How the distribution of development affects nitrogen export in the Lamprey watershed

Madeleine M. Mineau
W.M. Wollheim & R.J. Stewart
University of New Hampshire

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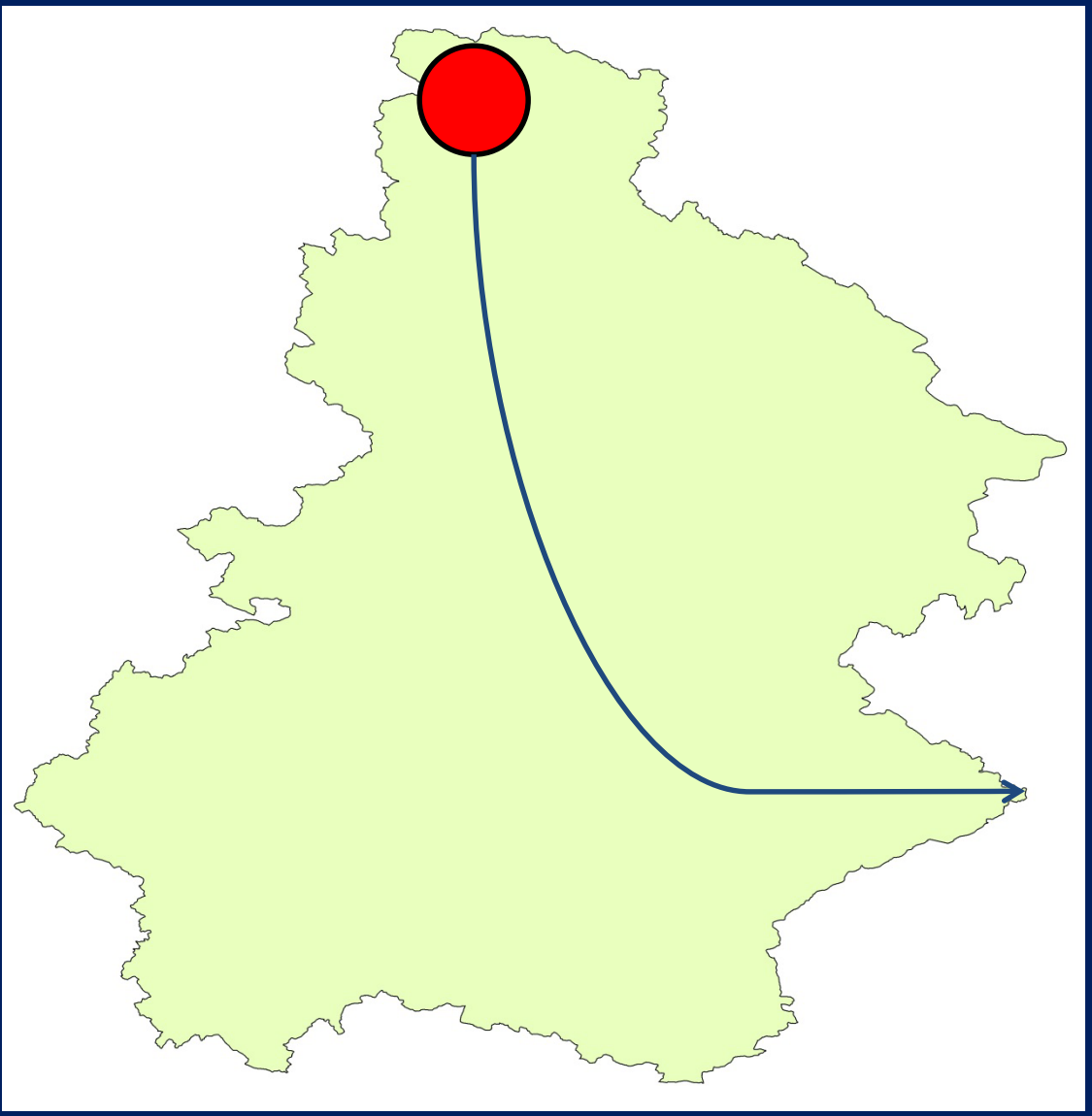
Introduction

- Watershed N export to coastal zones
- Distribution of land use rarely considered

Goal: Investigate the effects of the distribution of land uses that act as N sources and N sinks within watersheds on N export.

