Ecological Limits of Hydrologic Alteration in Wisconsin Streams

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Little Plover River

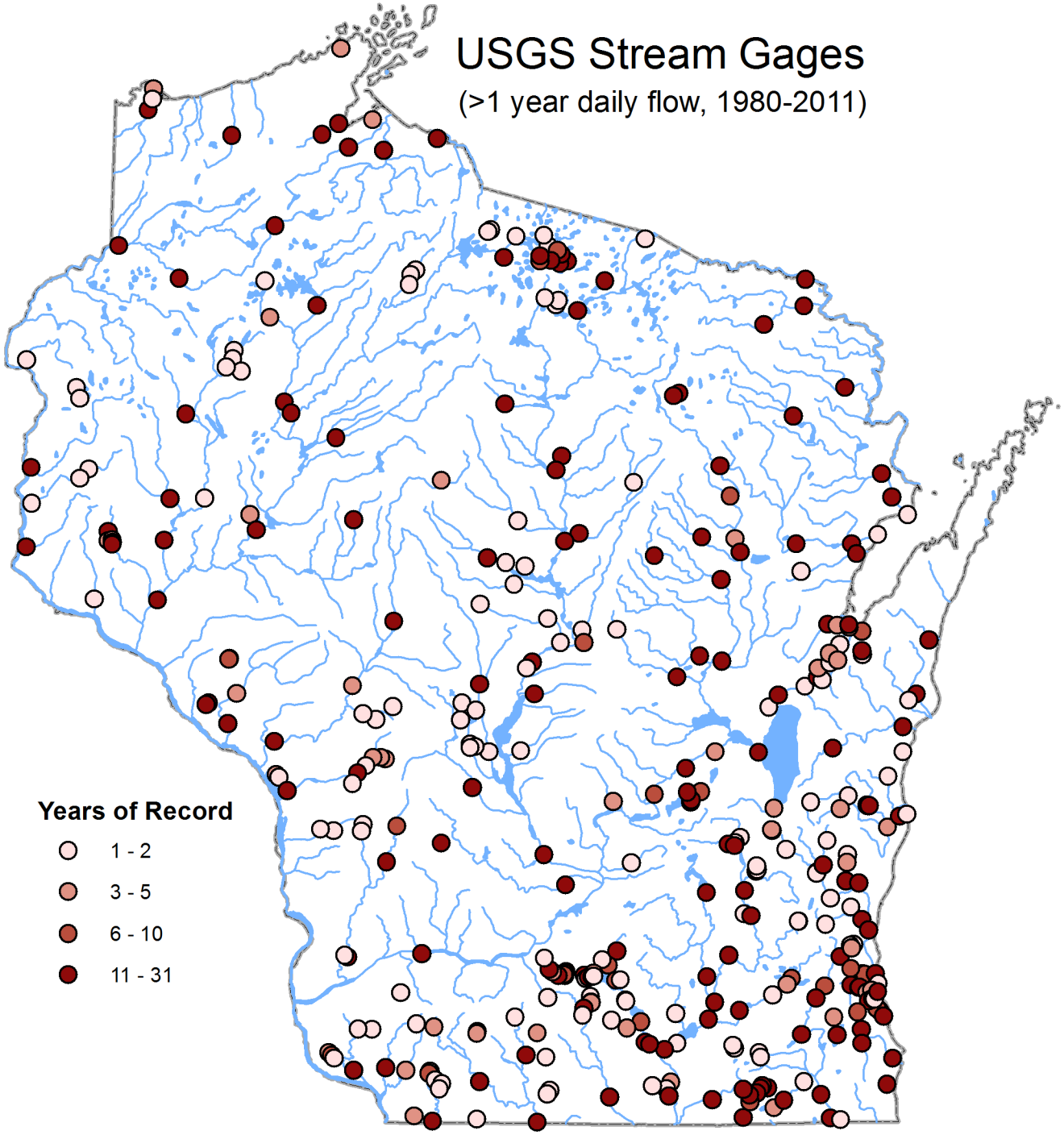
Motivation:

Which streams are most sensitive to disturbance by human activities?

