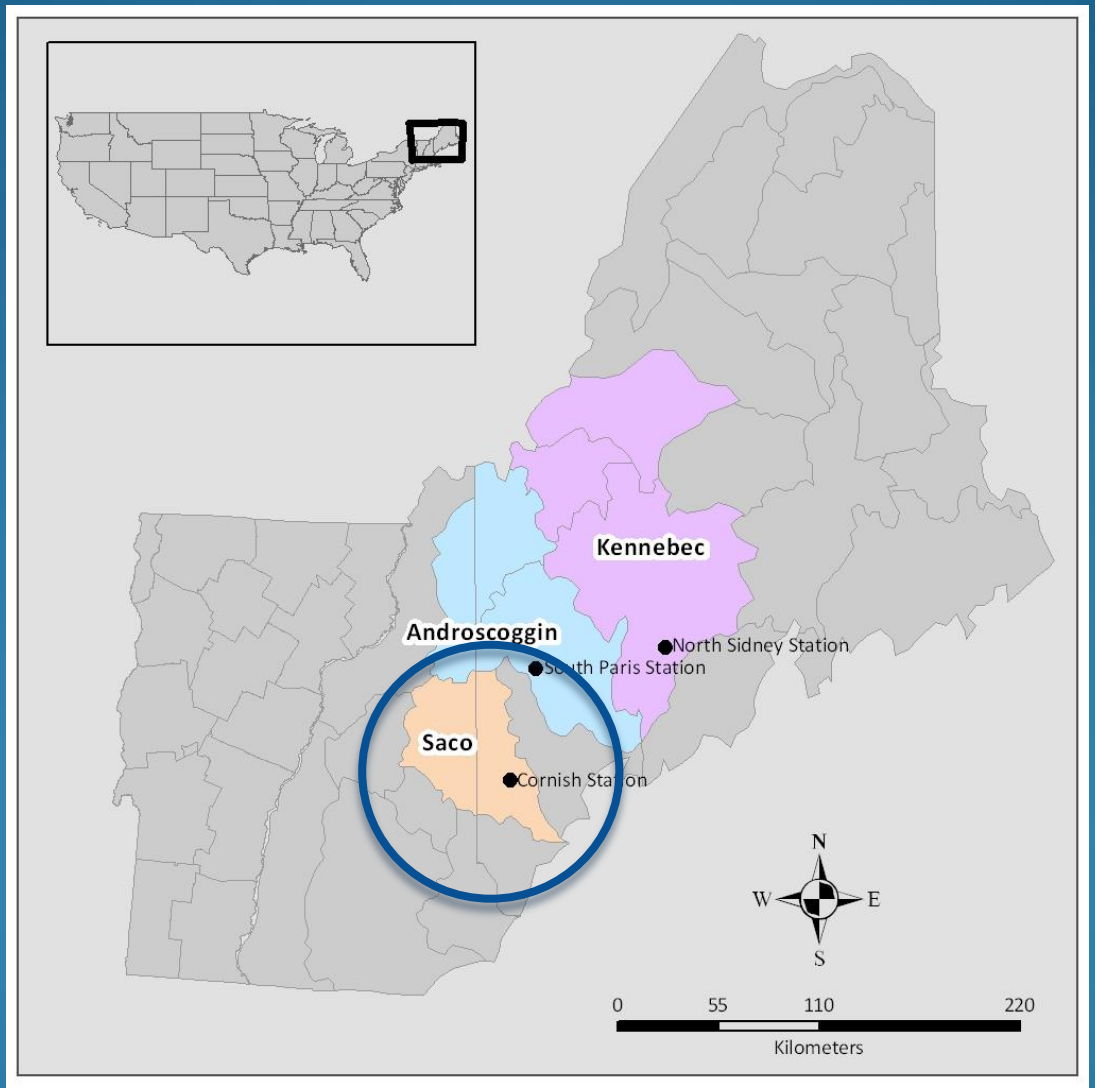
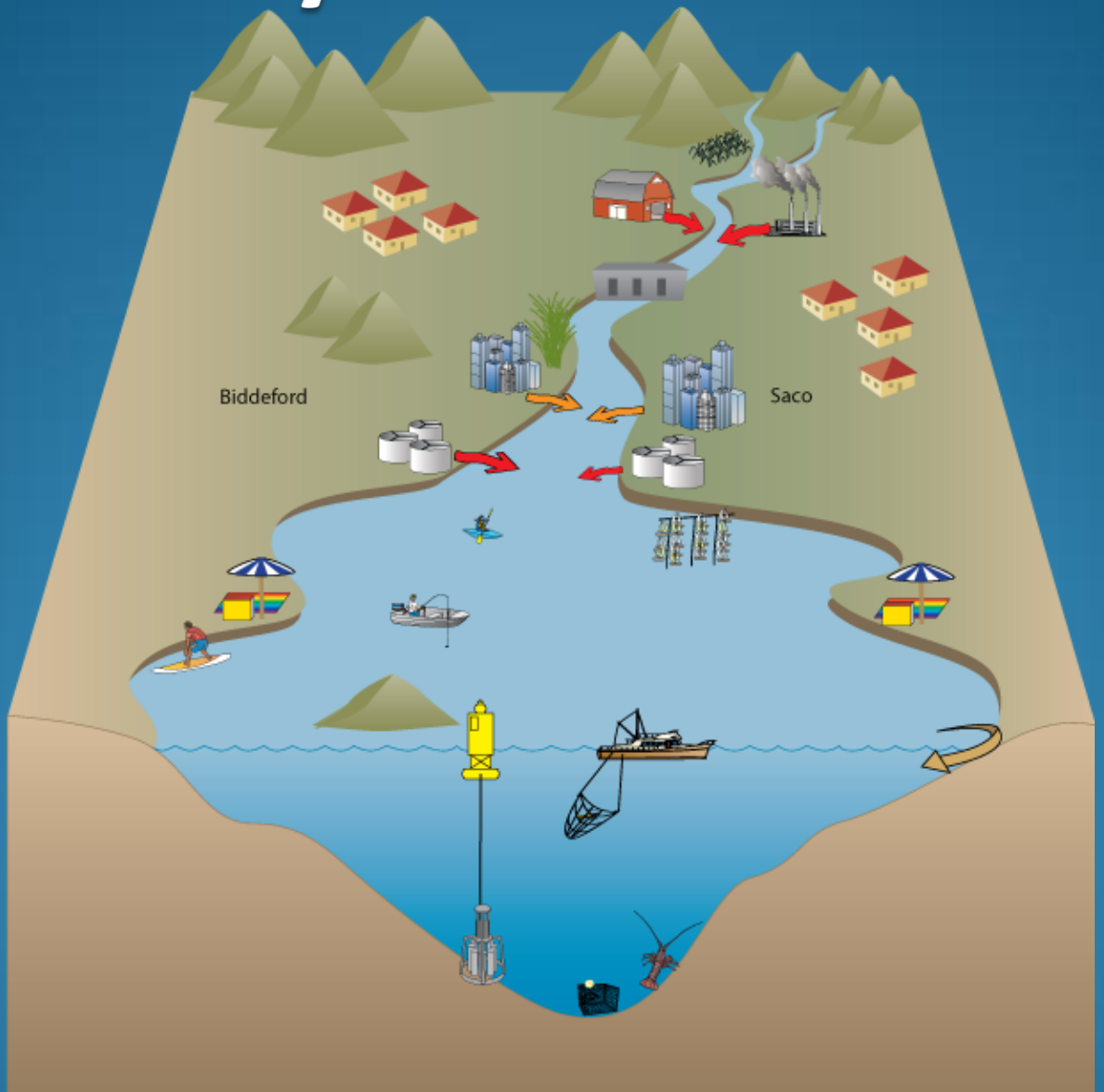
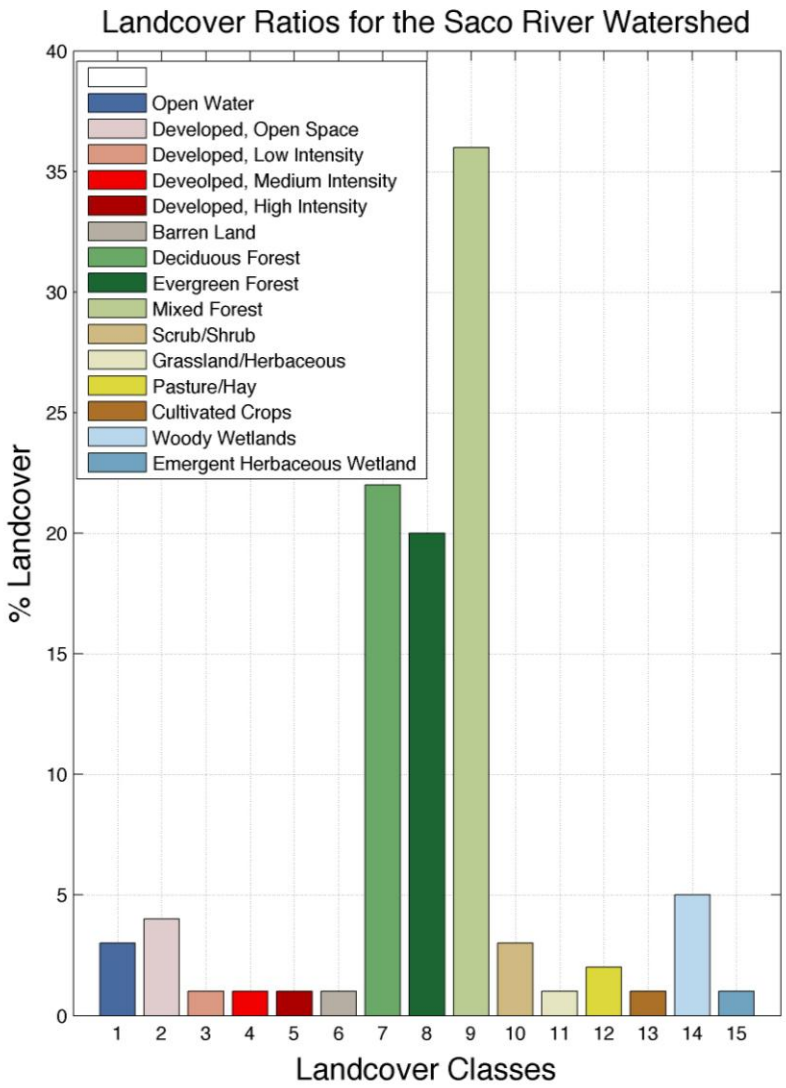
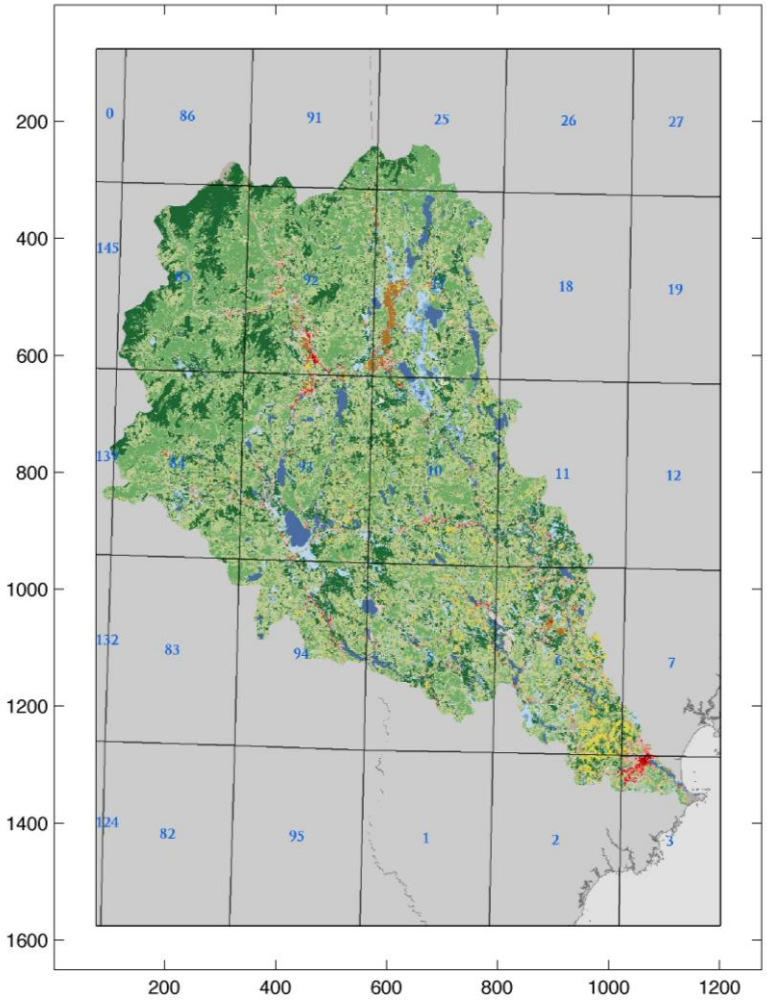


Saco Bay and Watershed



Land use in Saco River Watershed





4,410 km^2 area

mean discharge = 90 m^3/s

What are Maine's water quality standards?