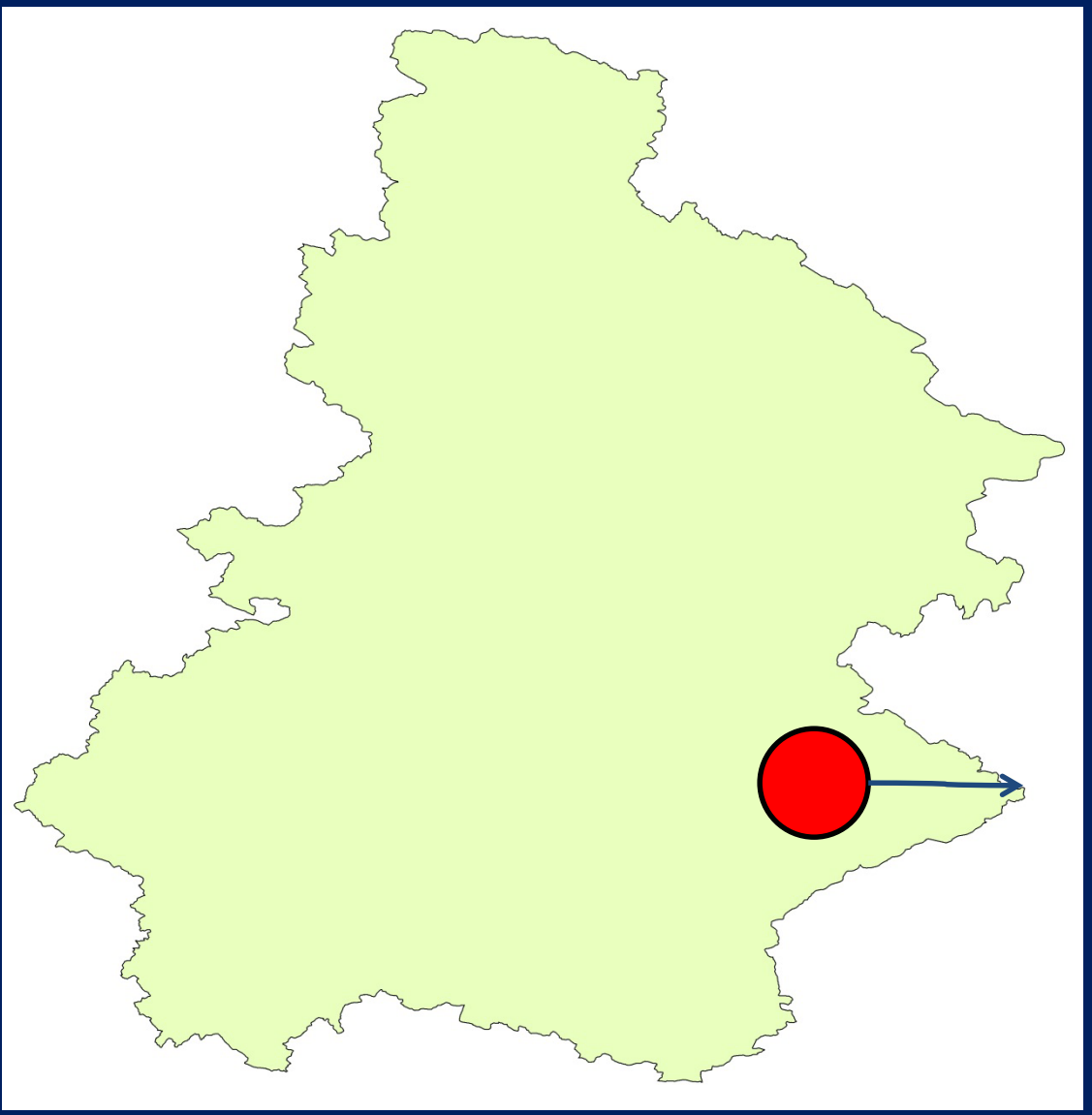
Distribution of N sources and sinks



N from sources in the headwaters have longer hydrologic travel time

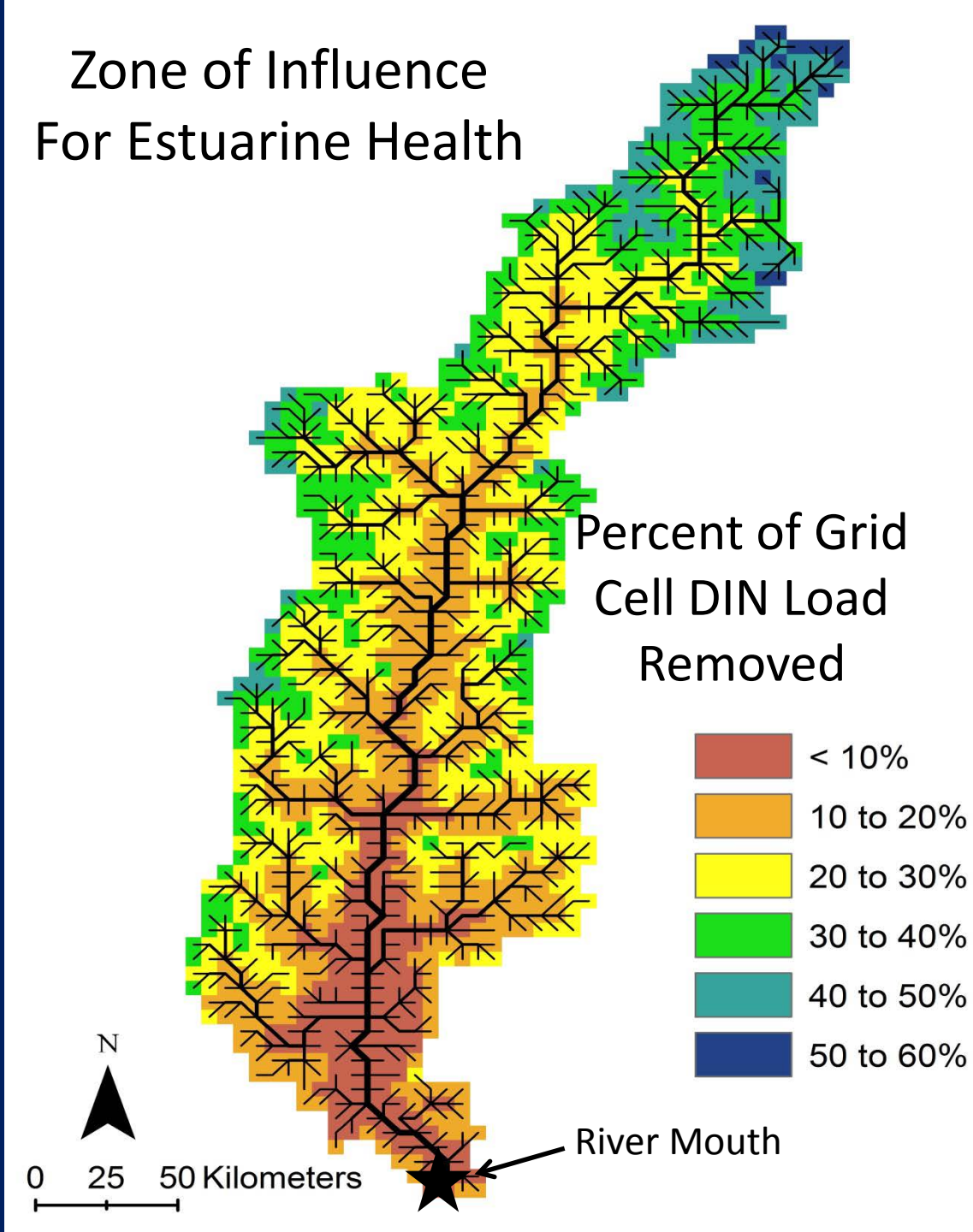
Longer residence time results in greater N removal

Distribution of N sources and sinks

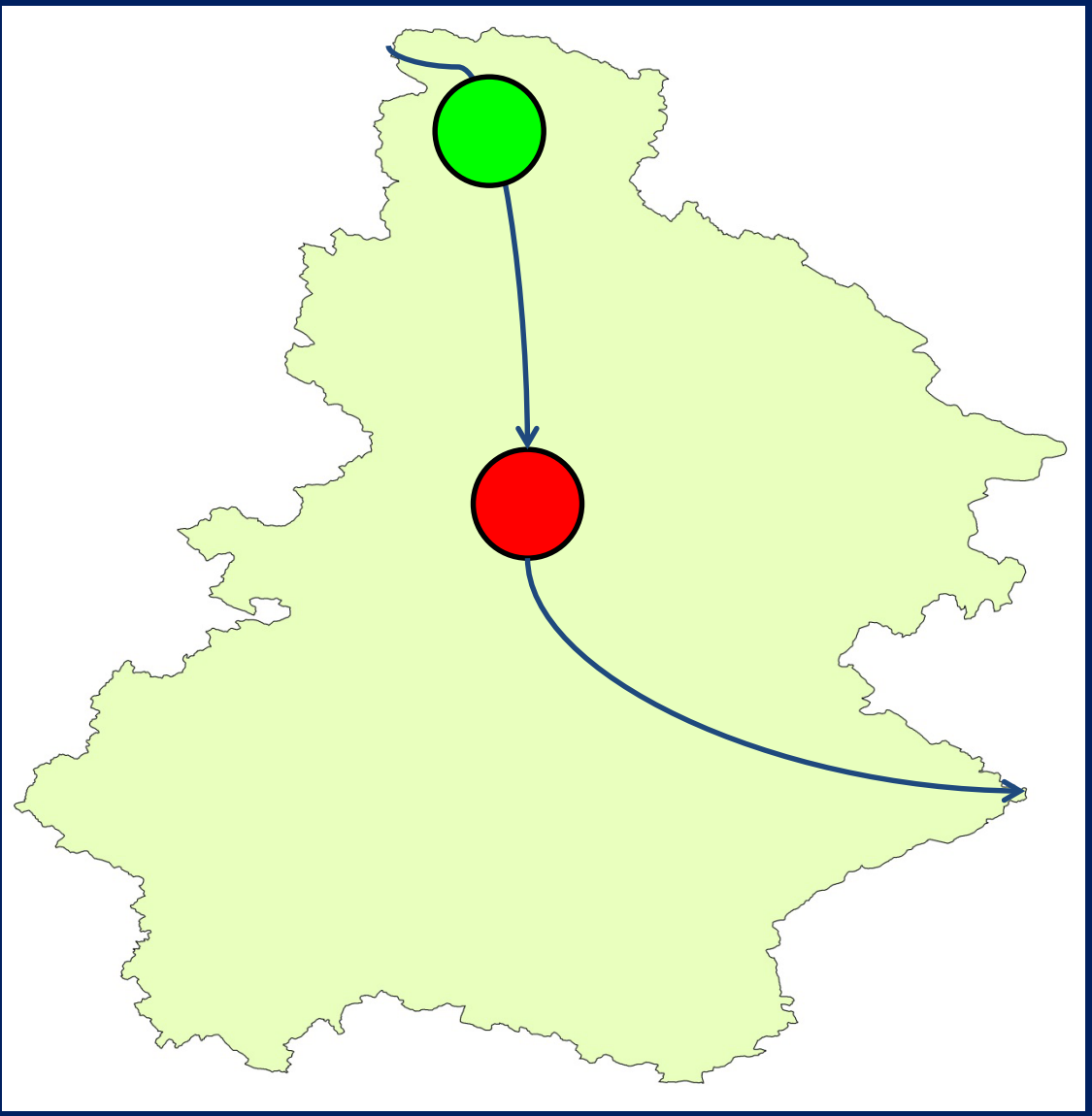


Shifting N sources downstream shortens residence time and limits opportunities for N removal

Zone of Influence For Estuarine Health

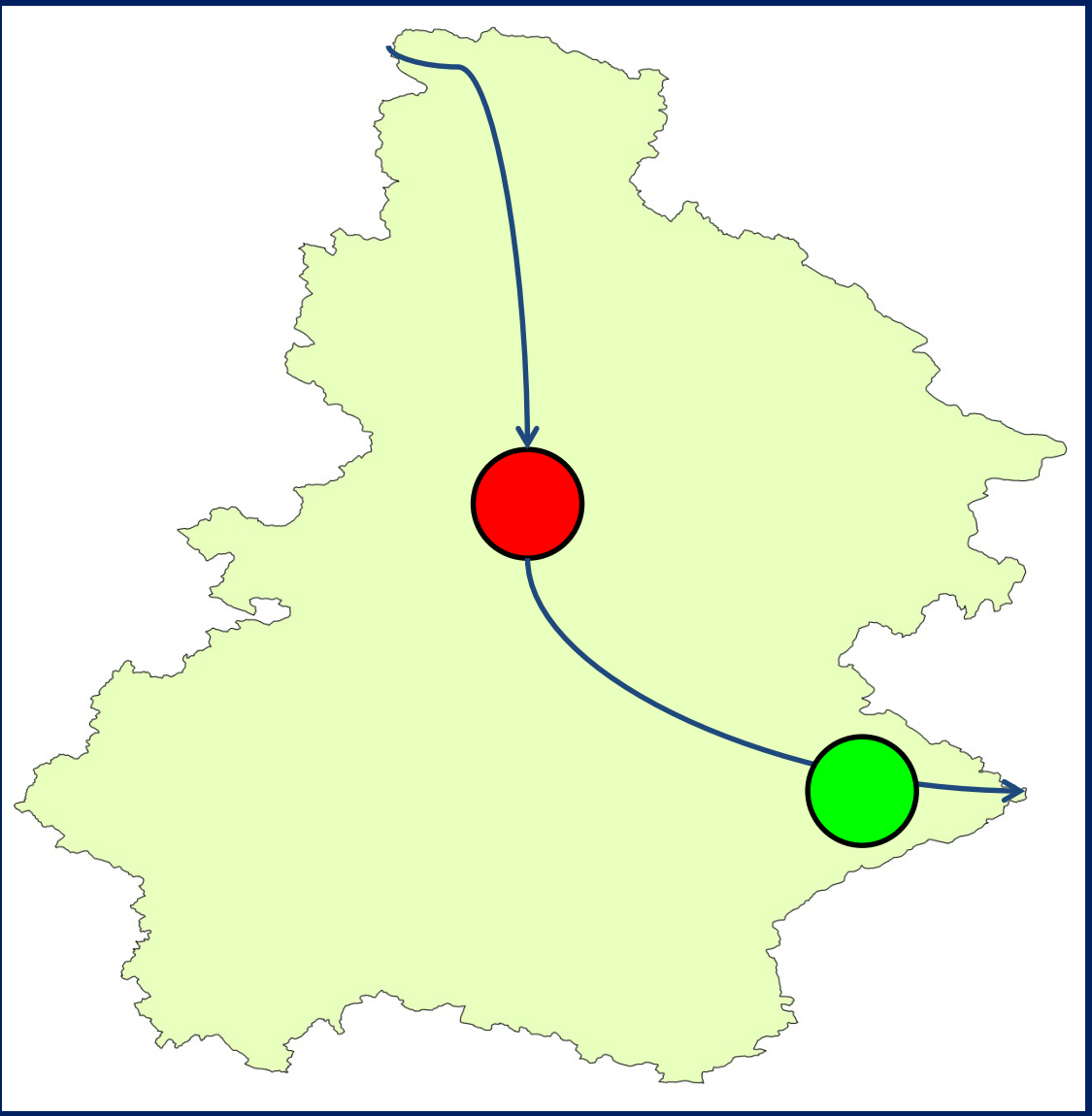


Distribution of N sources and sinks



Distribution of sinks relative to sources may also affect N export.