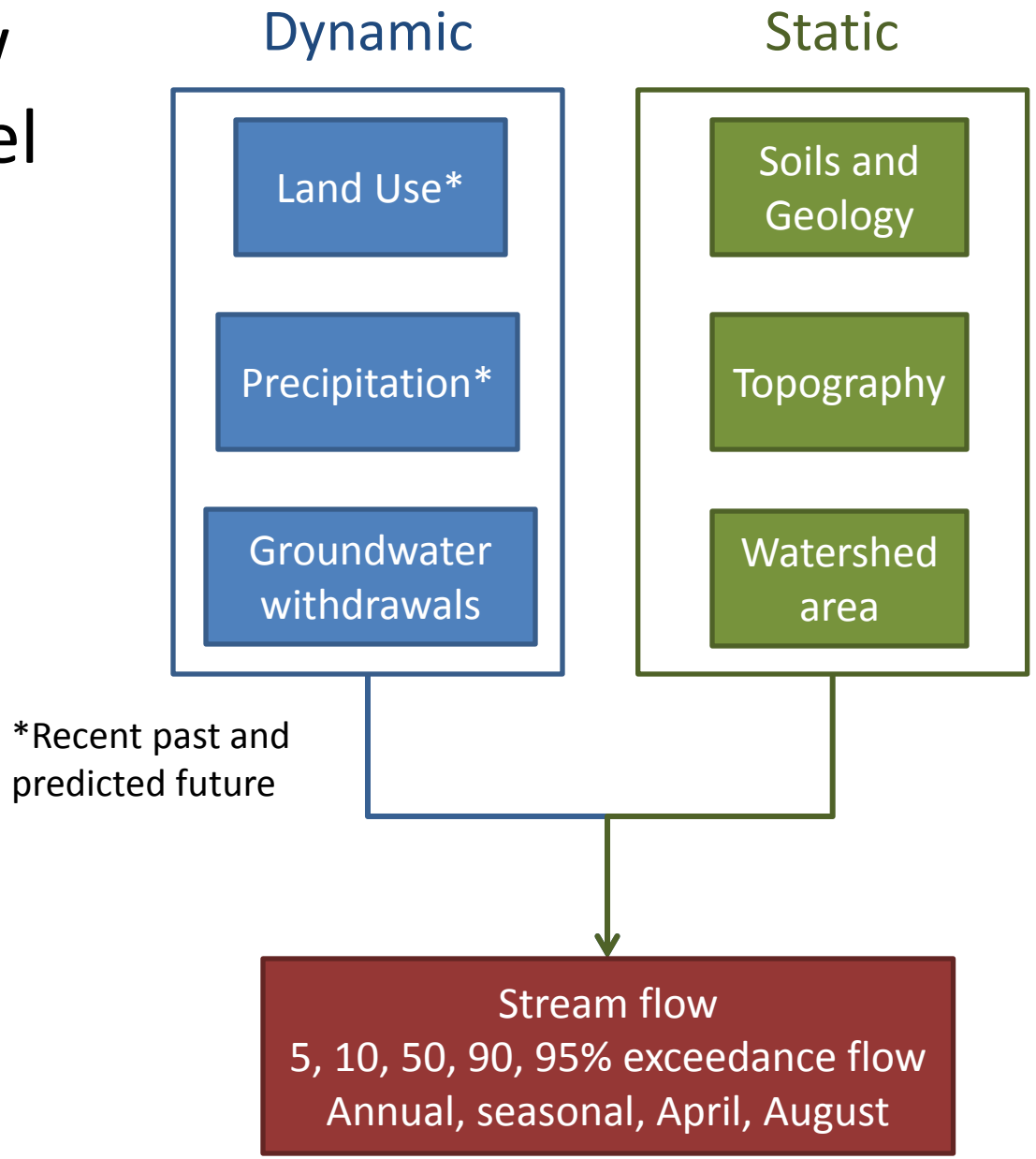
"Significant adverse environmental impact“…degradation of environmental quality including biological and ecological aspects of the affected water resource NR 820.12 (19)

Objectives:

1. Model stream flow duration curves.
2. Model fish species distributions.
3. Predict changes to fish communities that would result from flow alterations.

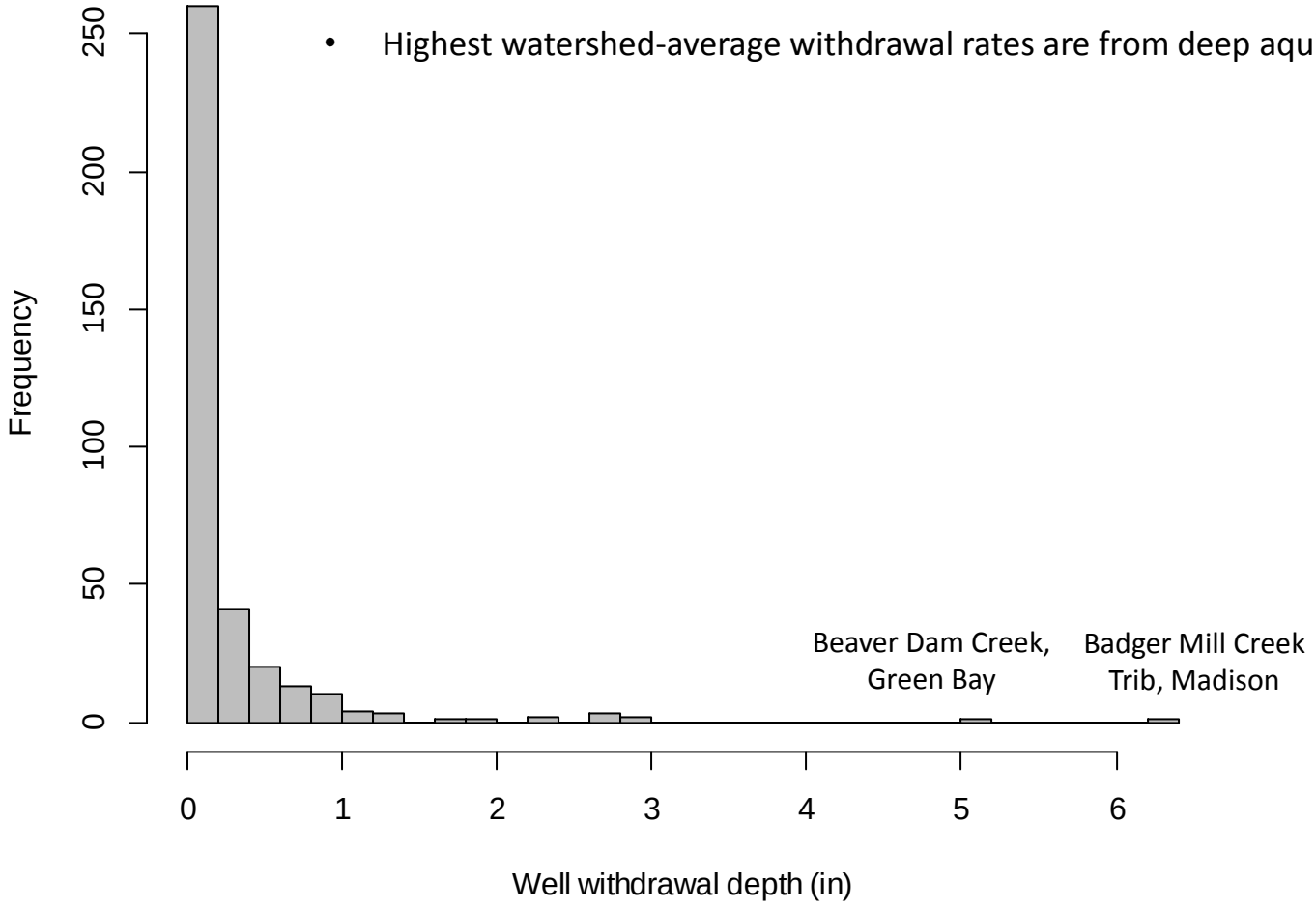

USGS Stream Gages
(>1 year daily flow, 1980-2011)
Years of Record
1 - 2
3 - 5
6 - 10
11 - 31