Rivers and Streams -

E. coli of human and domestic animal origin shall not to exceed a geometric mean of 64/100mL or an instantaneous level of 236/100mL

Estuarine and Marine Waters –

Enterococcus of human and domestic animal origin shall not to exceed a geometric mean of 8/100mL or an instantaneous level of 54/100mL.

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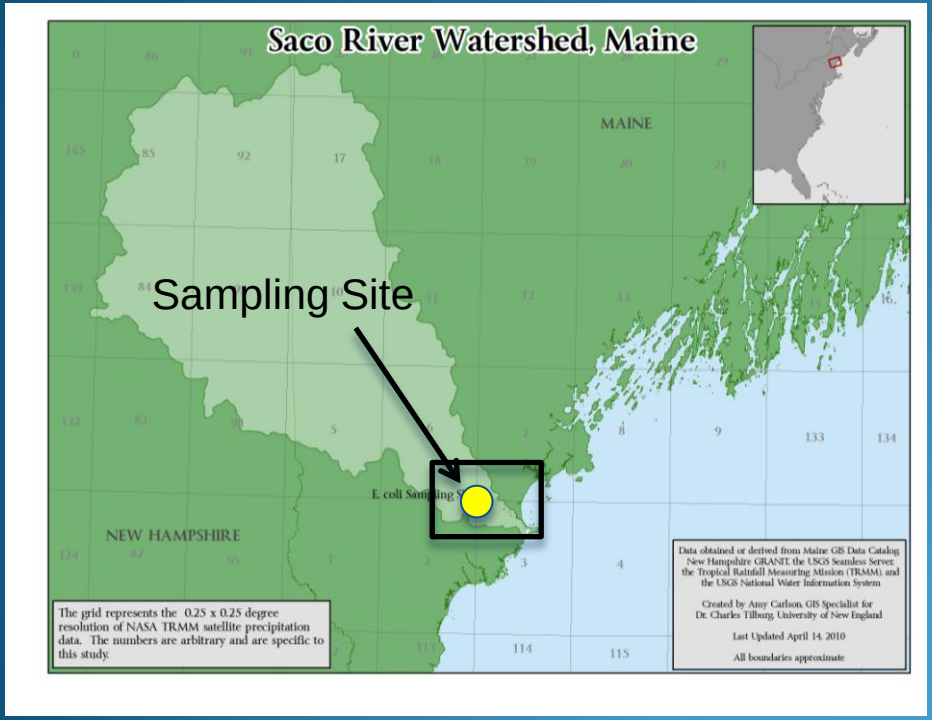
What does Maine do now?

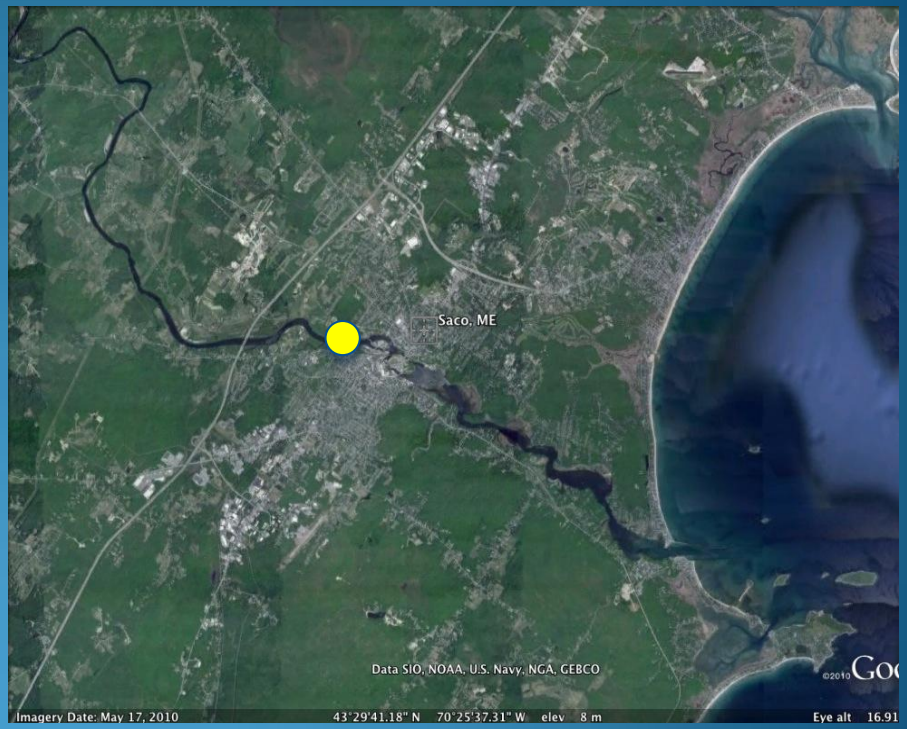
- No quick, accurate method of measuring water quality
- Closes swimming areas and shellfish beds when measured discharge exceeds a given value

The Challenge

- Resource managers need accurate prediction of reduced water quality
- Fisherman and local economies need minimum number of false alarms

Saco River *E. Coli* Measurements





Measurements collected by Saco River Corridor Commission.

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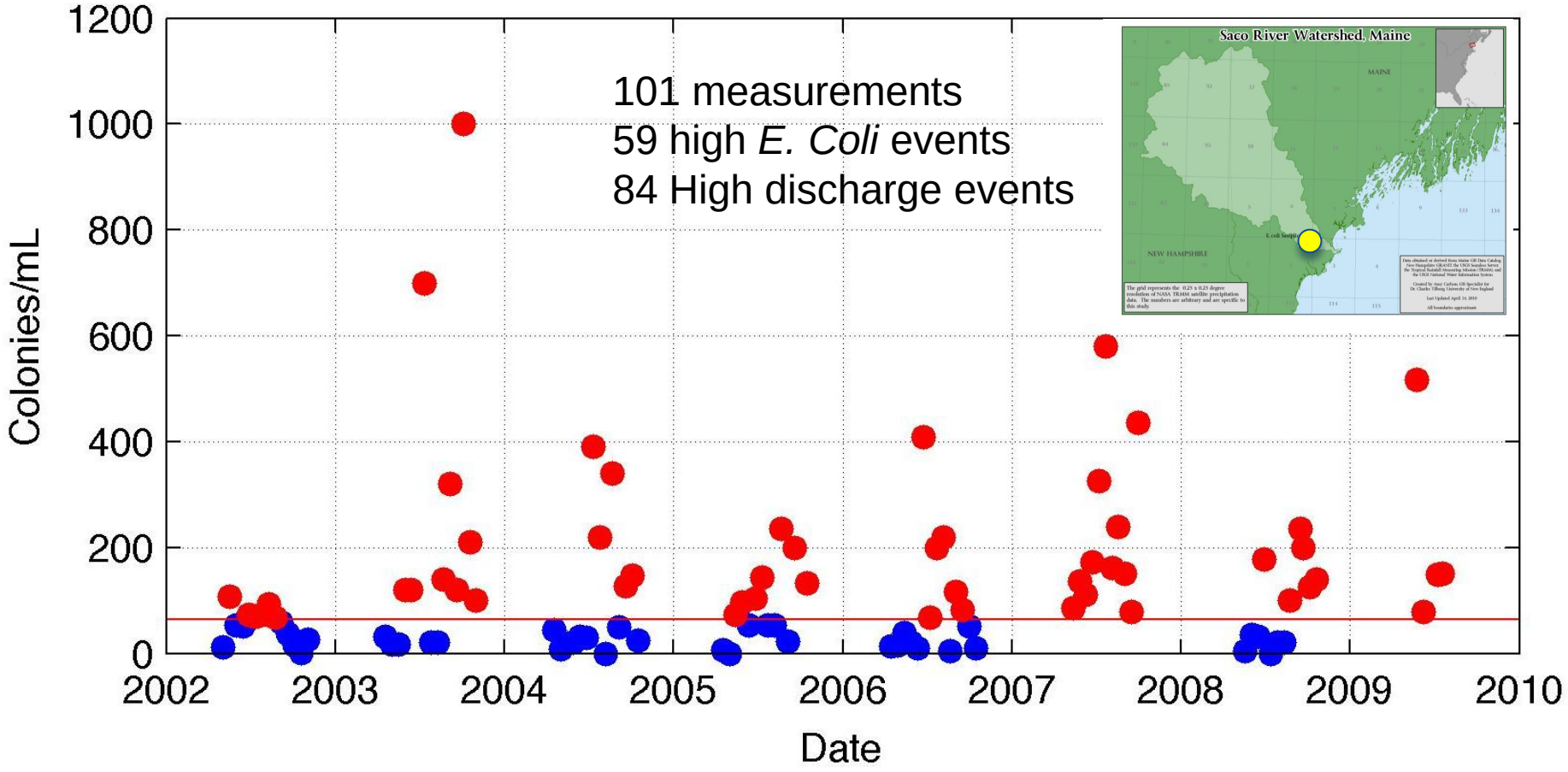