Distribution of N sources and sinks



Distribution of sinks relative to sources may also affect N export.

Methods

Model: FrAMES Wollheim et al. 2008, Stewart et al. 2011

Land use:

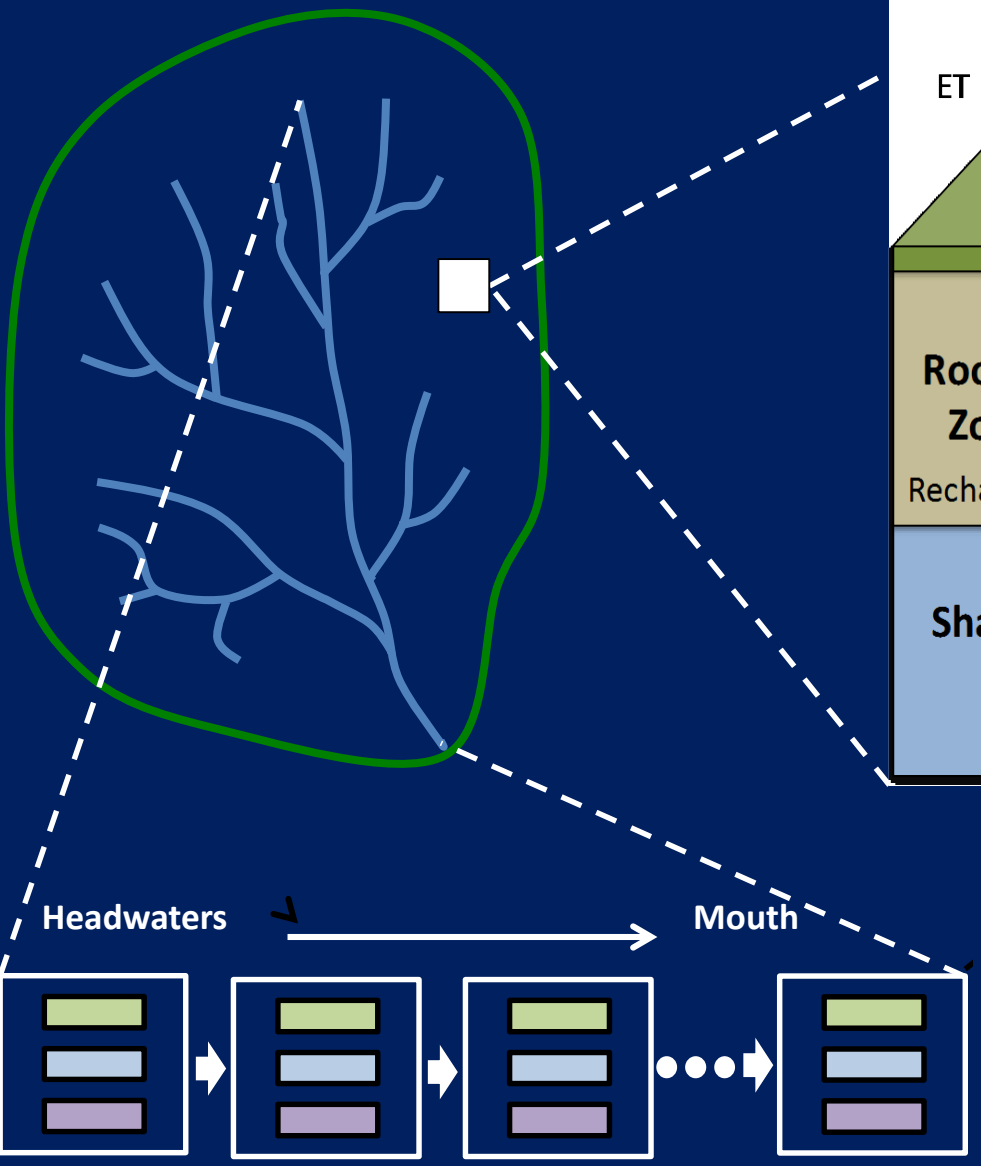
N sources: Residential and agricultural

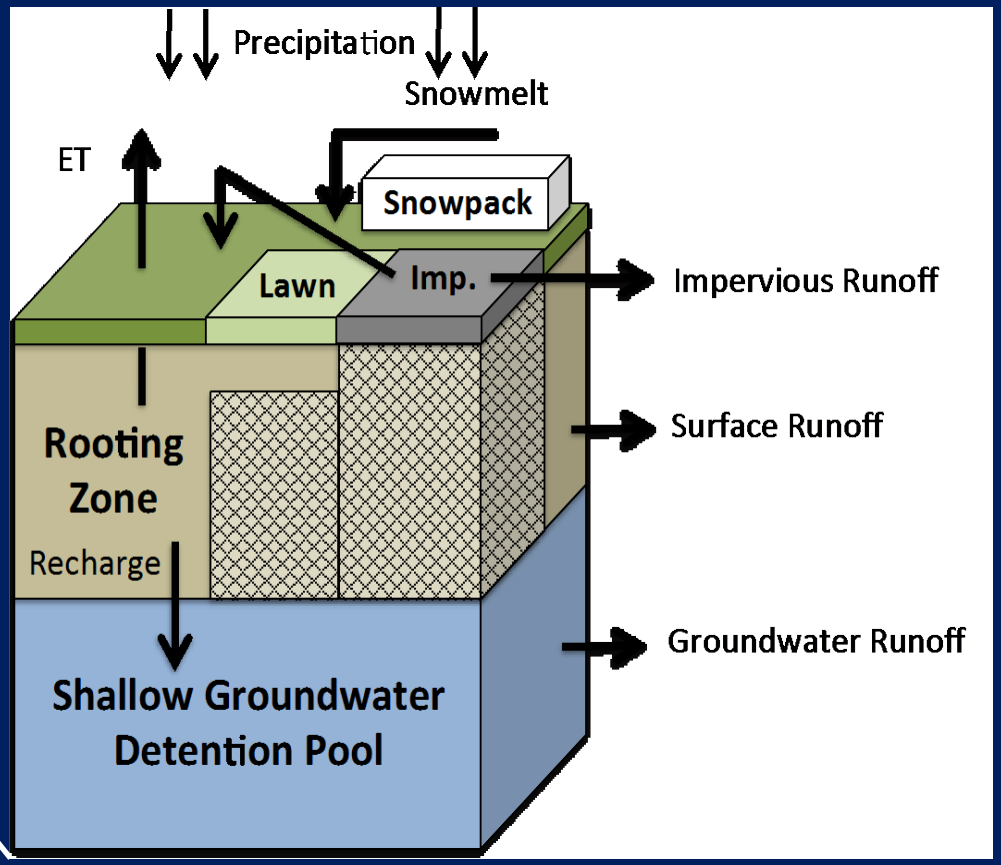
NLCD 2006

N sink: River and wetland processing

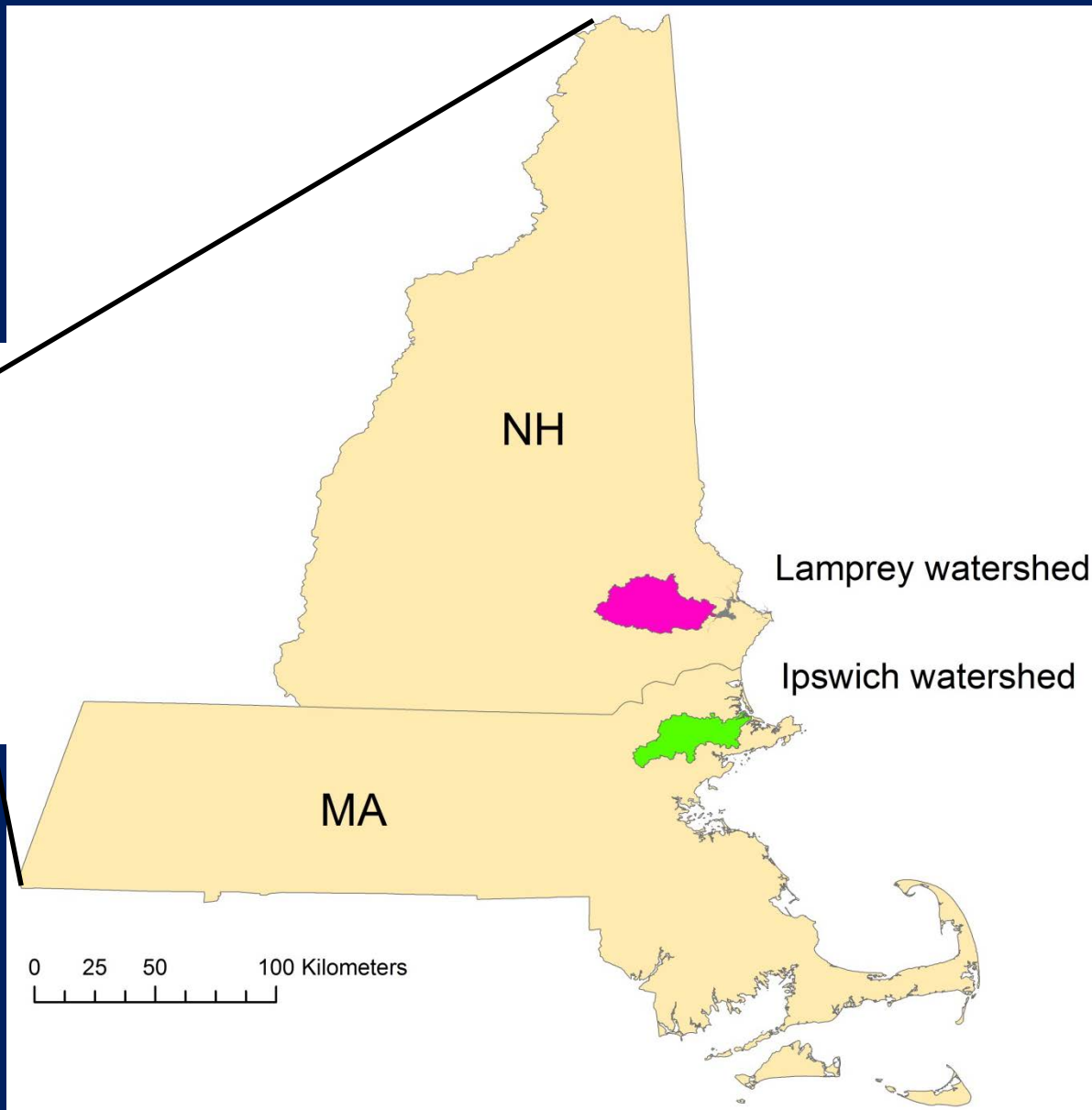
Mulholland et al 2008 and Wollheim et al In Review