Flow Model

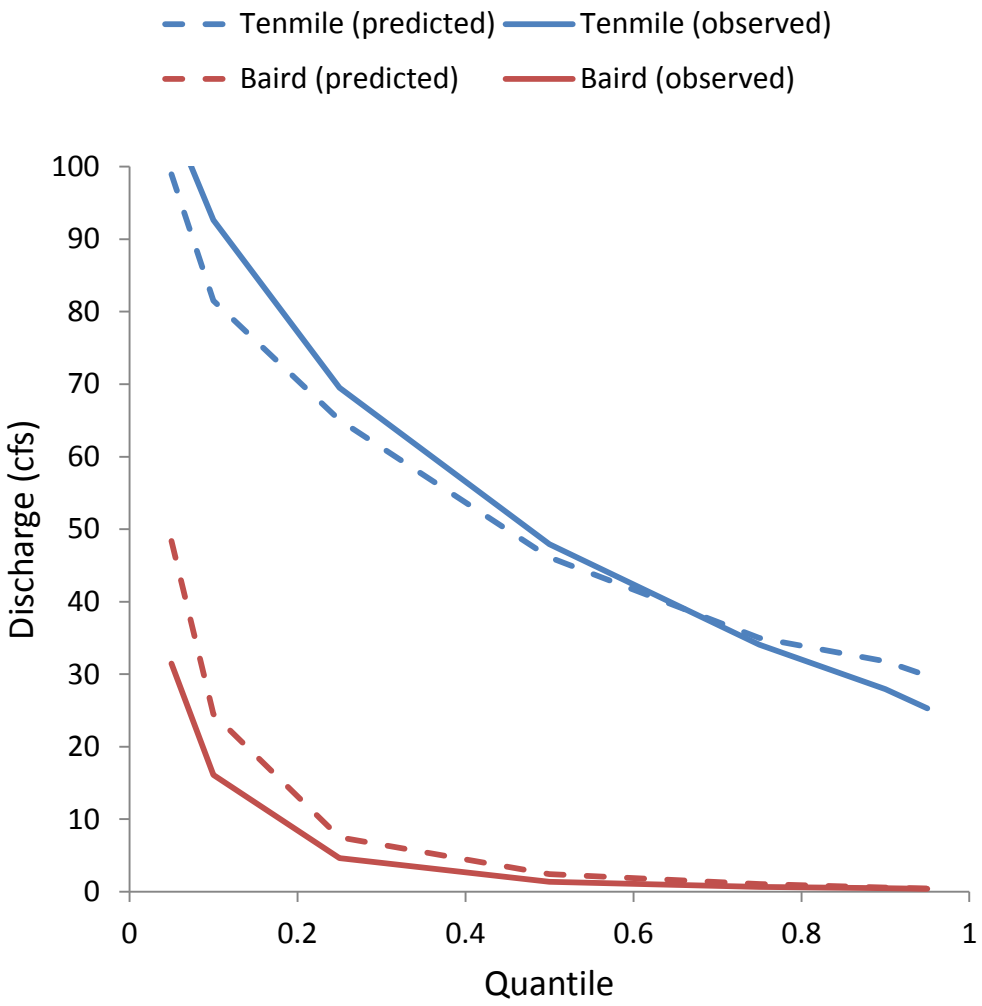

Dynamic
Static
Land Use*
Precipitation*
Groundwater withdrawals
Soils and Geology
Topography
Watershed area
*Recent past and predicted future
Stream flow
5, 10, 50, 90, 95% exceedance flow
Annual, seasonal, April, August

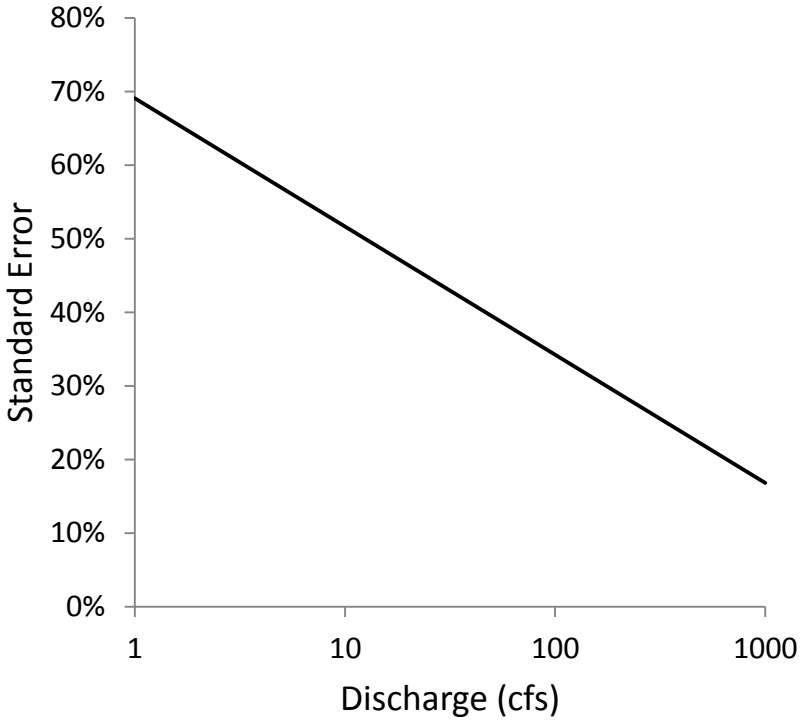
At the statewide scale, no effect of groundwater withdrawals on stream flows could be detected.