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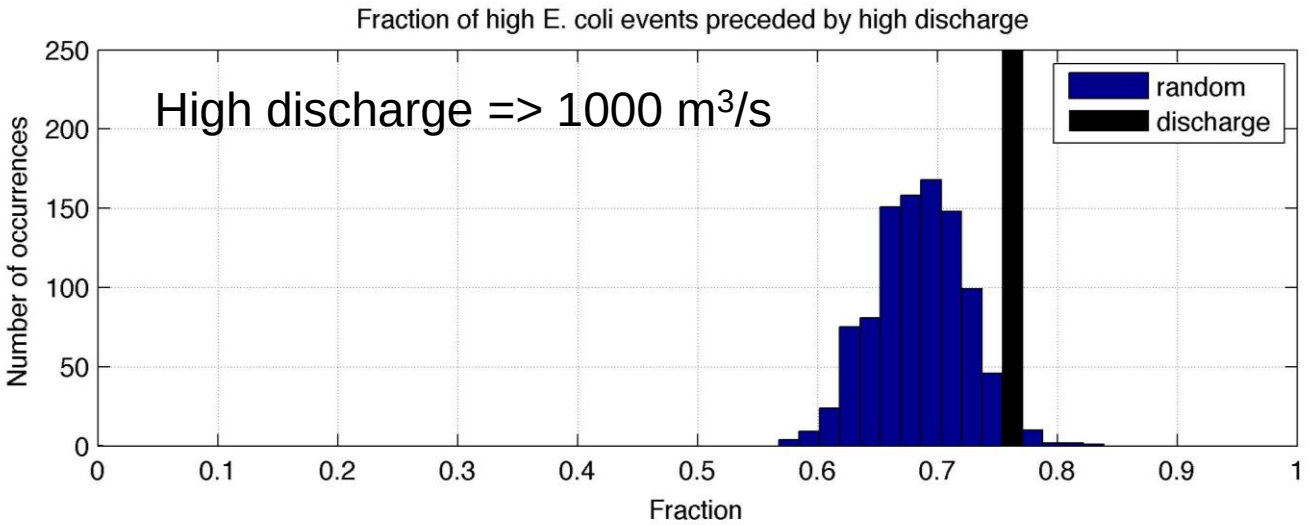

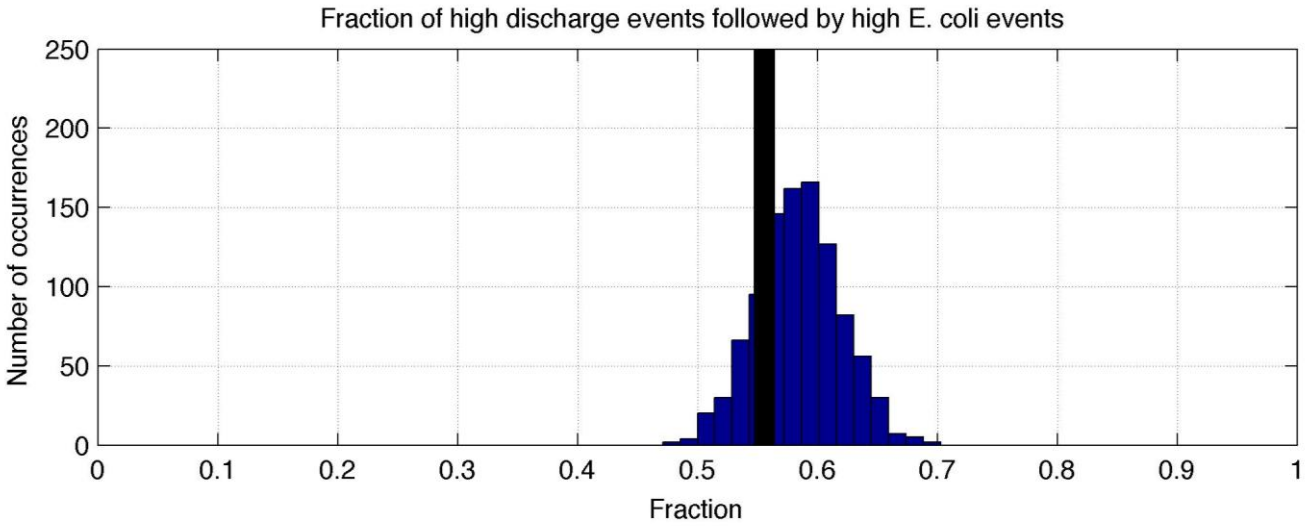

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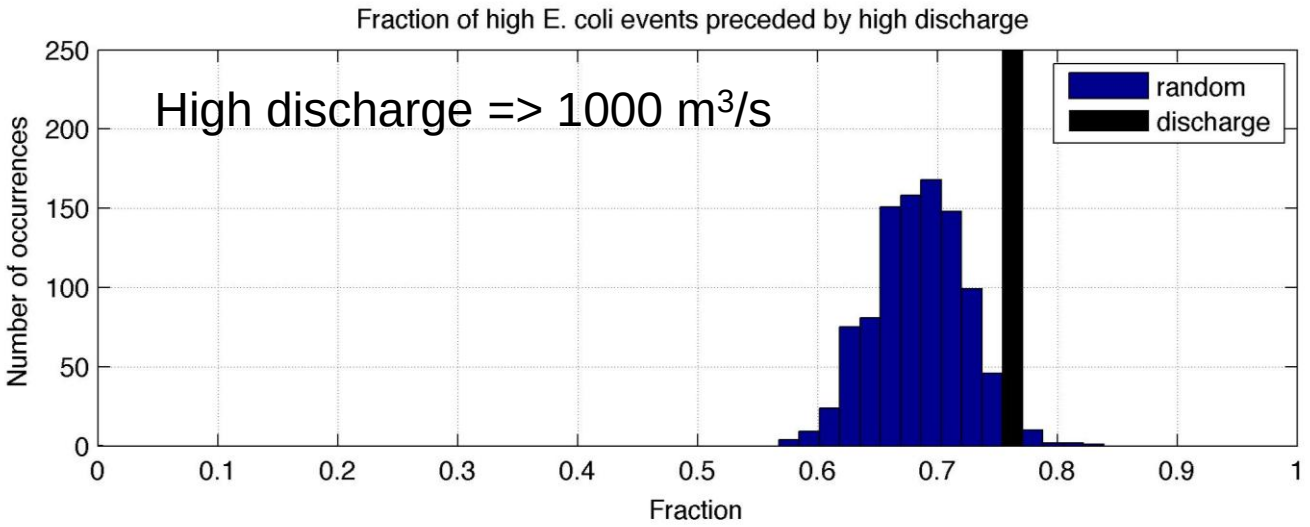

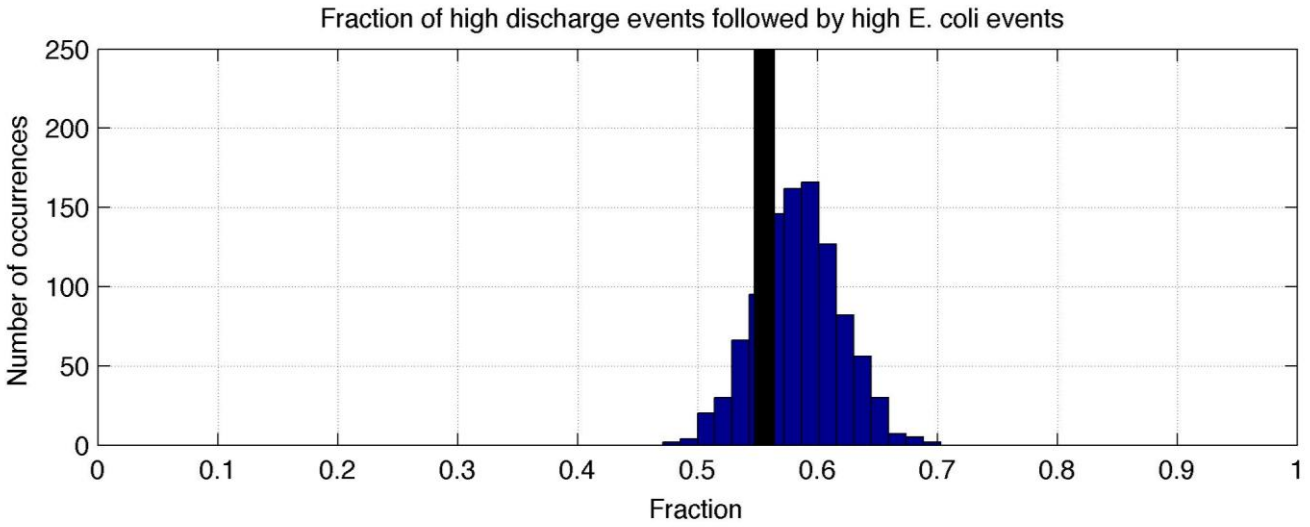

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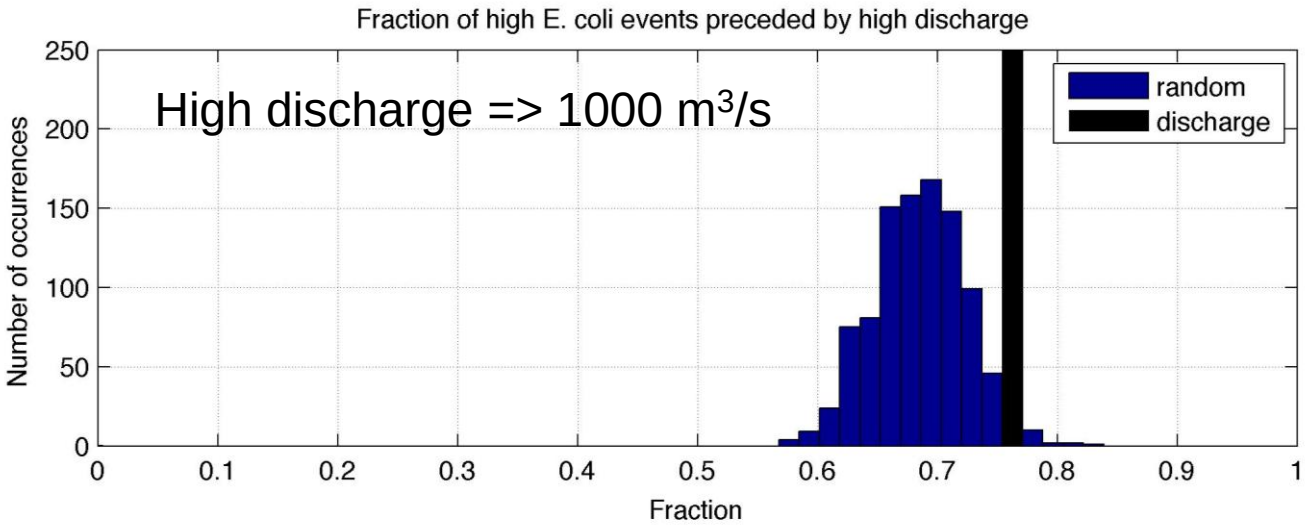