FrAMES Model





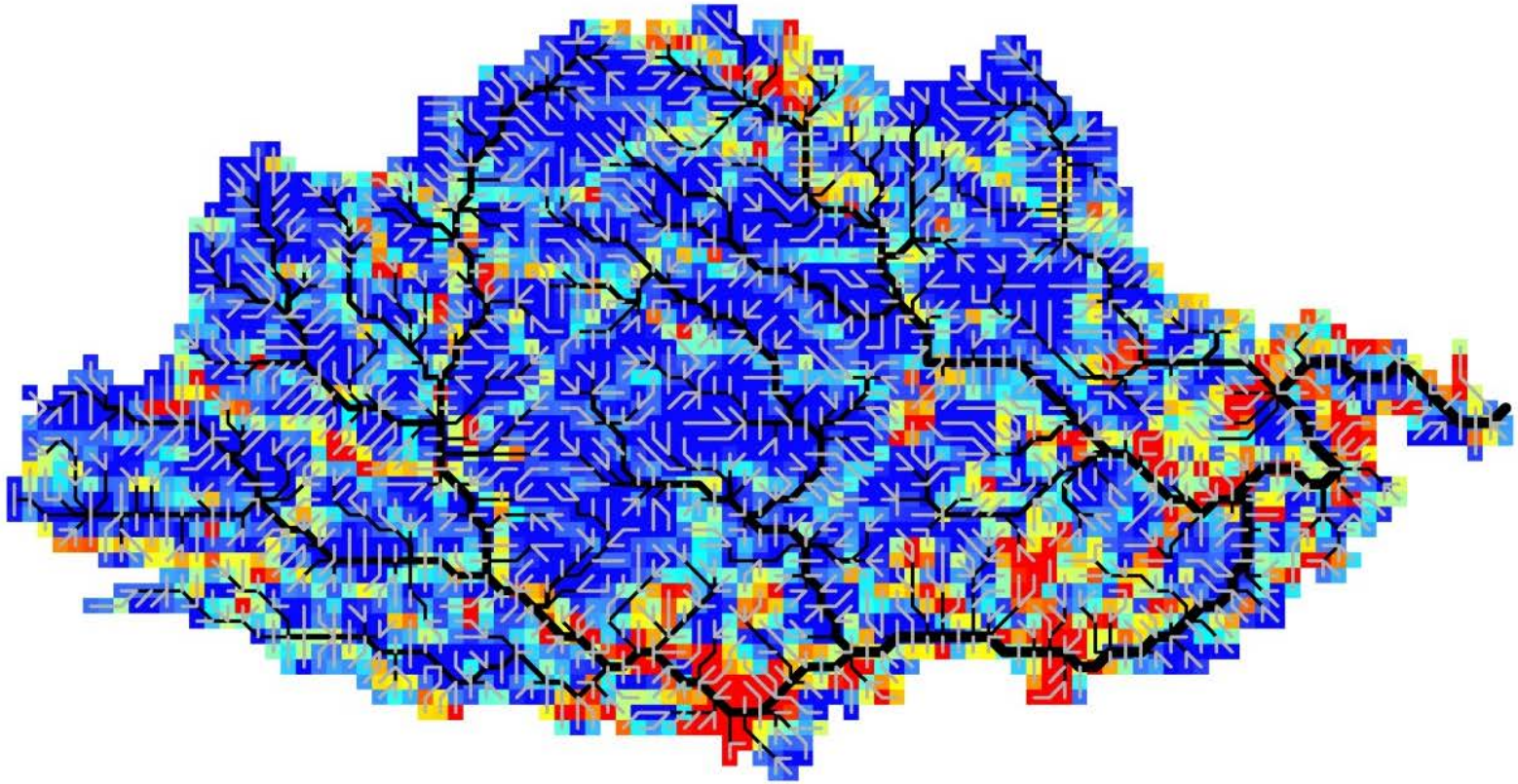
Watersheds


NH
Lamprey watershed
Ipswich watershed
MA
0 25 50 100 Kilometers

Watershed characteristics

Watershed Name	Watershed Area km^2	Population Density $\#/km^2$	% area developed	% wetland
Lamprey	474	72	14	10
Ipswich	400	310	37	20