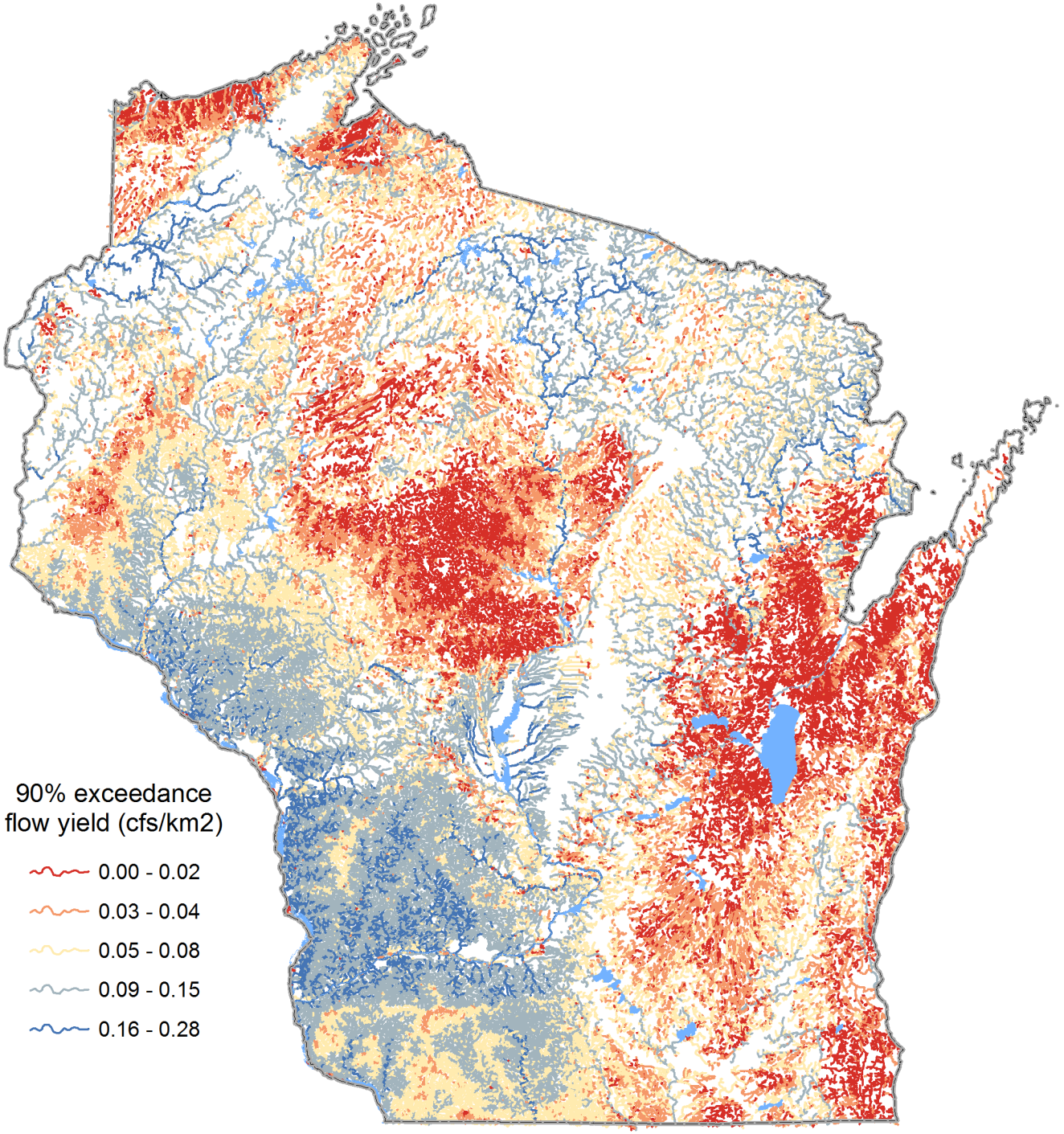
- Most gaged watersheds have low withdrawal
- Highest watershed-average withdrawal rates are from deep aquifers