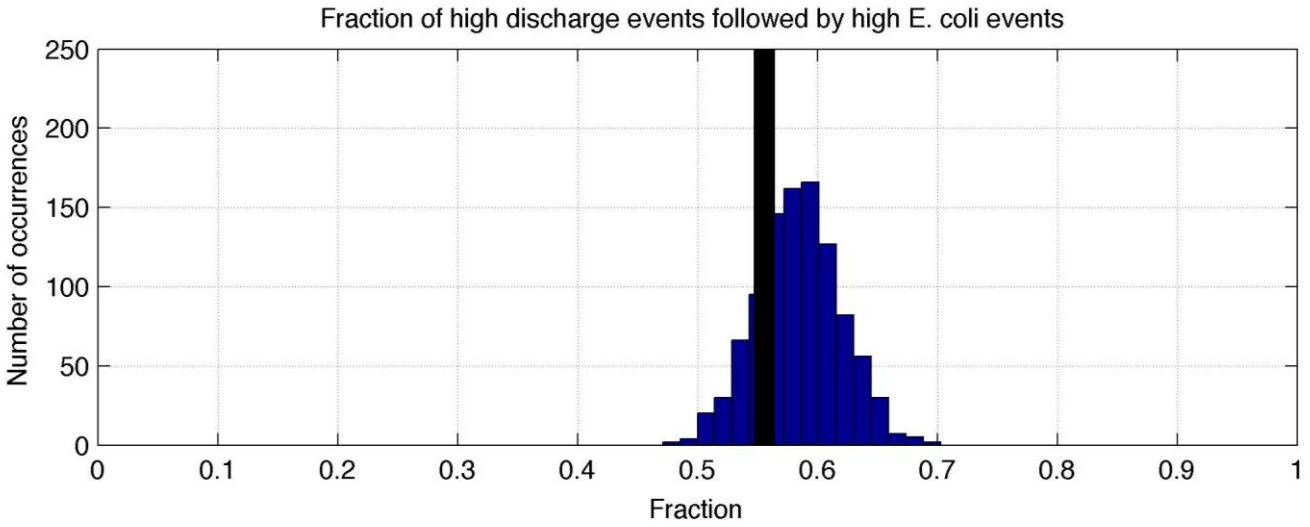

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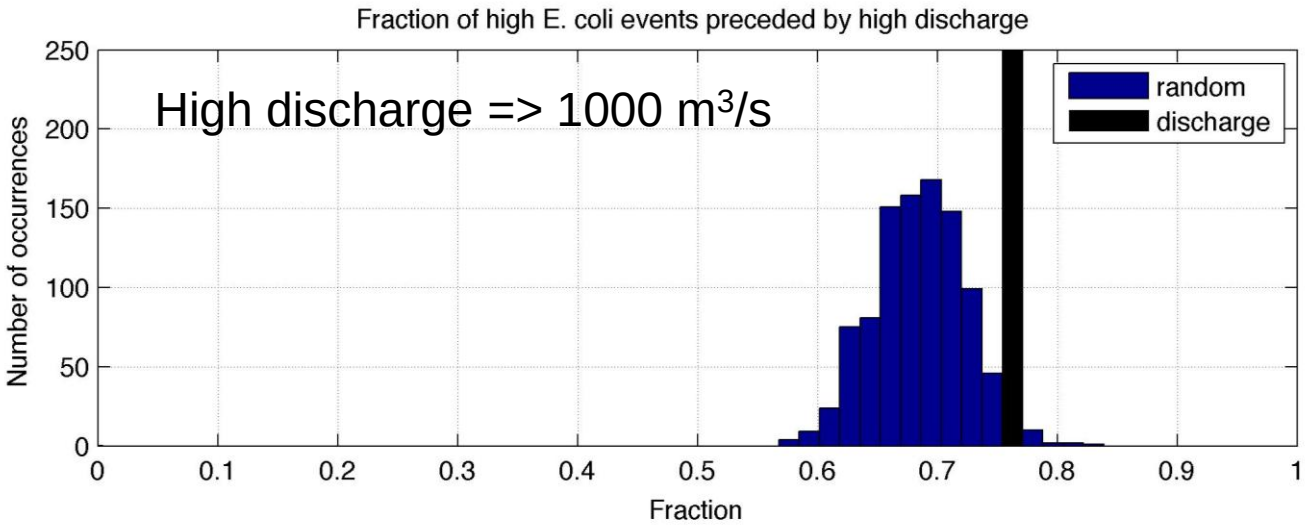
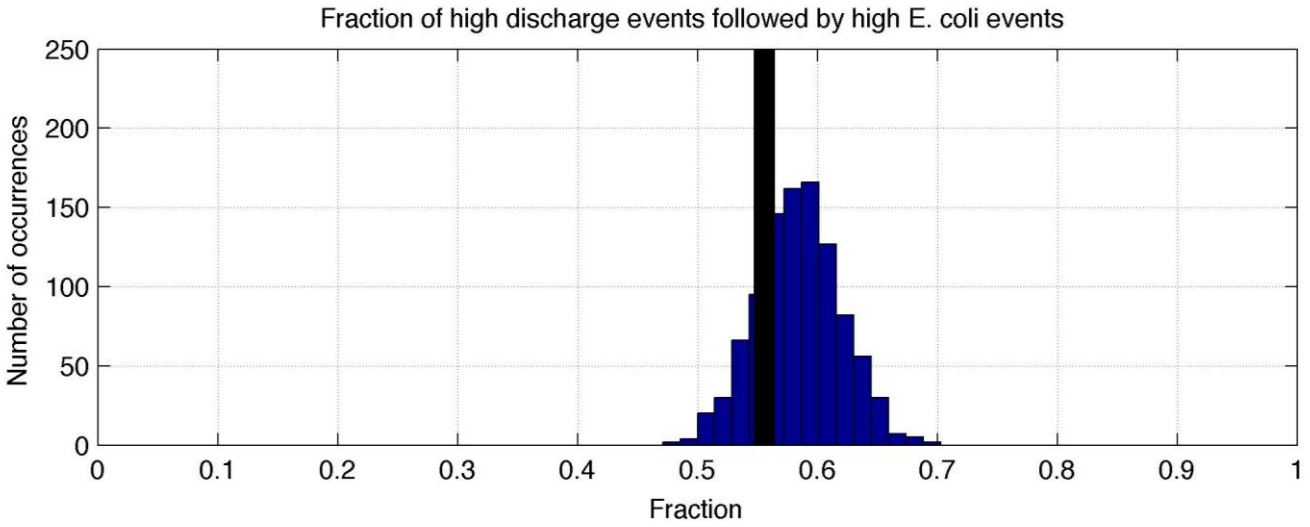


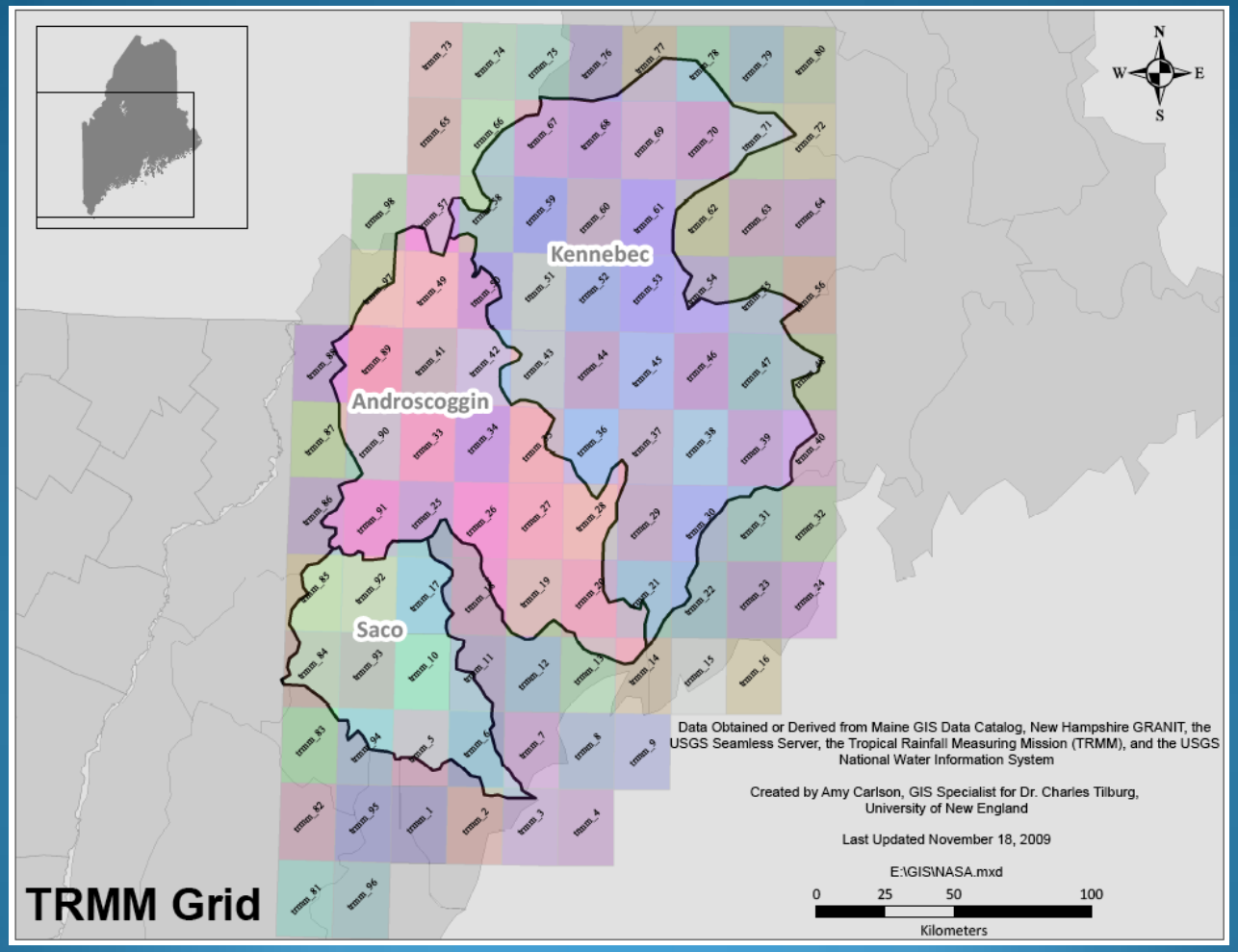


44.4% of the time, this method results in a false alarm!

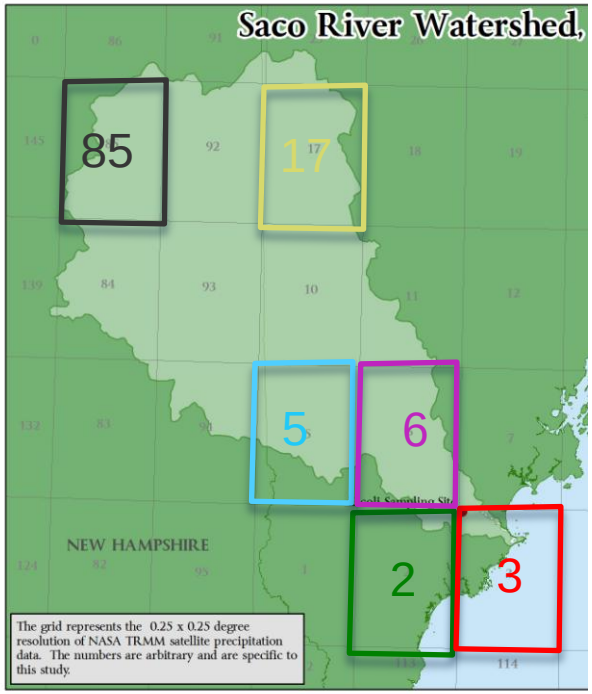
The method works, but it results in a lot of unnecessary closings.

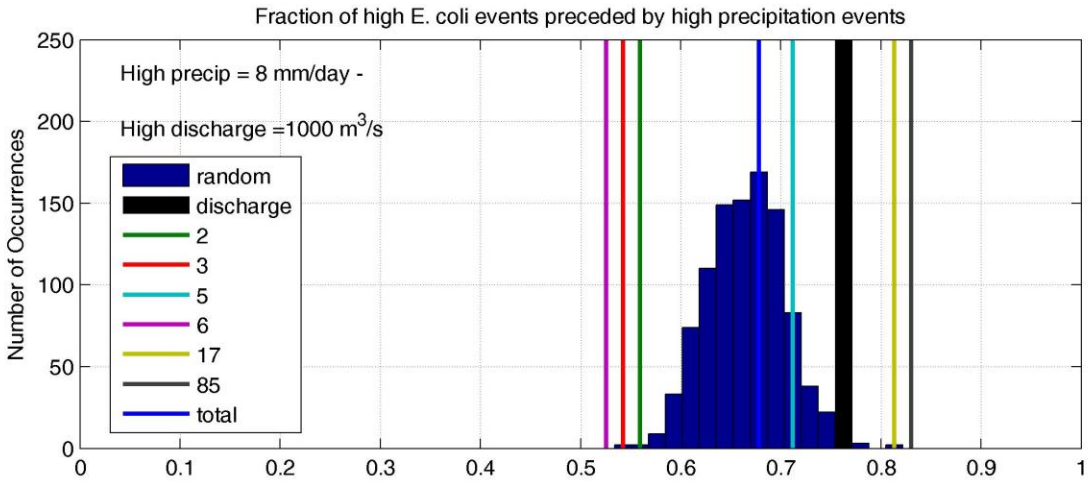
Can we do better?