Lamprey River watershed



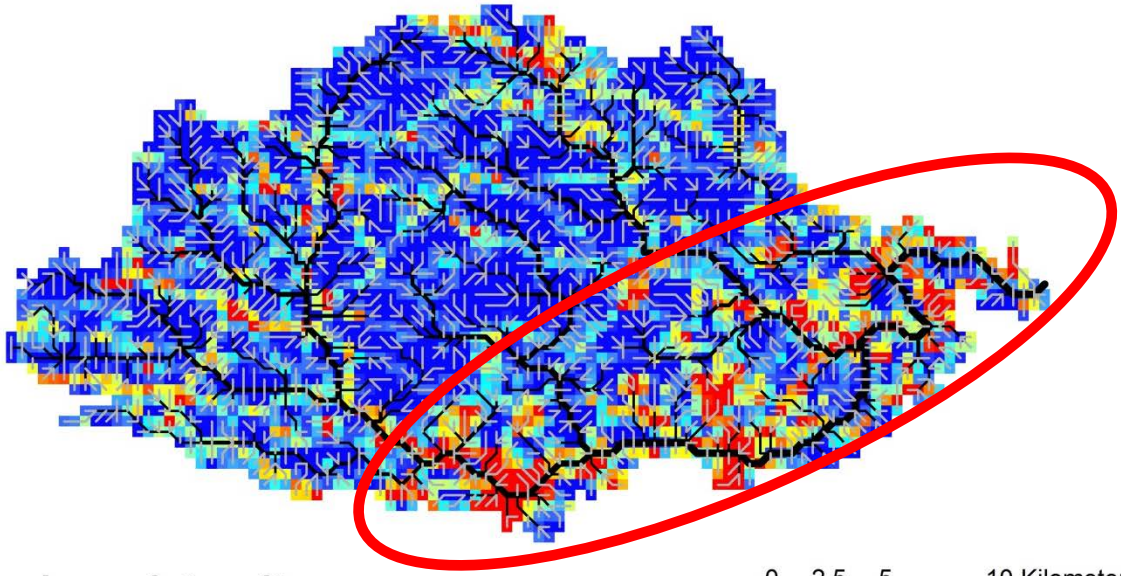
Developed area intensity

High : 1

Low : 0

0 2.5 5 10 Kilometers

Lamprey River watershed



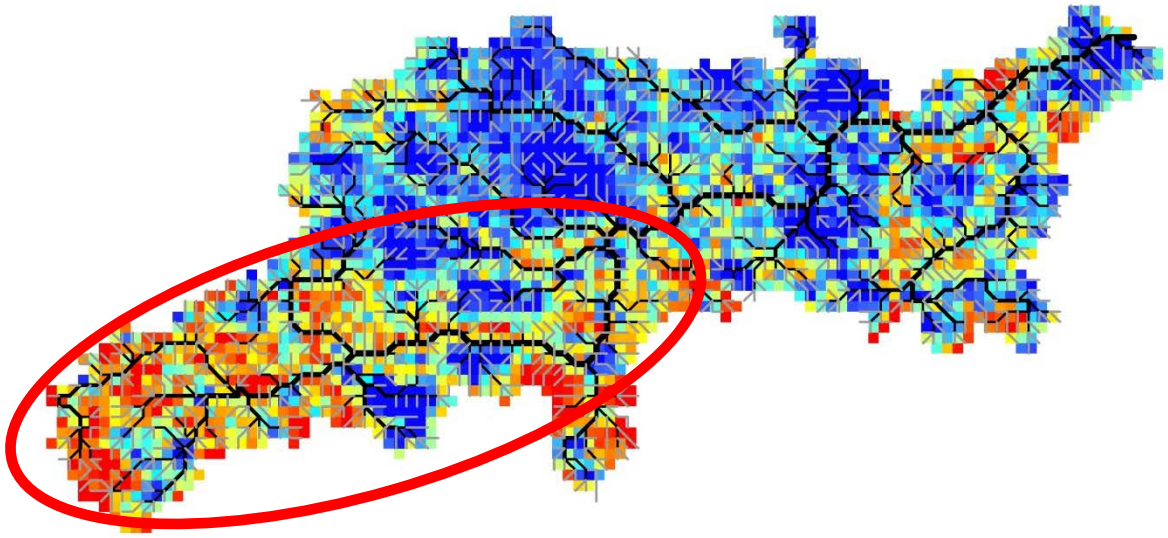
Developed area intensity

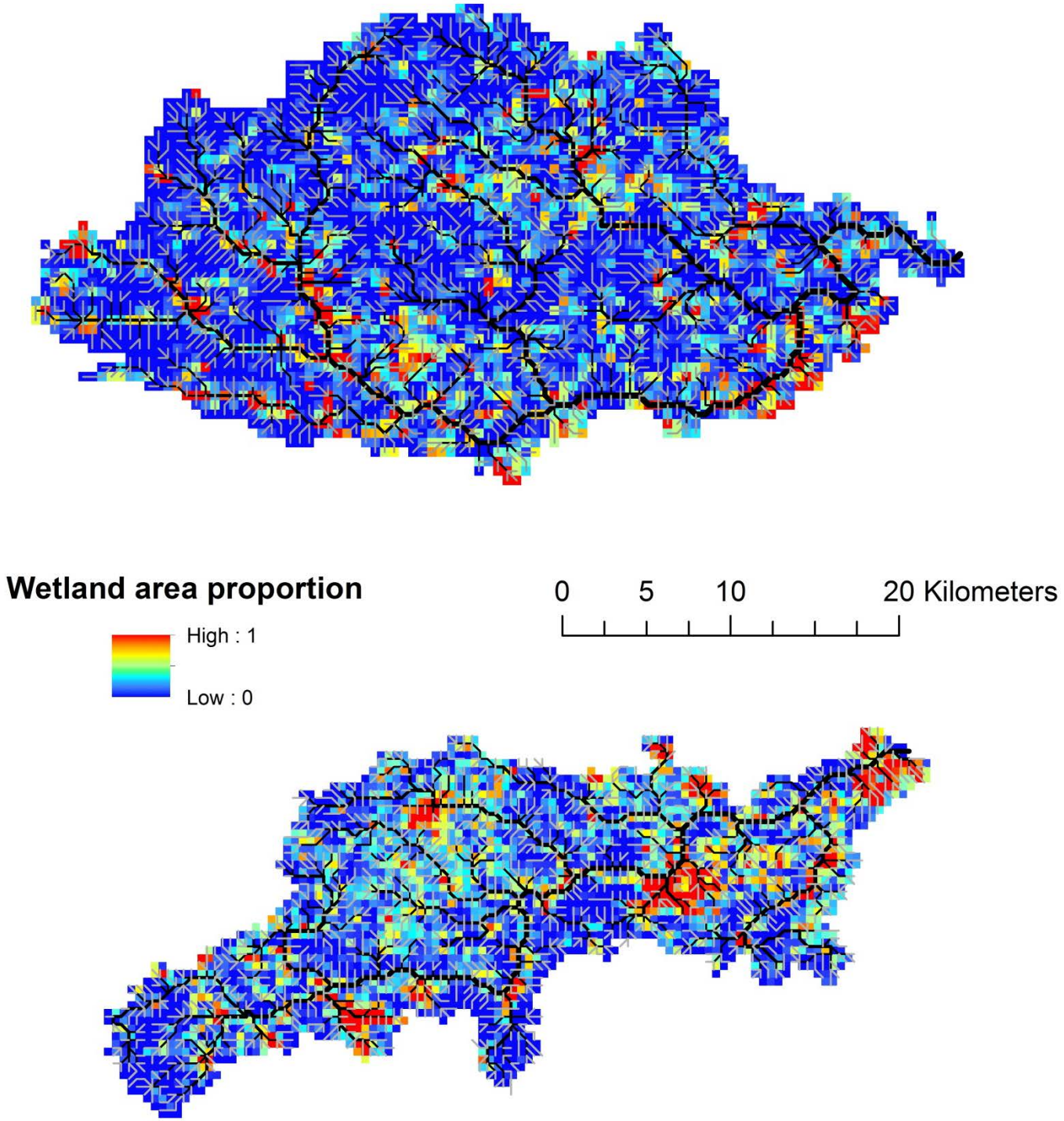
High : 1

Low : 0

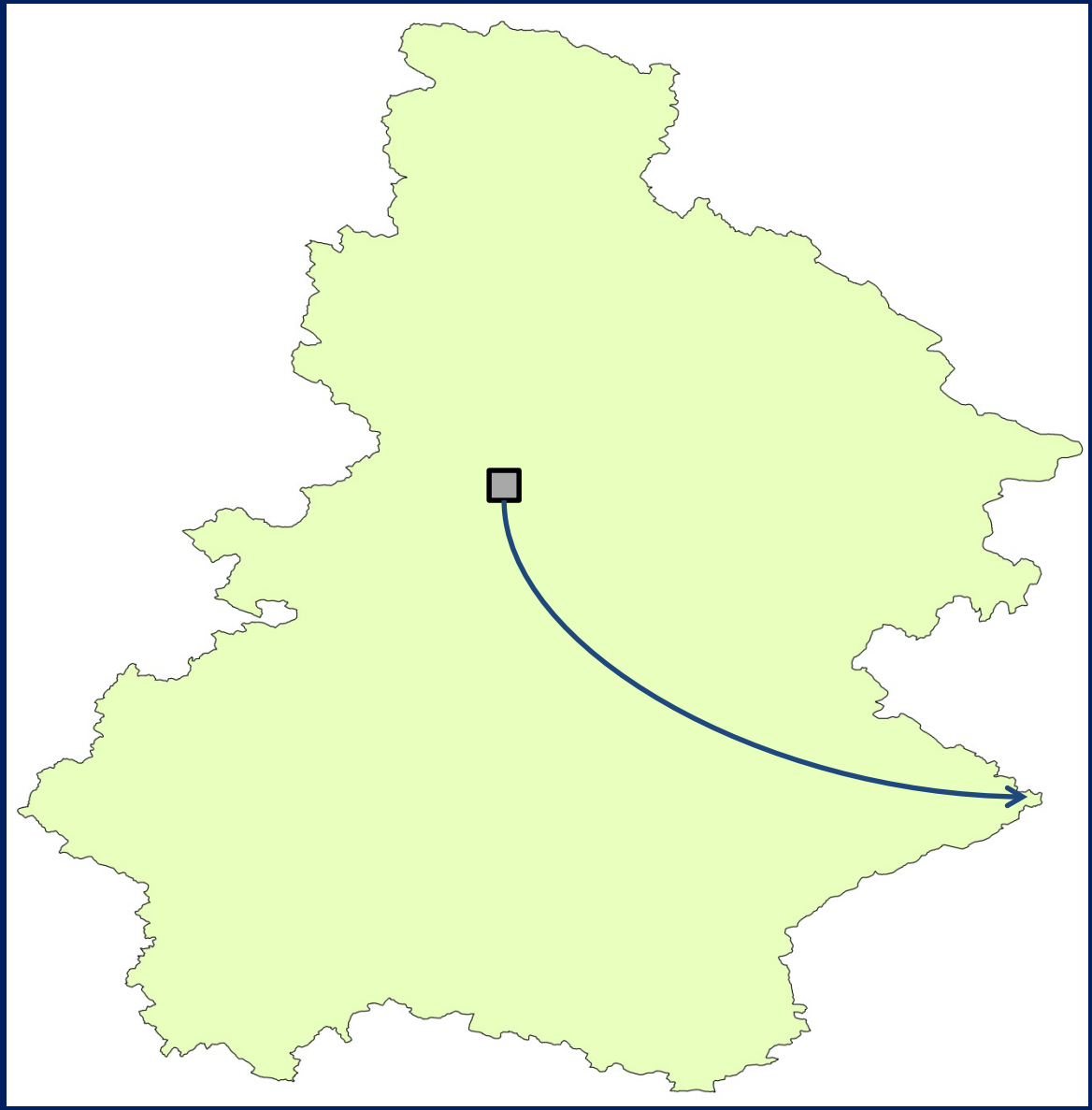
0 2.5 5 10 Kilometers

Ipswich River watershed




Wetland area proportion
High : 1
Low : 0
0
5
10
20 Kilometers

Skewness index



Land use weighted mean distance / Unweighted mean distance

1 = not skewed

>1 headwater

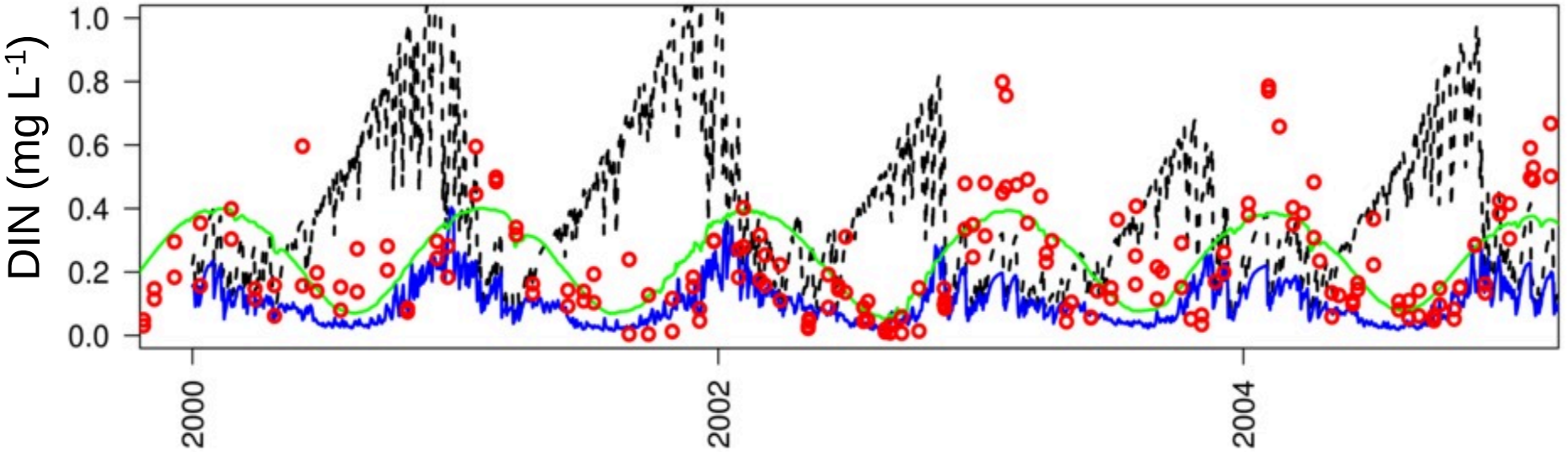
<1 mouth

Watershed Name	Developed skewness	Wetland skewness	Mean annual DIN export Kg/km^2/y	Mean annual export Kg/person /y
Lamprey	0.89	0.94	77	1.07
Ipswich	1.09	0.88	171	0.55