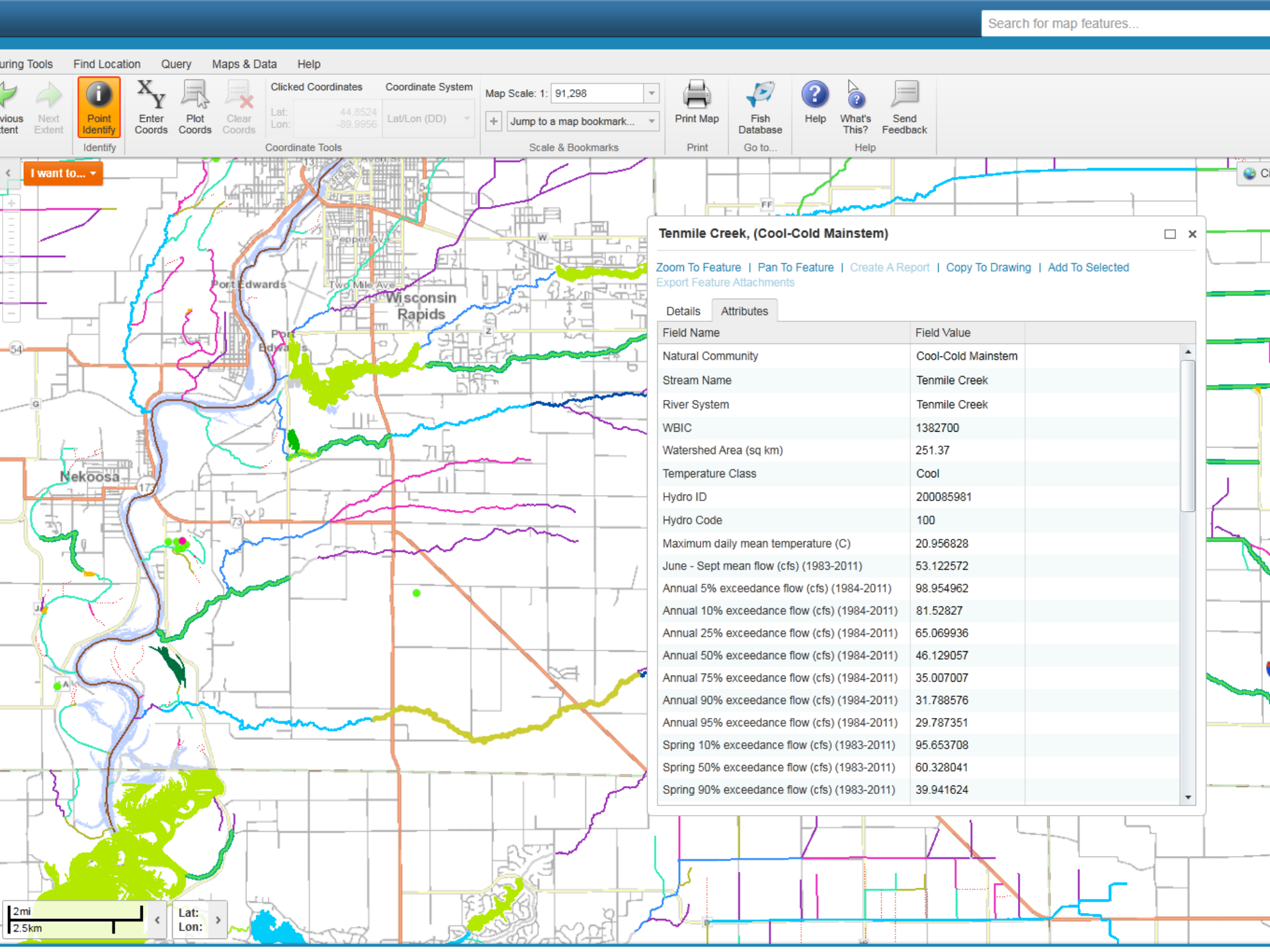


Model Accuracy






90% exceedance
flow yield (cfs/km2)
0.00 - 0.02
0.03 - 0.04
0.05 - 0.08
0.09 - 0.15
0.16 - 0.28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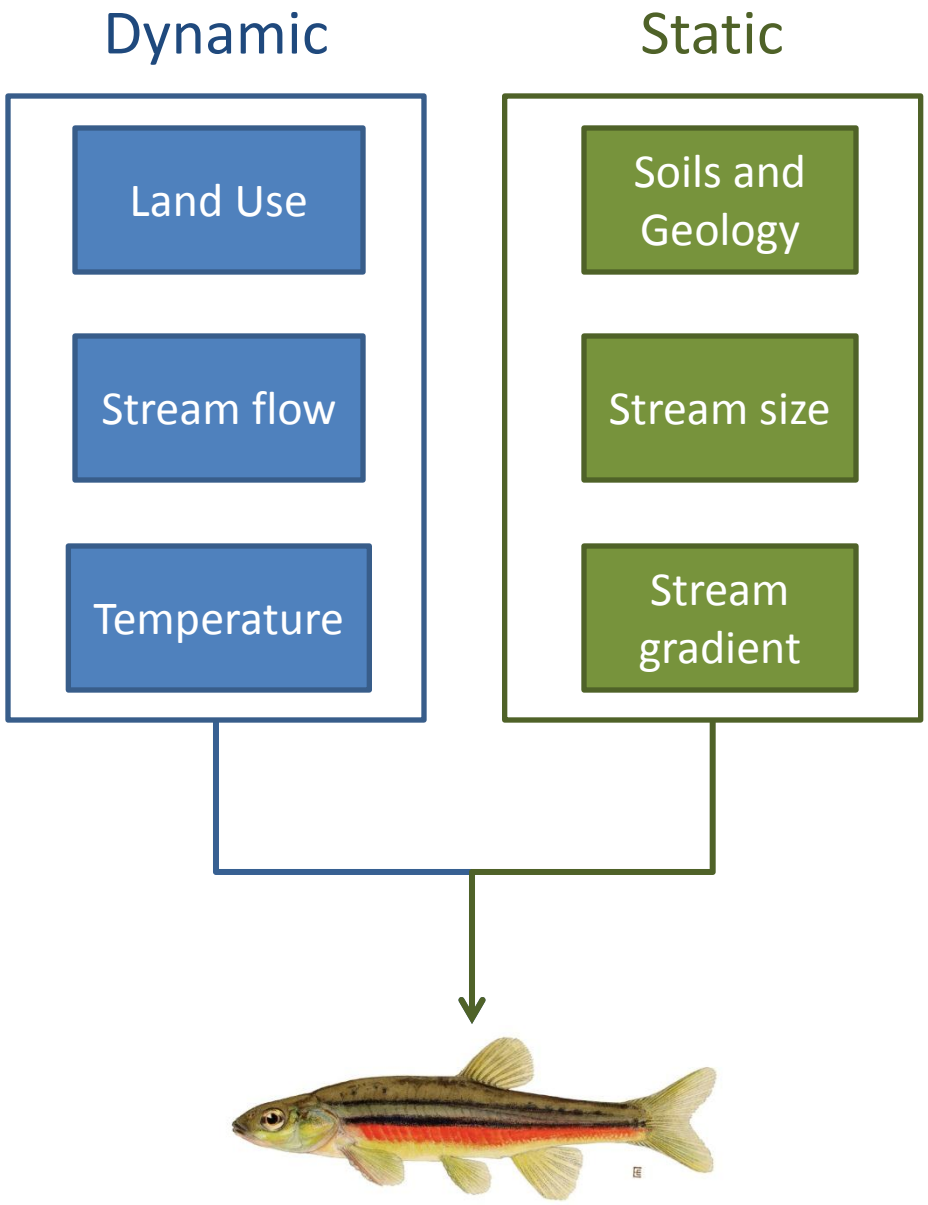
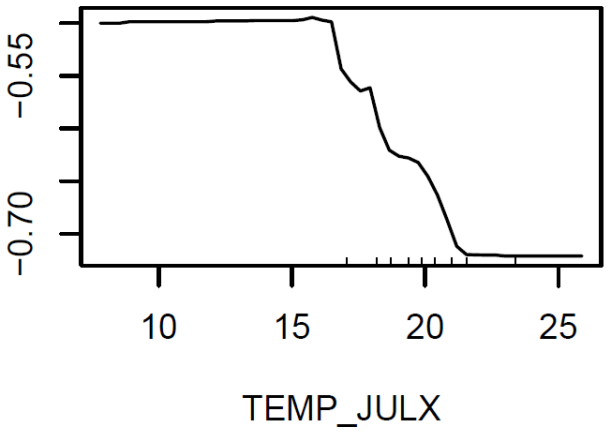
uring Tools
Find Location
Query
Maps & Data
Help
Point Identify
Identify
Enter Coords
Plot Coords
Clear Coords
Clicked Coordinates
Coordinate System
Lat:
Lon:
44.8524
-89.9956
Lat/Lon (DD)
Coordinate Tools
Map Scale: 1: 91,298
Jump to a map bookmark...
Scale & Bookmarks
Print Map
Print
Fish Database
Go to...
Help
What's This?
Send Feedback
Help
I want to...
Port Edwards
Two Mile Ave
Wisconsin Rapids
Nekoosa
Tenmile Creek, (Cool-Cold Mainstem)
Zoom To Feature | Pan To Feature | Create A Report | Copy To Drawing | Add To Selected
Export Feature Attachments
Details
Attributes
Field Name
Field Value
Natural Community
Cool-Cold Mainstem
Stream Name
Tenmile Creek
River System
Tenmile Creek
WBIC
1382700
Watershed Area (sq km)
251.37
Temperature Class
Cool
Hydro ID
200085981
Hydro Code
100
Maximum daily mean temperature (C)
20.956828
June - Sept mean flow (cfs) (1983-2011)
53.122572
Annual 5% exceedance flow (cfs) (1984-2011)
98.954962
Annual 10% exceedance flow (cfs) (1984-2011)
81.52827
Annual 25% exceedance flow (cfs) (1984-2011)
65.069936
Annual 50% exceedance flow (cfs) (1984-2011)
46.129057
Annual 75% exceedance flow (cfs) (1984-2011)
35.007007
Annual 90% exceedance flow (cfs) (1984-2011)
31.788576
Annual 95% exceedance flow (cfs) (1984-2011)
29.787351
Spring 10% exceedance flow (cfs) (1983-2011)
95.653708
Spring 50% exceedance flow (cfs) (1983-2011)
60.328041
Spring 90% exceedance flow (cfs) (1983-2011)
39.941624
2mi
2.5km
Lat:
Lon:

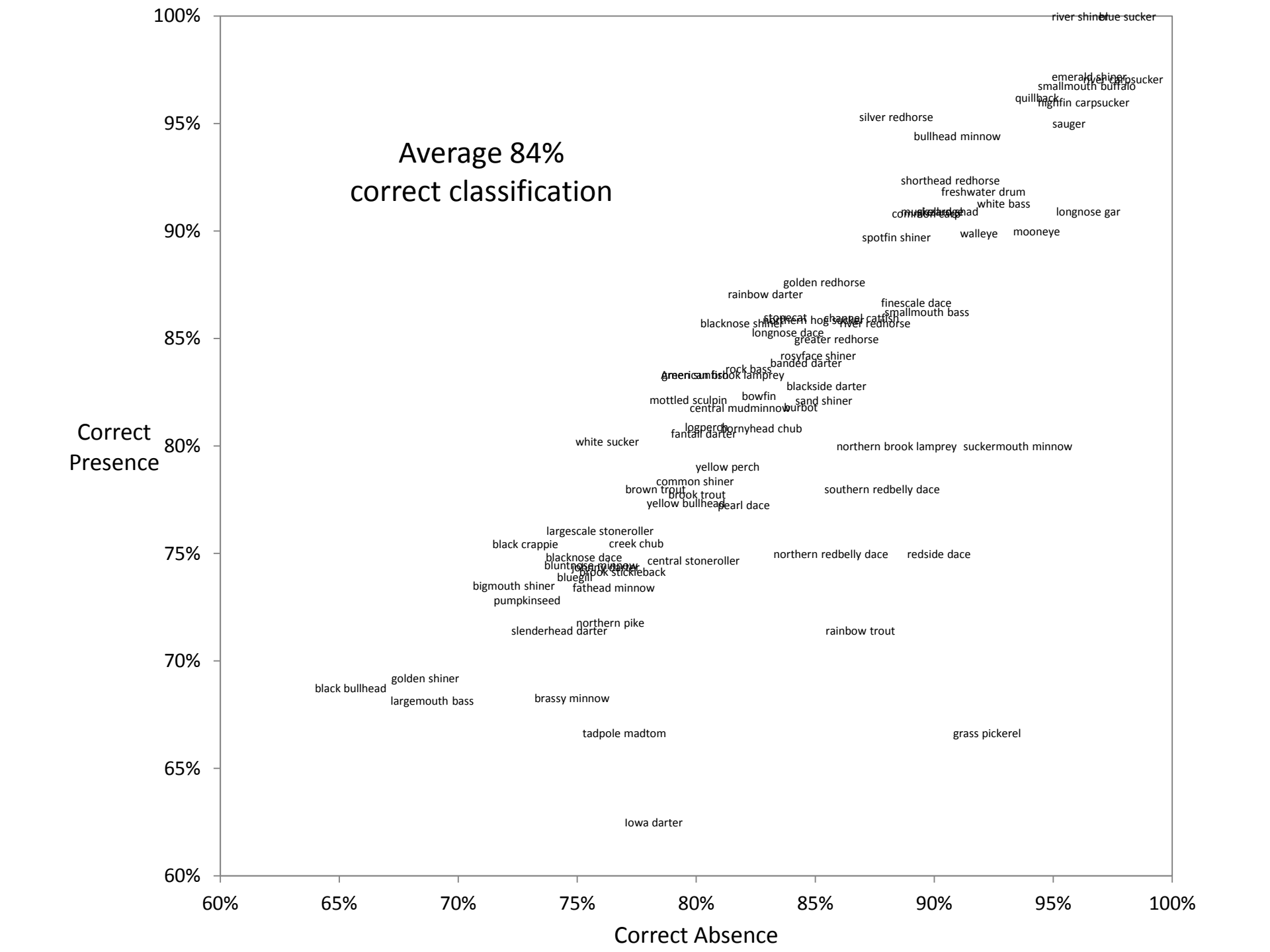
Fish Model

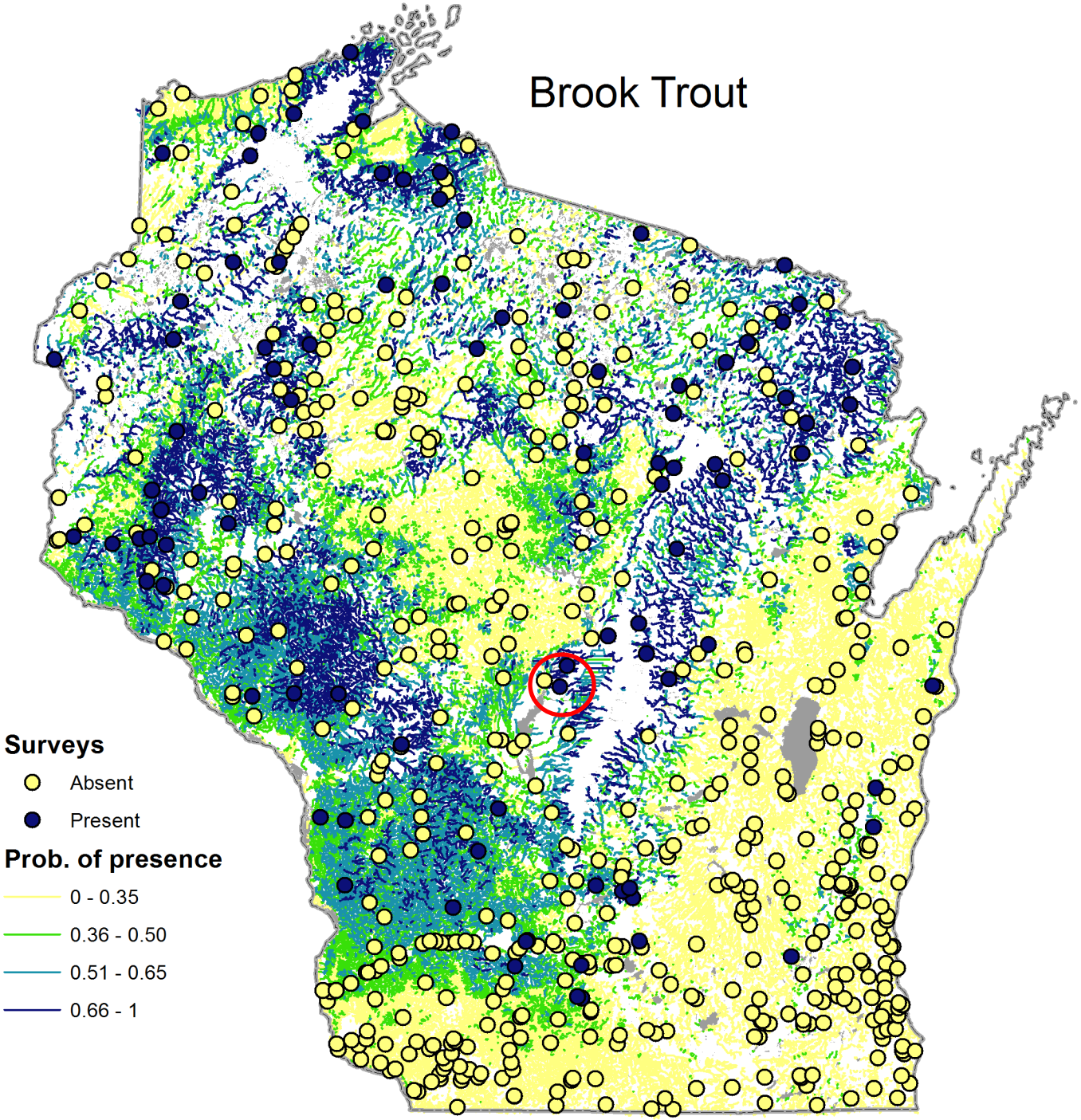

Dynamic
Static
Land Use
Stream flow
Temperature
Soils and Geology
Stream size
Stream gradient

Species Distribution Models

- Random Forest
- Presence/Absence
- 616 fish surveys used to build models
- Environmental predictors:
  - Watershed area
  - Water temperature (modeled)
  - Flow yield (modeled)
  - Channel gradient, sinuosity
  - Land cover
  - Geology/soils
  - Climate




Average 84%
correct classification
Correct Presence
Correct Absence
100%
95%
90%
85%
80%
75%
70%
65%
60%
river shiner
blue sucker
emerald shiner
river carpsucker
smallmouth buffalo
quillback
highfin carpsucker
silver redhorse
sauger
bullhead minnow
shorthead redhorse
freshwater drum
white bass
longnose gar
spotfin shiner
walleye
mooneye
golden redhorse
rainbow darter
finescale dace
smallmouth bass
blacknose shiner
river redhorse
longnose dace
greater redhorse
rosyface shiner
banded darter
rock bass
blackside darter
mottled sculpin
bowfin
sand shiner
central mudminnow
burbot
logperch
hornyhead chub
fantail darter
white sucker
northern brook lamprey
suckermouth minnow
yellow perch
common shiner
brown trout
brook trout
southern redbelly dace
yellow bullhead
pearl dace
largescale stoneroller
black crappie
creek chub
blacknose dace
northern redbelly dace
redside dace
central stoneroller
brook stickleback
bluegill
bigmouth shiner
fathead minnow
pumpkinseed
northern pike
slenderhead darter
rainbow trout
golden shiner
black bullhead
largemouth bass
brassy minnow
tadpole madtom
grass pickerel
Iowa darter