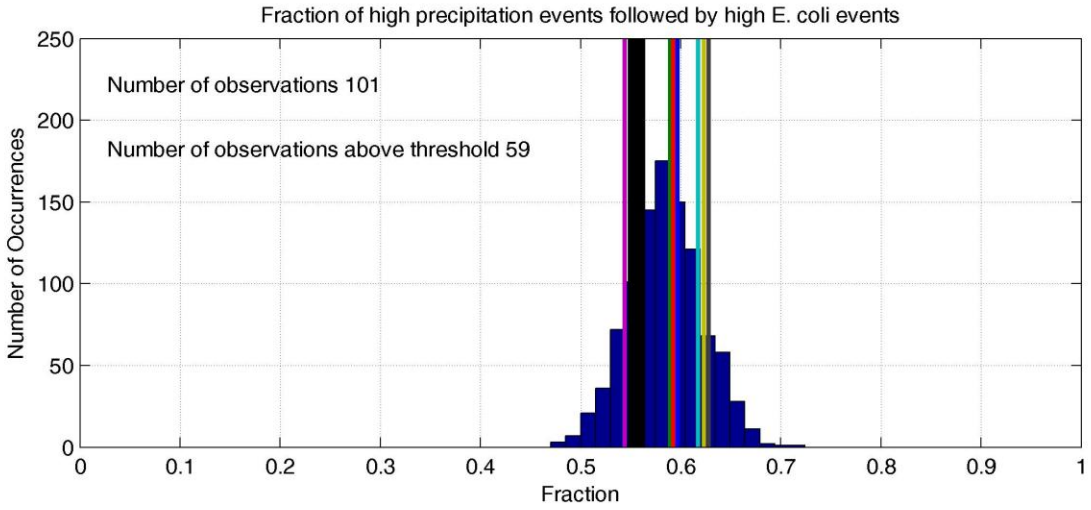
Our Method: Precipitation as predictor



Precipitation ***can*** be a better predictor of reduced water quality than discharge

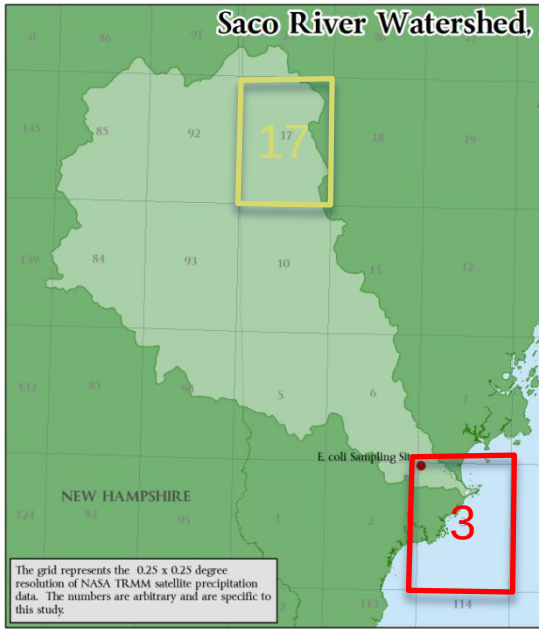


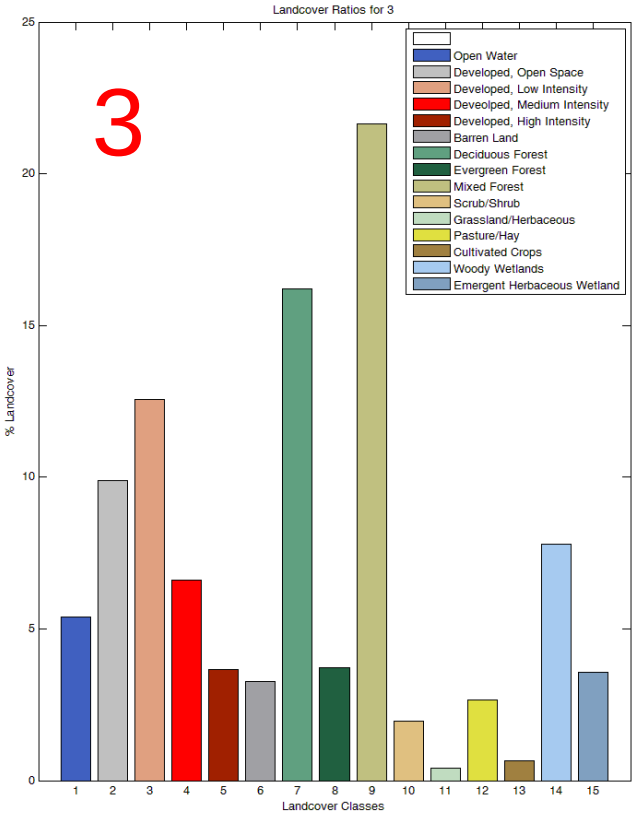




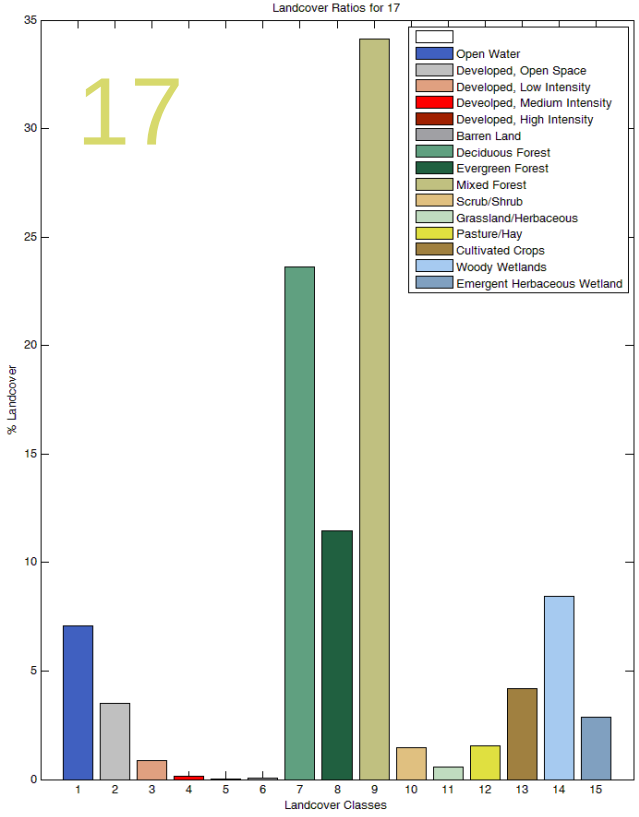
Yes, we can.

Reduced water quality is a function of ***location*** within watershed.