Development scenarios

1. Current development
2. 2x development as currently distributed
3. Same increase as 2 but evenly distributed (2x even)

Ipswich Dam



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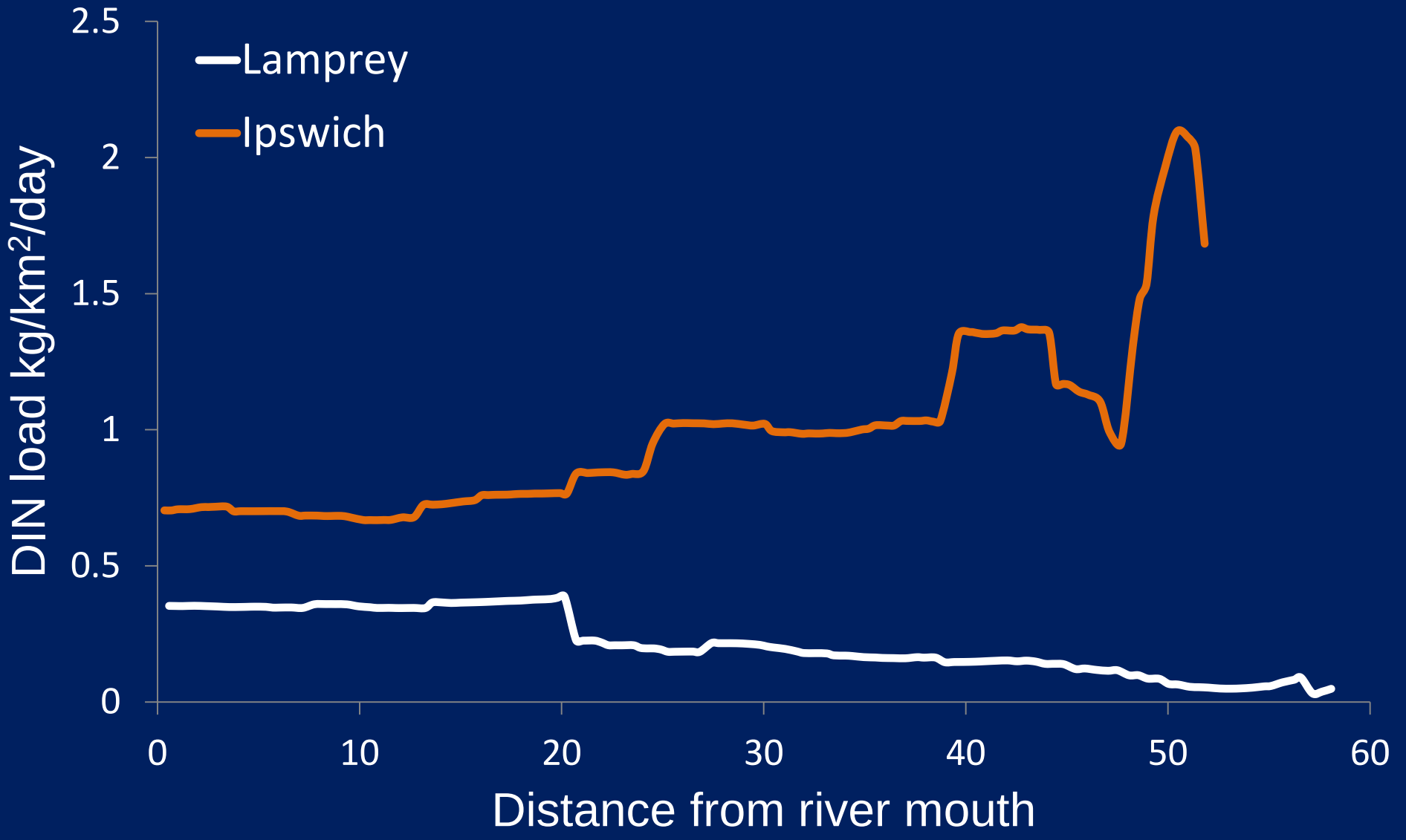
River+Wetland removal

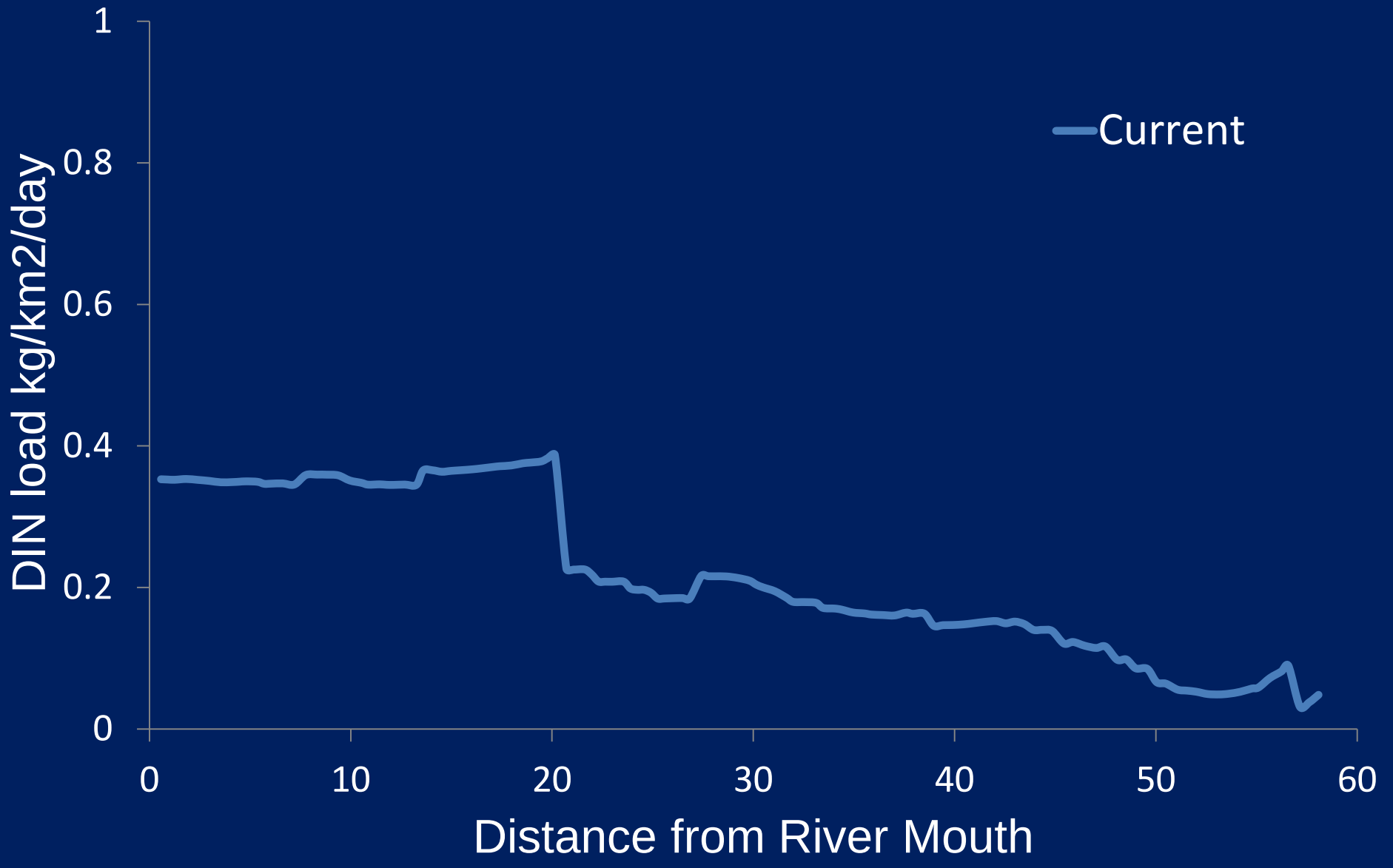
MBL/UNH Observations (NO_3 + NH_4)

LOADEST simulation (Morse unpublished data)