Brook Trout
Surveys
Absent
Present
Prob. of presence
0 - 0.35
0.36 - 0.50
0.51 - 0.65
0.66 - 1

Tenmile Creek fish community


Brook trout


Brown trout


N. Brook lamprey


Black bullhead


Central mudminnow


Mottled sculpin


Brassy minnow

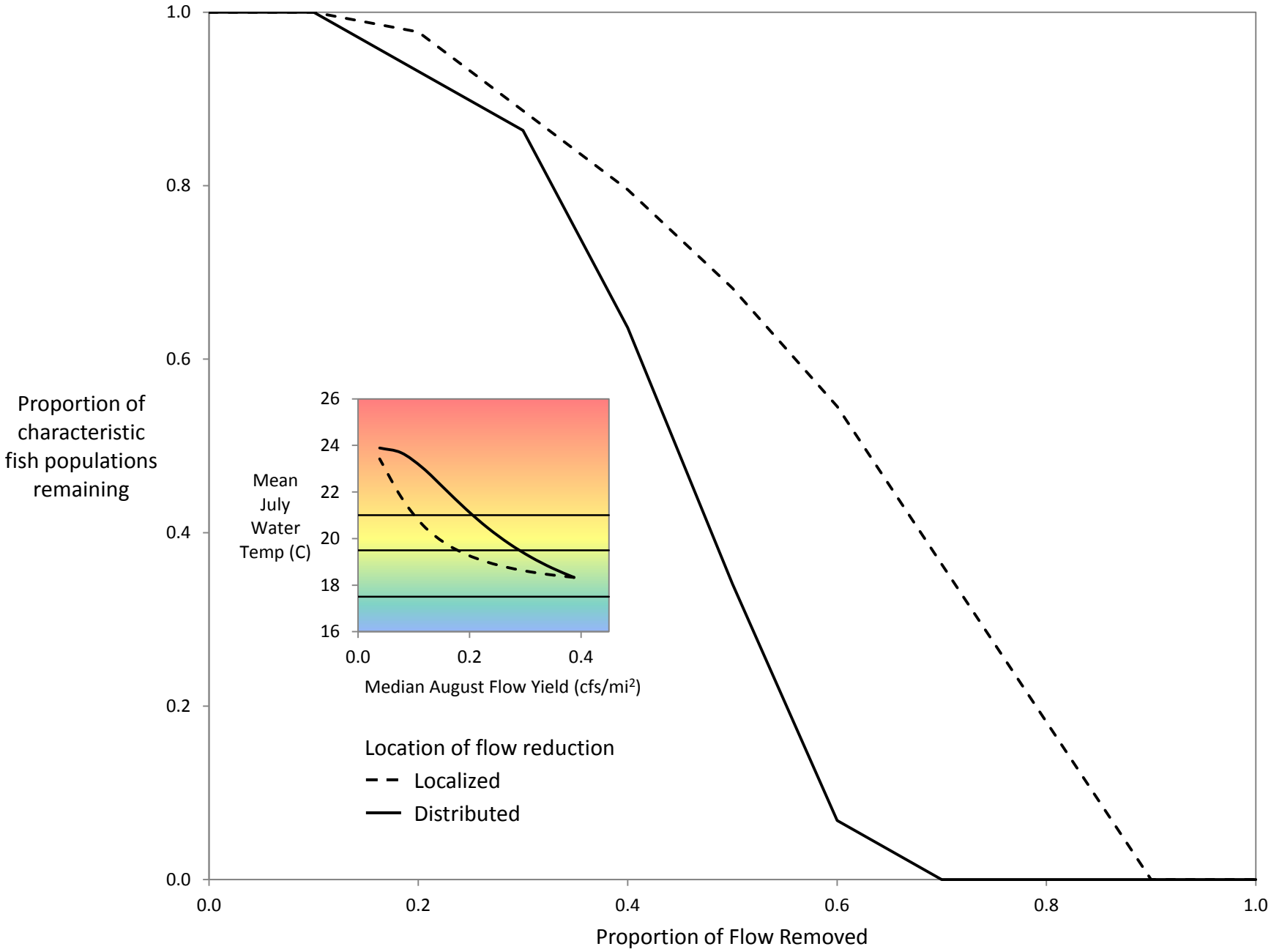

Common shiner


Bigmouth shiner


Pearl dace


White sucker


brook trout
Mean July Temperature (C)
16
18
20
22
24
26
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
August Median Flow Yield (cfs/sq mi)
Flow / temp
niche
(95% abundance)


1.0
0.8
0.6
0.4
0.2
0.0
Proportion of characteristic fish populations remaining
0.0
0.2
0.4
0.6
0.8
1.0
Proportion of Flow Removed
26
24
22
20
18
16
Mean July Water Temp (C)
0.0
0.2
0.4
Median August Flow Yield (cfs/mi²)
Location of flow reduction
Localized
Distributed

Limitations

- Need hydrogeological models to simulate groundwater/surface water interactions
- Cannot model flow intermittency
- Temperature response to flow change is approximate
- Fish response in terms of occurrence, not abundance
- Policy still needs societal values

Summary

Flow models

- Fill gap between USGS low flow and flood frequency models
- Predict flow duration curves at all Wisconsin streams
- Can be used to simulate pre-settlement and future flows

Fish models

- Predict fish community in all Wisconsin streams
- Can be used to identify streams that are biologically sensitive to changes in flow, temperature, land use, and climate.