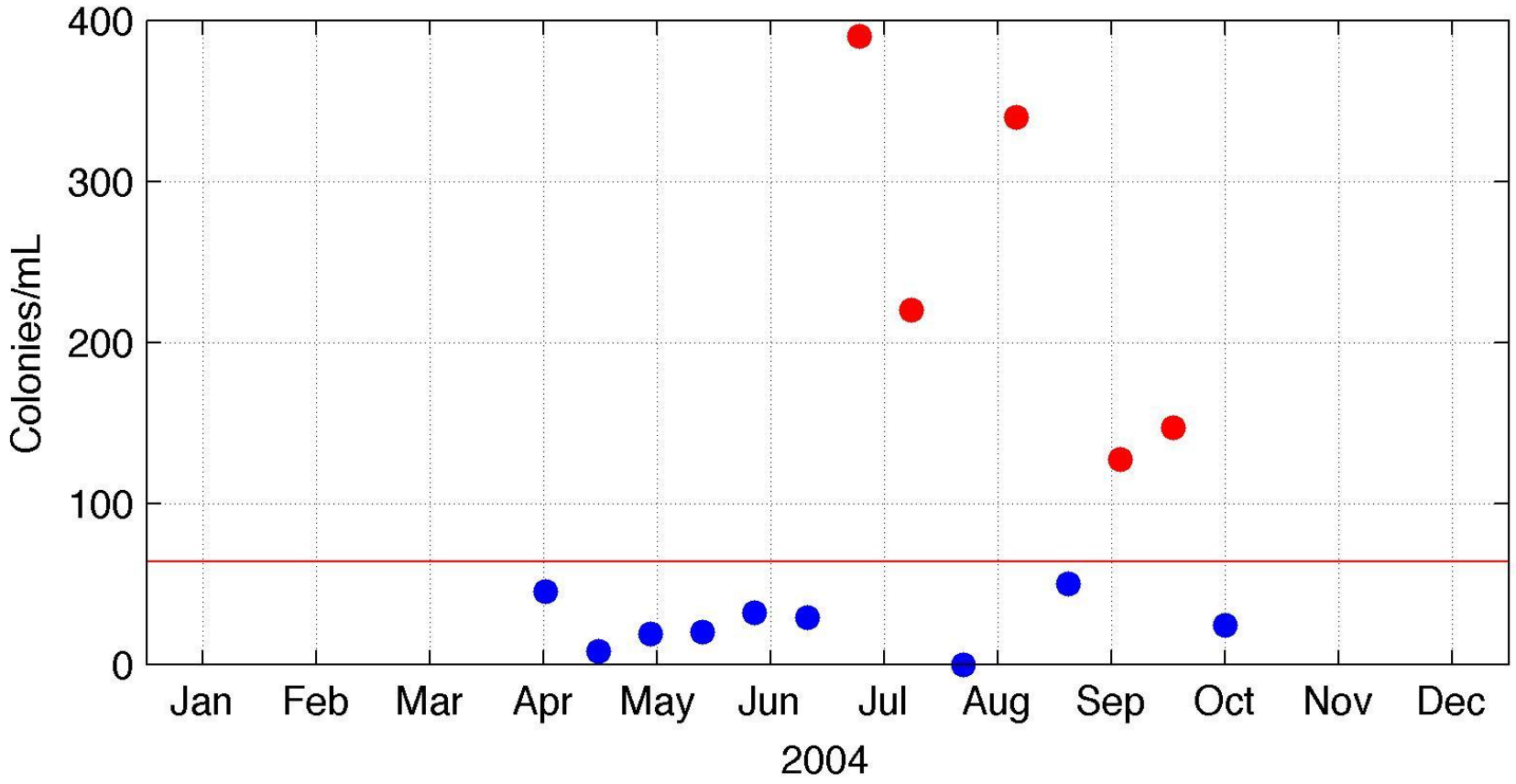


Low Skill



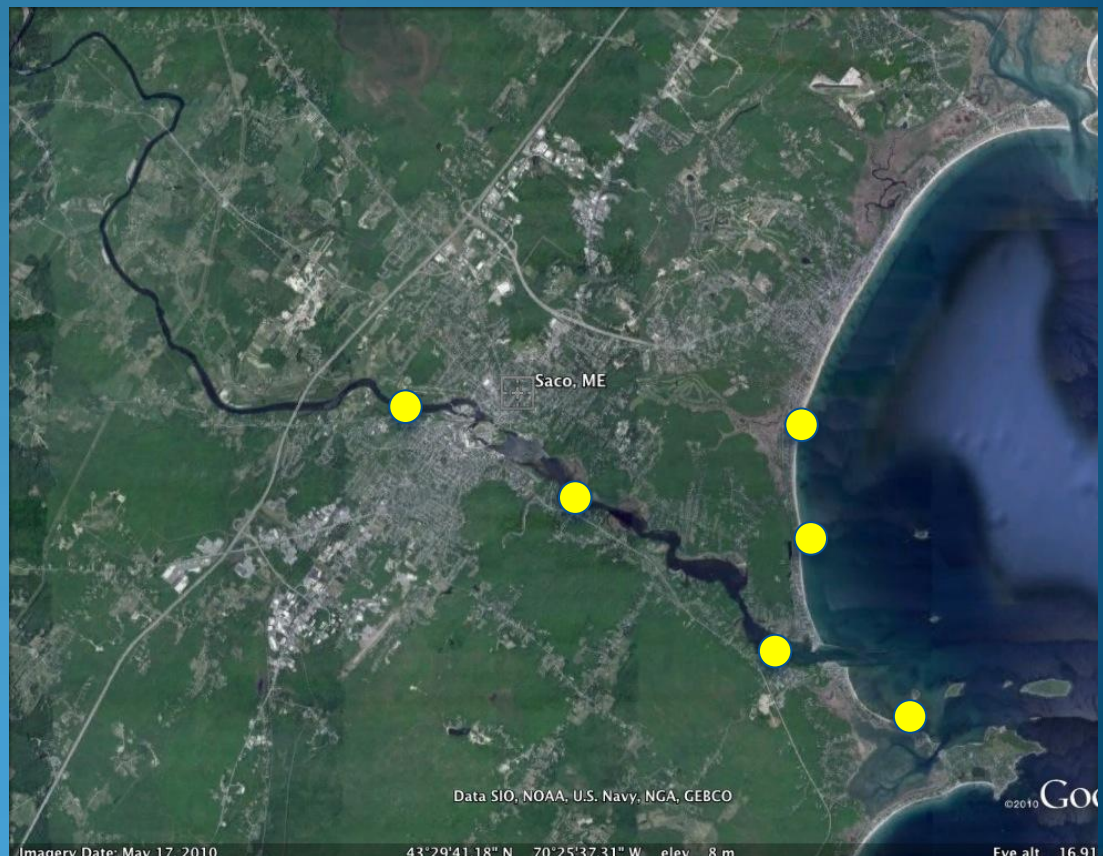
High Skill

… but infrequent sampling hampers the validation of our model



Future monitoring

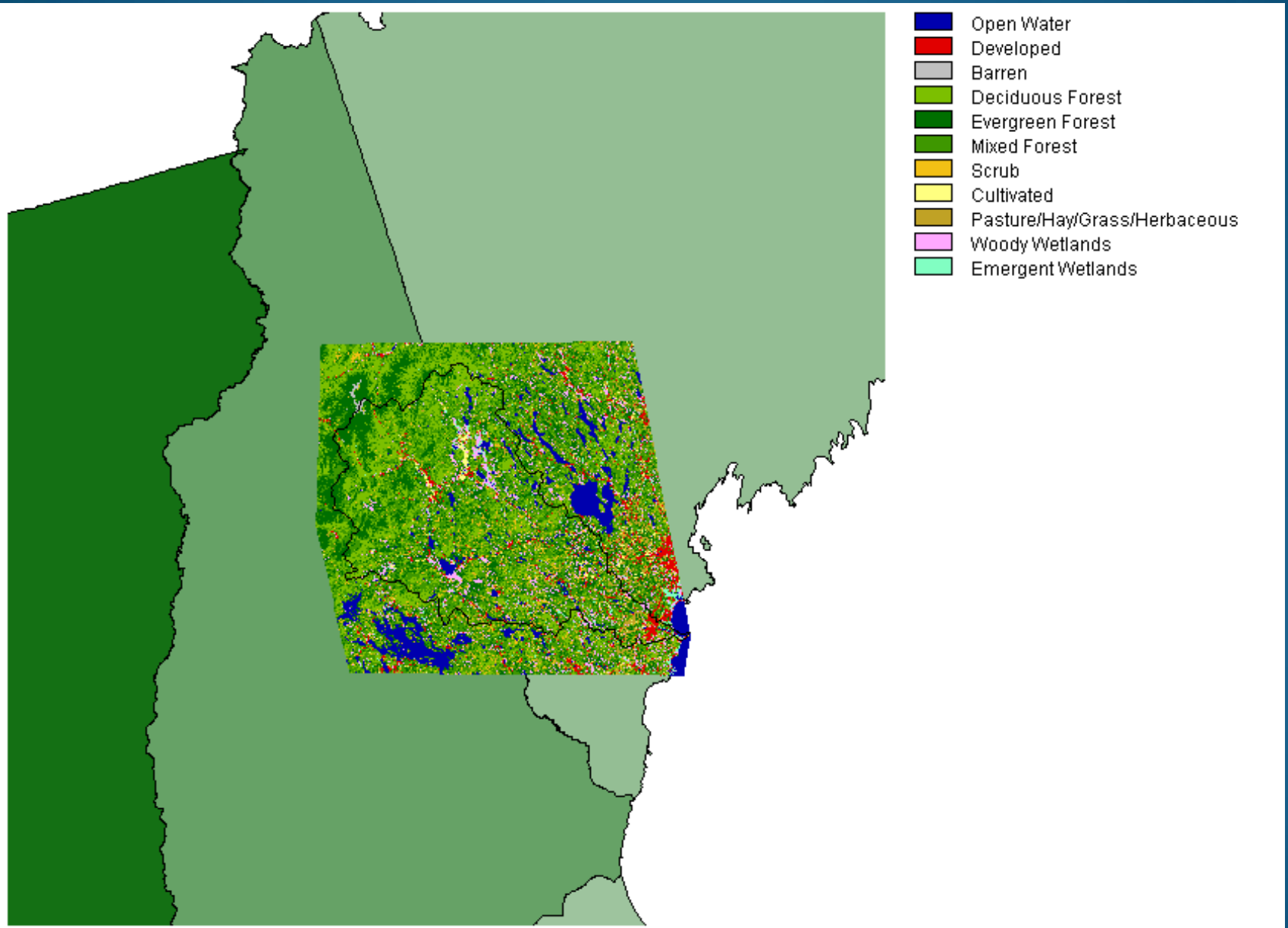
- October – December, 2010
- Increased sampling
  - *E. Coli*
  - *Enteroccocus*
- Increased temporal resolution
  - Daily sampling
- Increased spatial resolution
  - 6 locations along Saco River



How has land use / land cover changed in these watersheds?

How will it change?