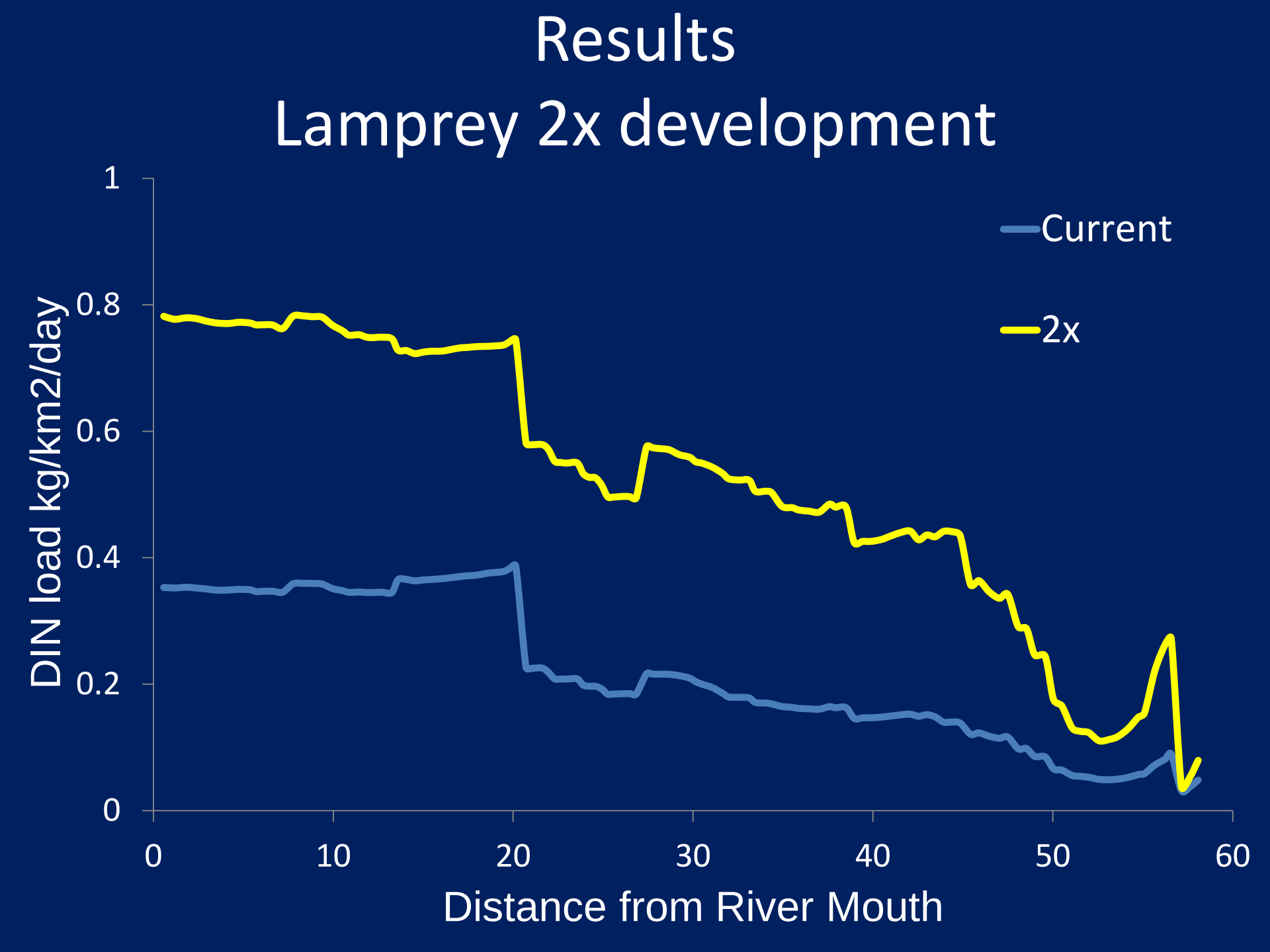
Results


Lamprey
Ipswich
DIN load kg/km²/day
2.5
2
1.5
1
0.5
0
0
10
20
30
40
50
60
Distance from river mouth