IDRISI Land Use Model Domain



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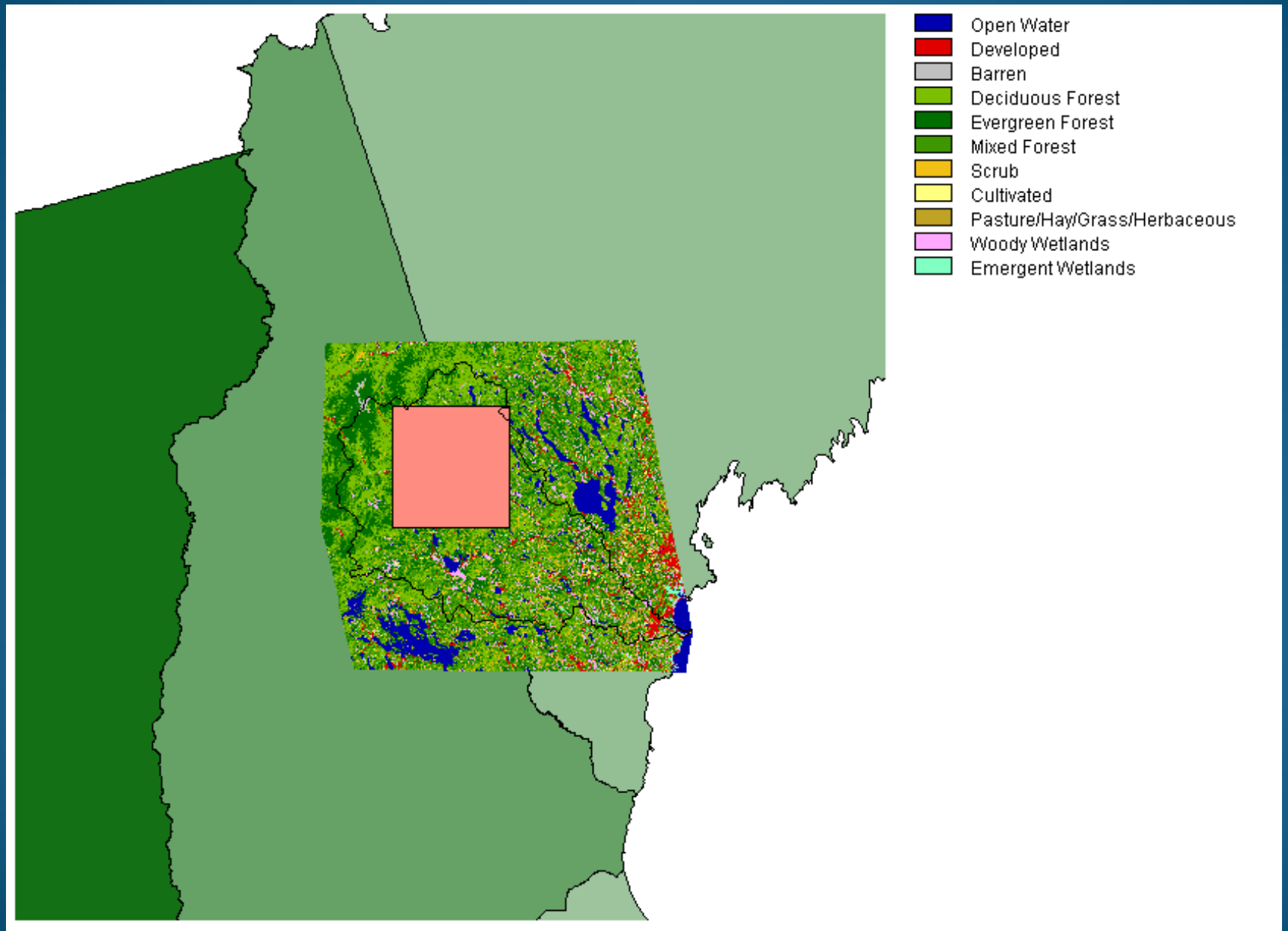
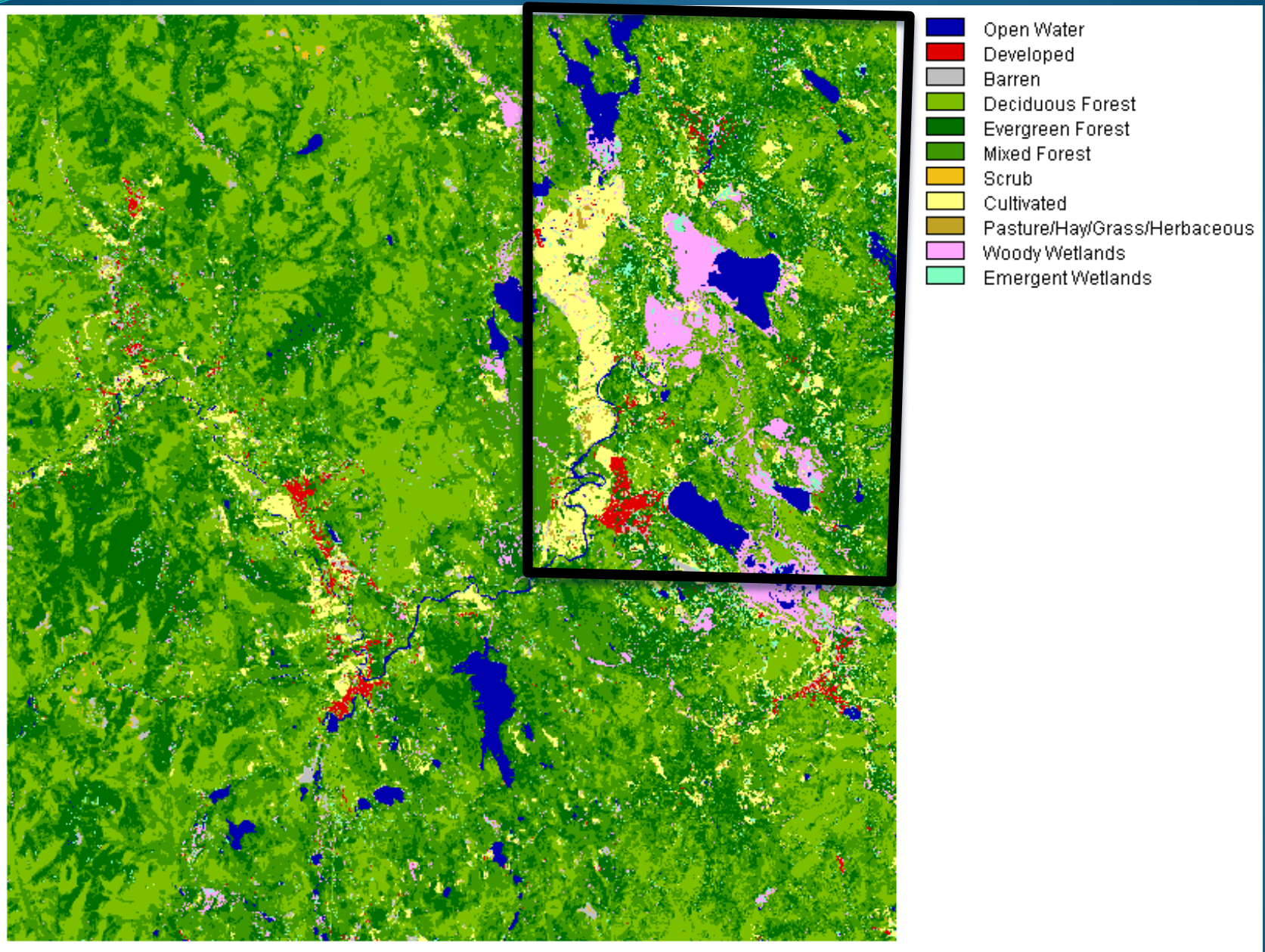
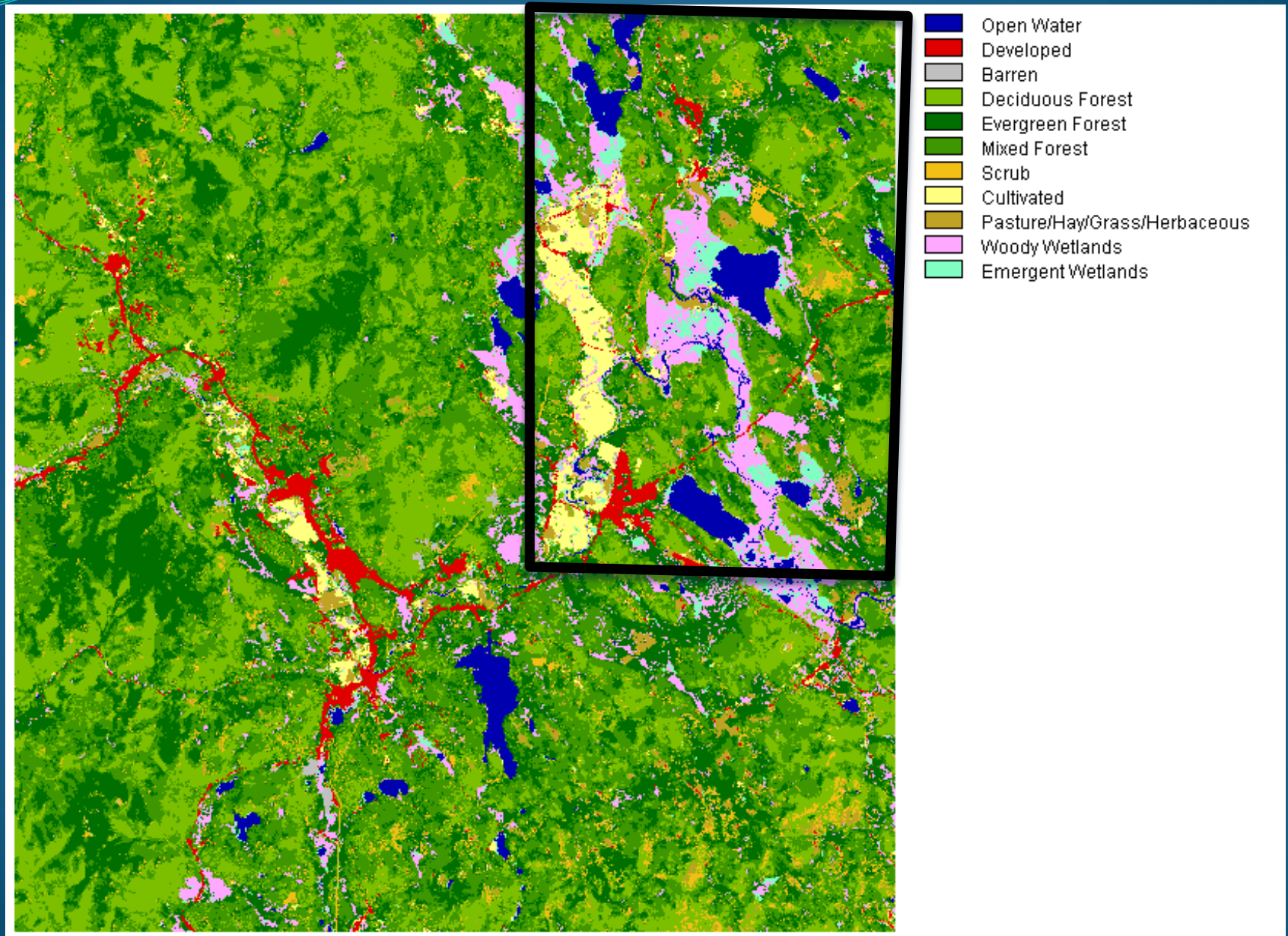


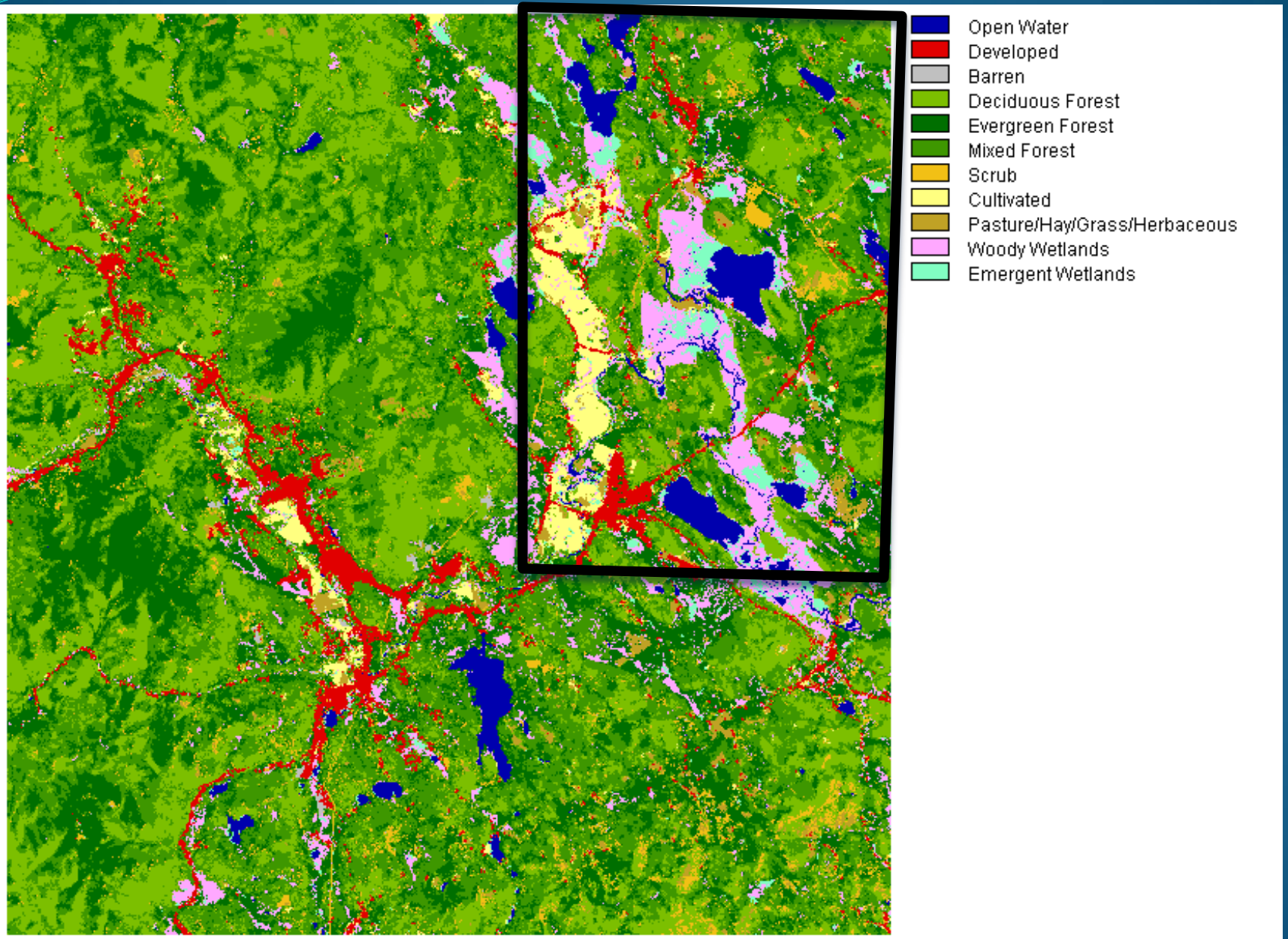
1992 Land Use/Land Cover



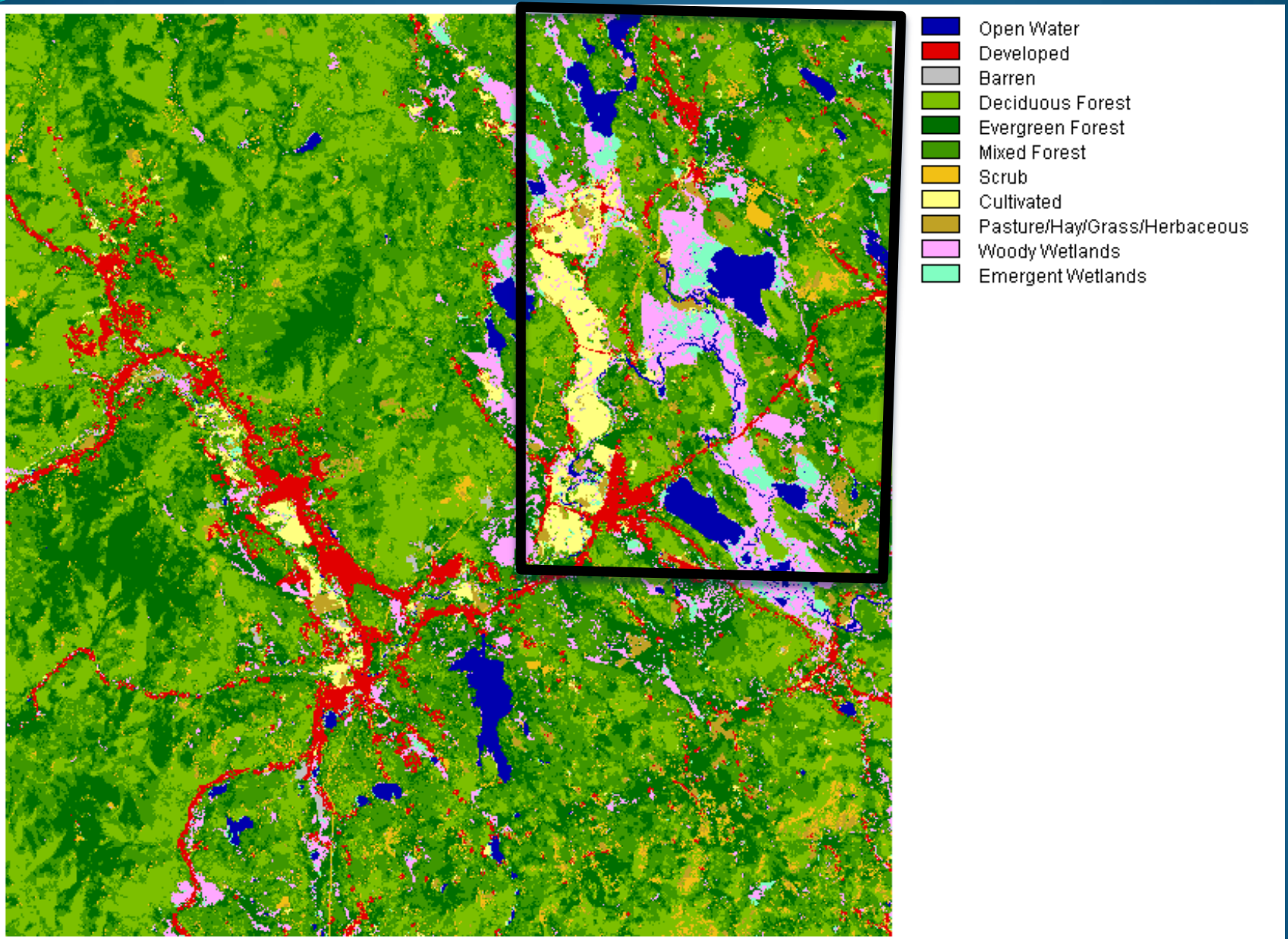
2001 Land Use/Land Cover



2010 Land Use/Land Cover



2030 Predicted Land Use/Land Cover



Summary and Conclusions

The use of satellite derived precipitation data was successful in forecasting water quality in the coastal waters of Maine.

- Use of TRMM is a better predictor of reduced water quality events than Maine's current method.

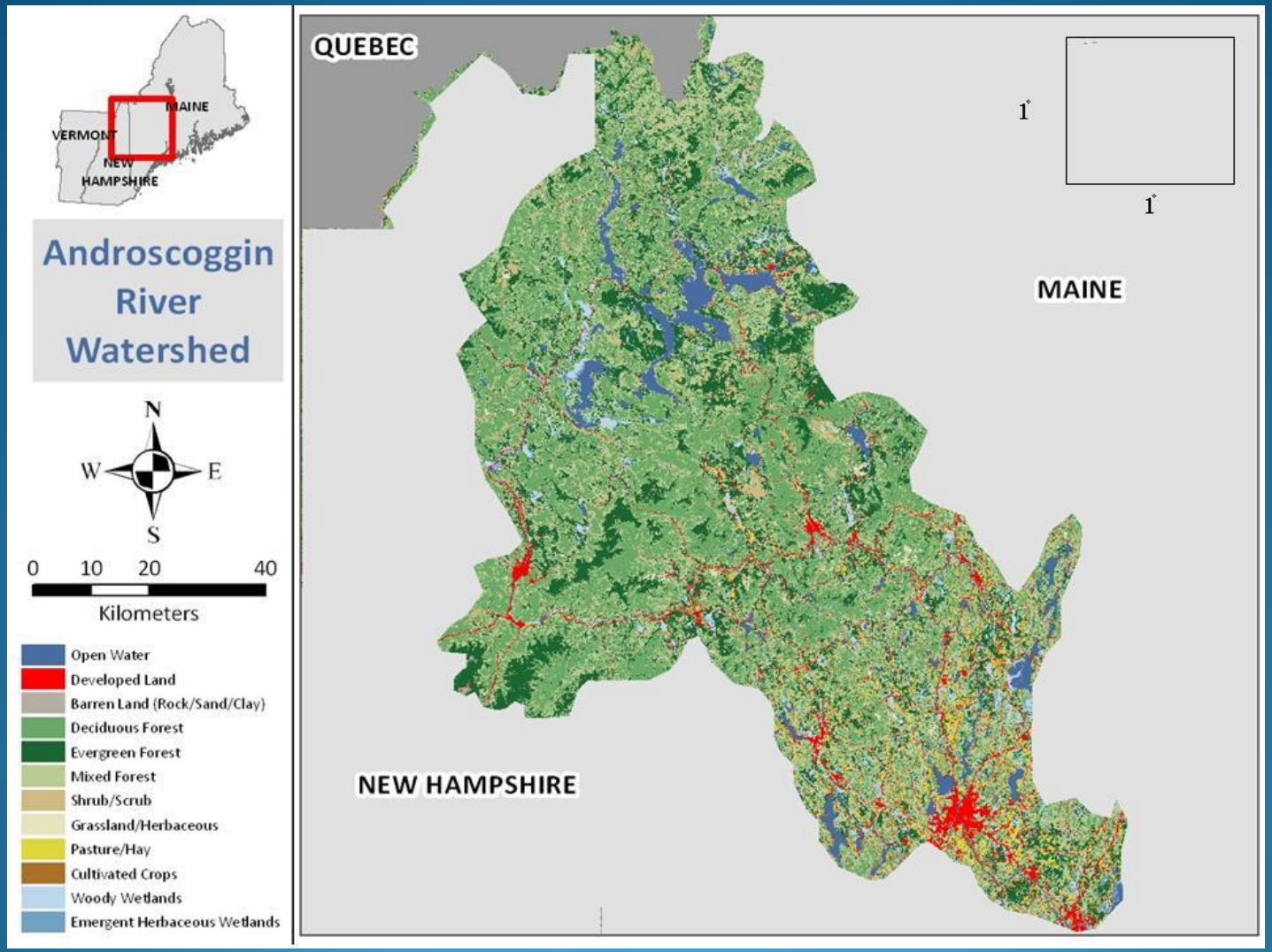
The use of precipitation data to forecast water quality at larger (and under-sampled) regions is promising.

- Link between land use and reduced water quality is not clear.
- Land-use projections indicate significant changes in all three watersheds.
- Infrequently sampled data hampers validation of predictive model.

Future Work

1. Additional sampling of water quality at mouth of Saco River.
2. Fine-tuning of model to predict discharge and water quality using newly collected water quality data.
3. Examination of link between land use, water travel times, and water quality events.
4. Extension of model to year 2030 using simple estimates of future precipitation.
5. Determination of future river discharges and water quality in coastal waters of the three watersheds.

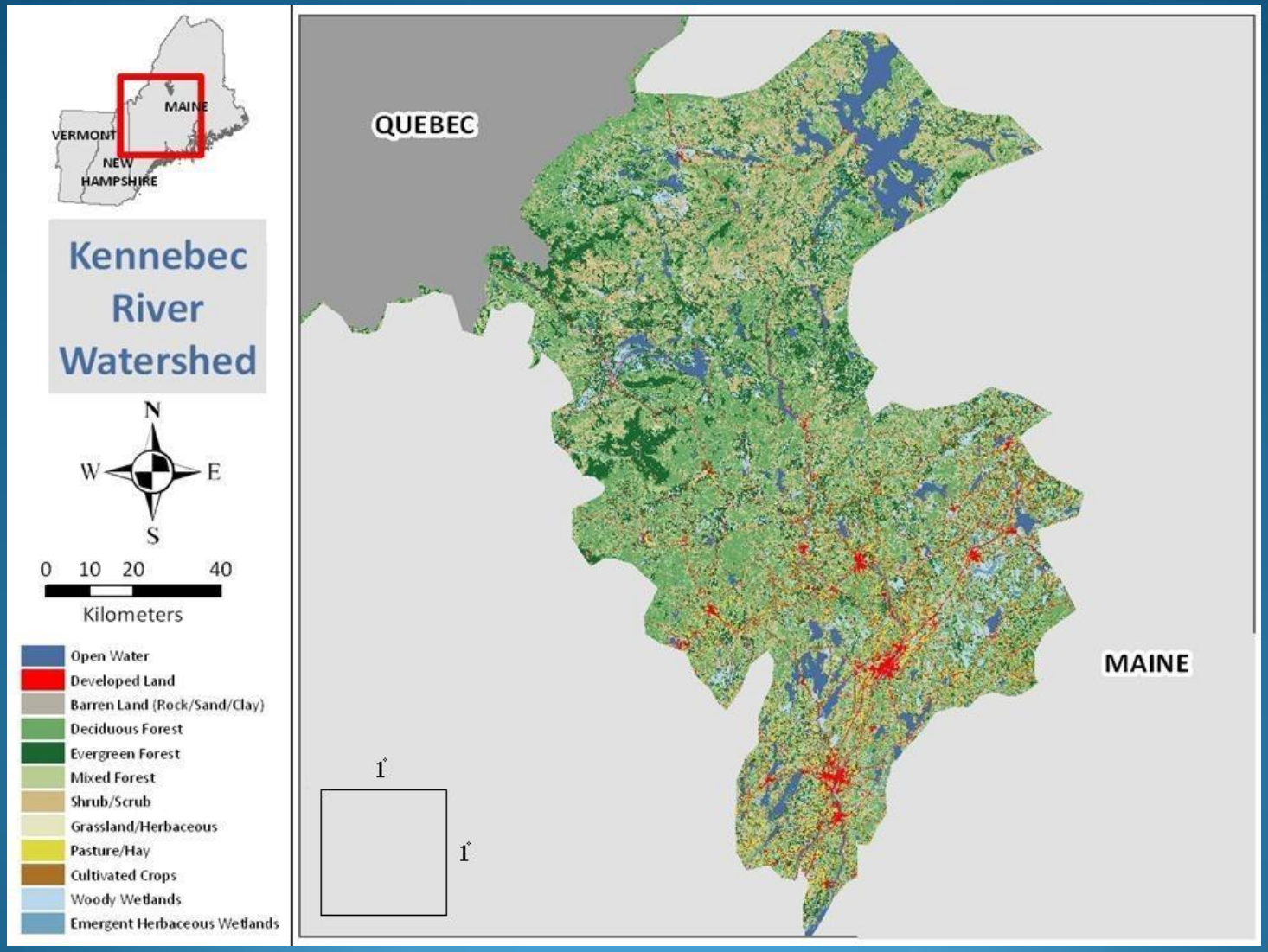
Land use in Androscoggin River Watershed



9,100 km^2 area

mean discharge = 175 m^3/s

Land use in Kennebec River Watershed



15,200 km^2 area

mean discharge = 258 m^3/s