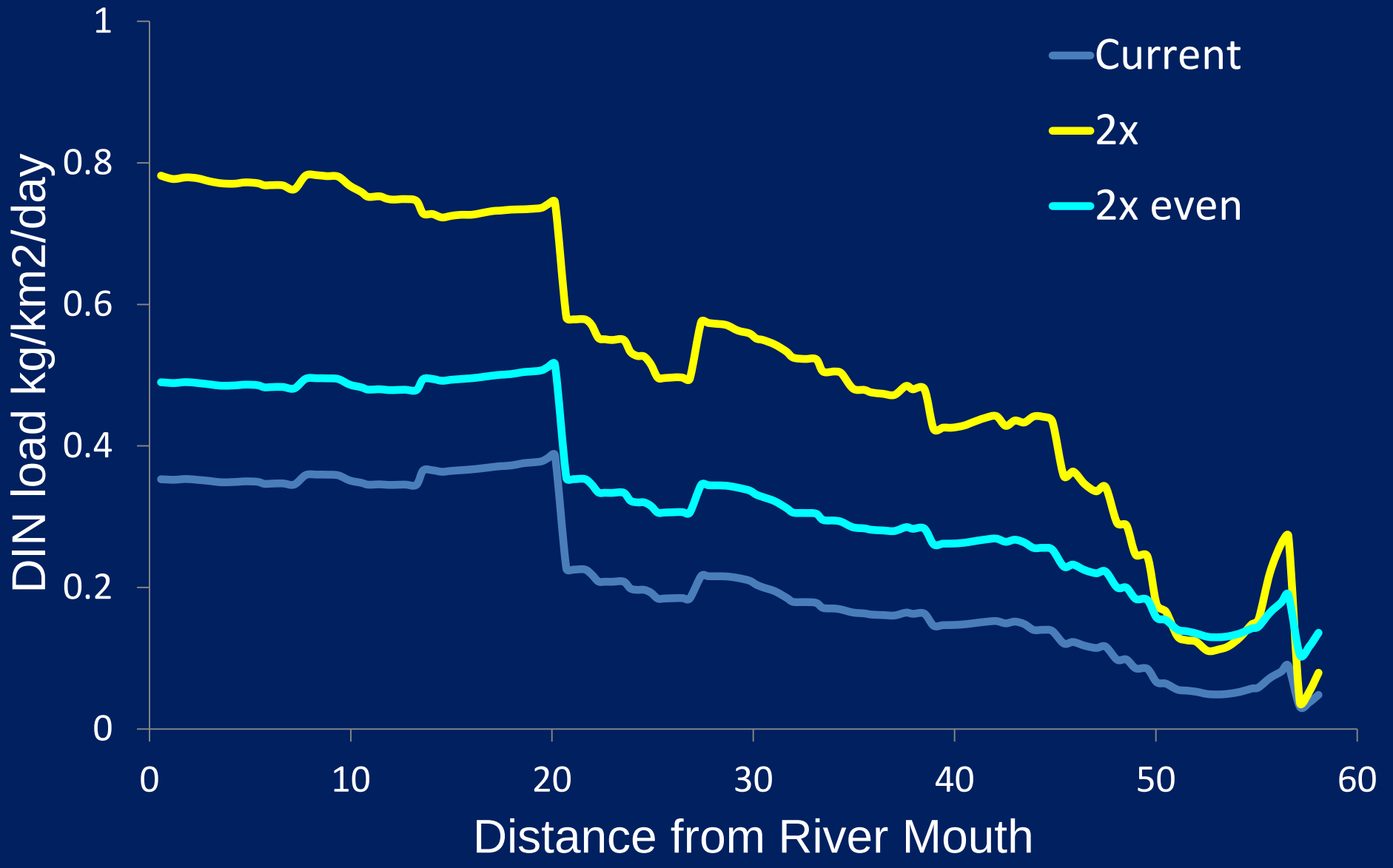
Results
Lamprey current development



Results
Lamprey 2x development

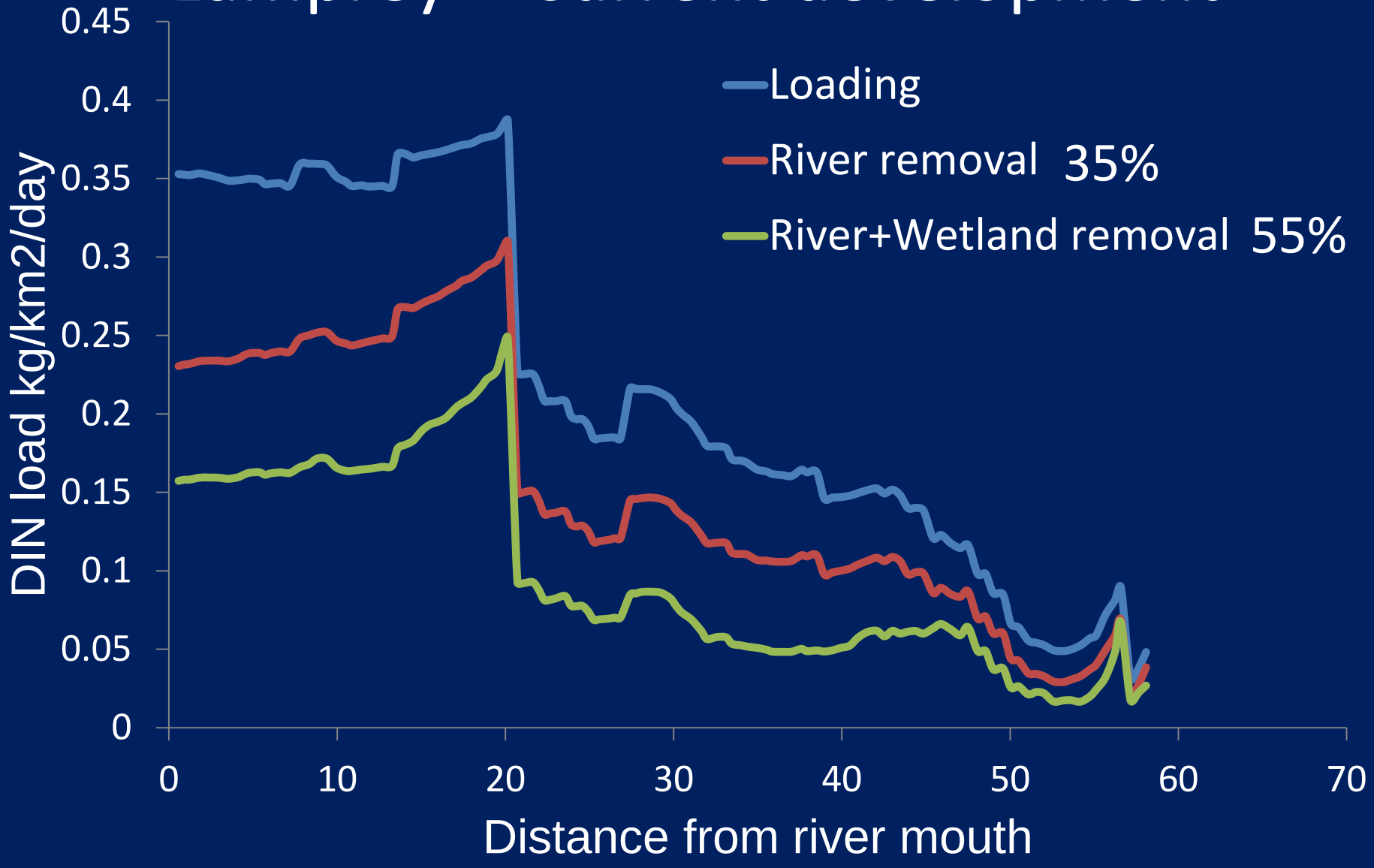


Results
Lamprey 2x development



Results

Lamprey – Current development



Results

Watershed	N Loading		N Removal		
	2x development	Even 2x development	2x development	Even 2x development	Wetland effect
Lamprey	+122%	+38%	-5%	-1%	+21%
Ipswich	+113%	+78%	-7%	-4%	+30%

Conclusions

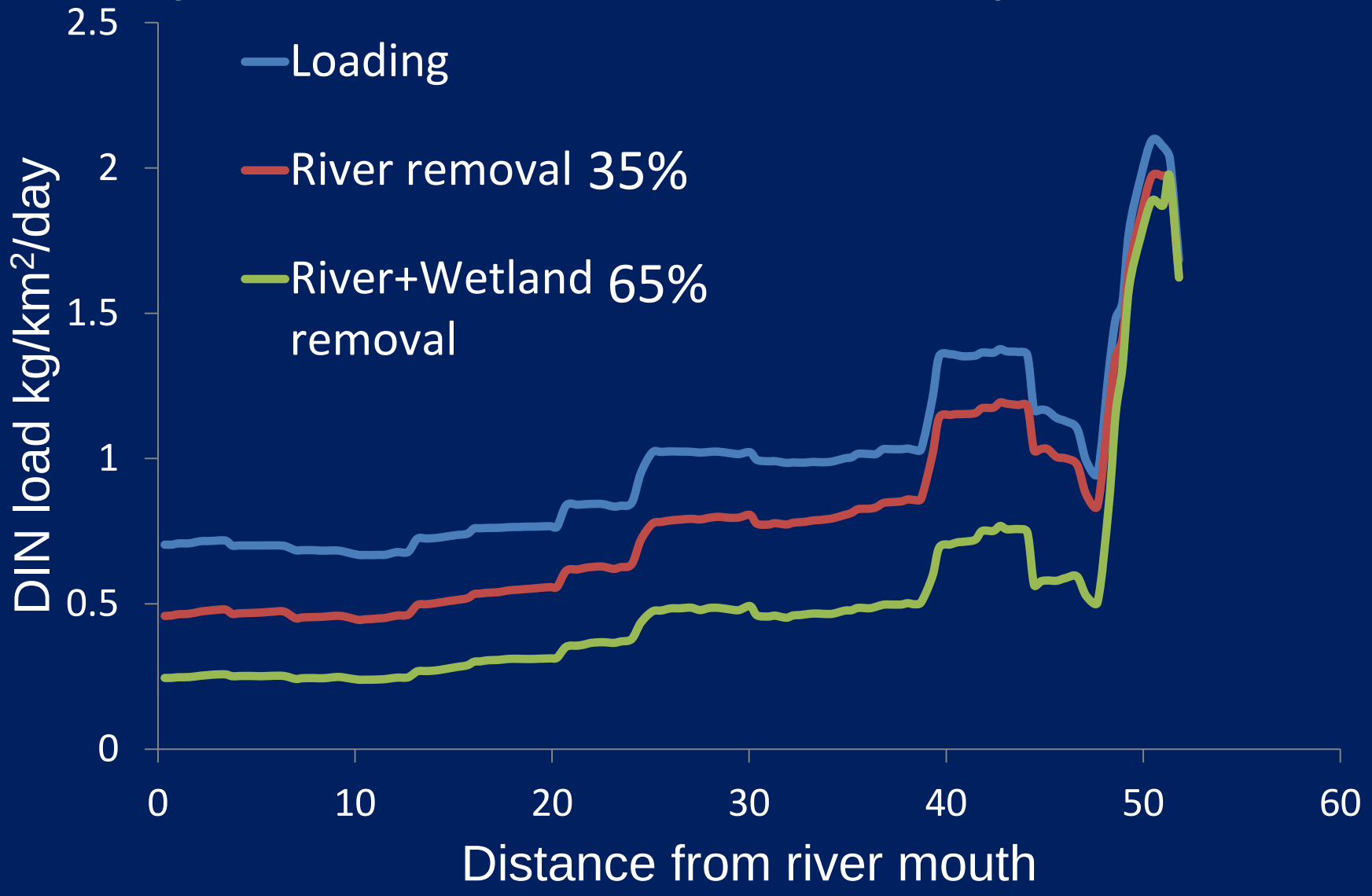
- Diffuse, even development results in lower watershed N export than equivalent concentrated development
- Development skewed towards river mouth further increases watershed N export.
- Wetland N processing has large effect on watershed N removal.

Take home

- The distribution as well as the quantity of watershed development influences watershed N export
- Landscape complexity plays an important role in regulating watershed N export and should be considered in models

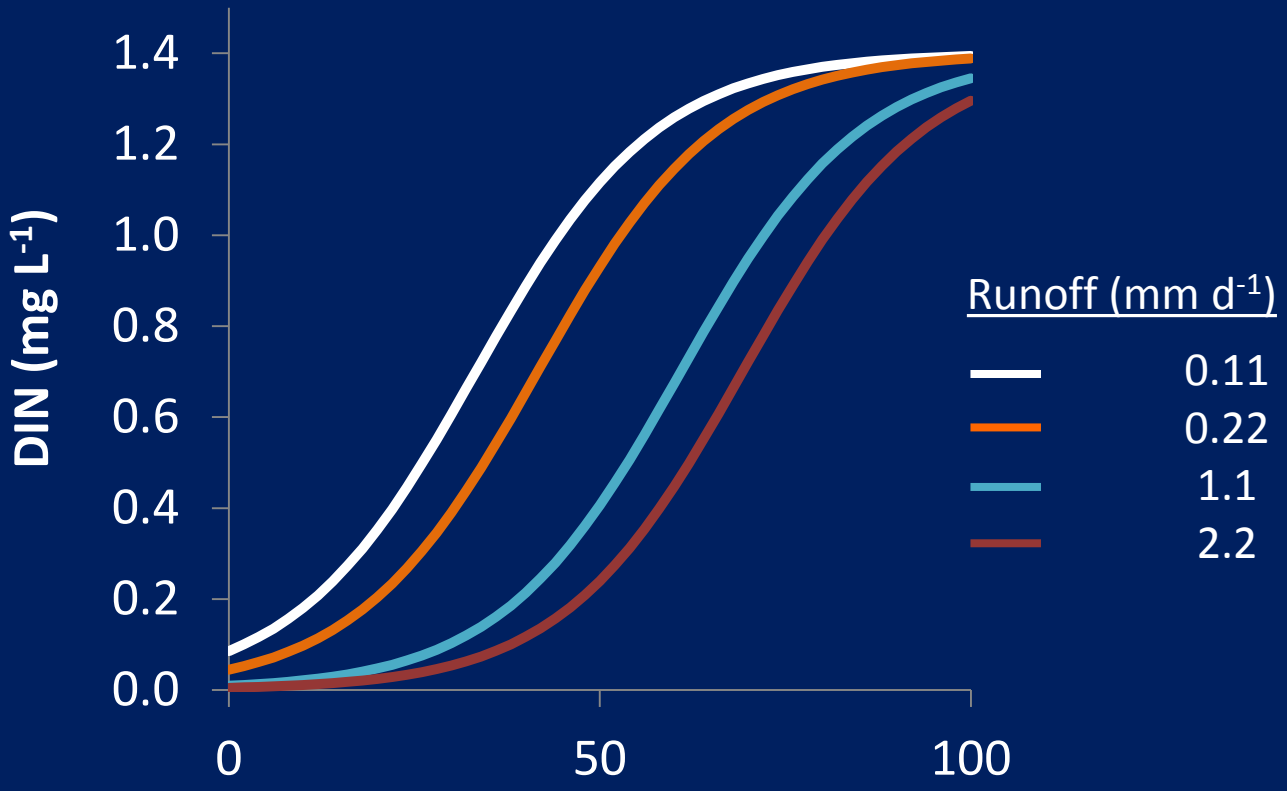
Results

Ipswich – Current development



Conclusions

Diffuse development has a smaller effect on N export due to threshold effect



Wollheim et al. 2008

Conclusions

- Diffuse, evenly distributed development has a smaller effect on watershed N export than concentrated development especially if concentrated development is skewed towards the river mouth.

- Wetland N processing has large effect on watershed N removal. Uptake efficiency loss may be more important than total wetland area or location of wetlands.