Ecological Processes of Isolated Wetlands; Ecosystem Services and the Significant Nexus

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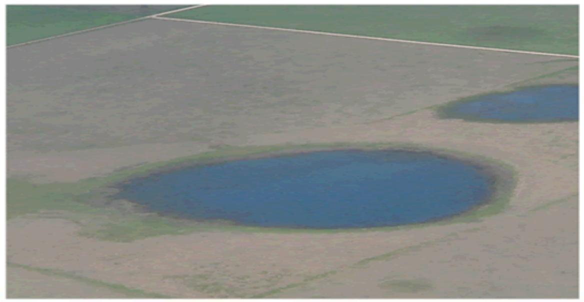
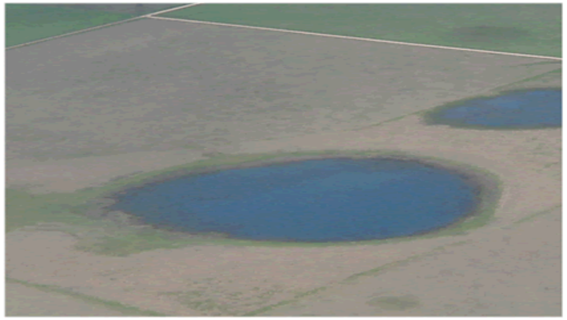
Presentation Overview

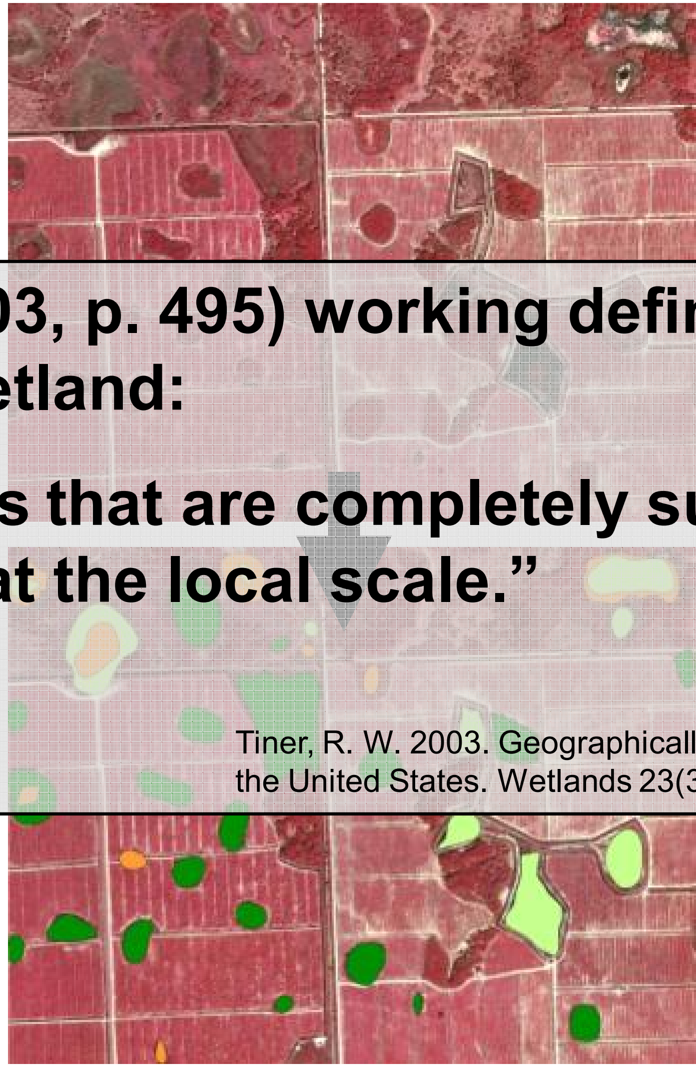
- Geographically Isolated Wetlands
- State of the Science Synthesis Conclusions
- Resource Extent
- Functional Measures
- Challenges & Opportunities





Background: Isolated Wetlands



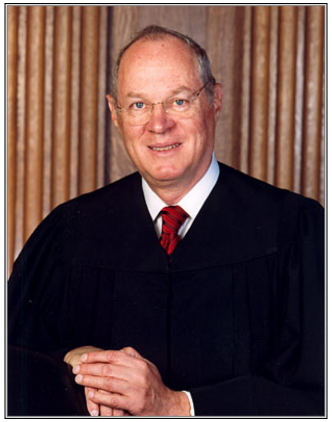


Tiner's (2003, p. 495) working definition of Isolated Wetland:

"…wetlands that are completely surrounded by upland at the local scale."

Tiner, R. W. 2003. Geographically isolated wetlands of the United States. Wetlands 23(3): 494-516

Isolated Wetlands in Context

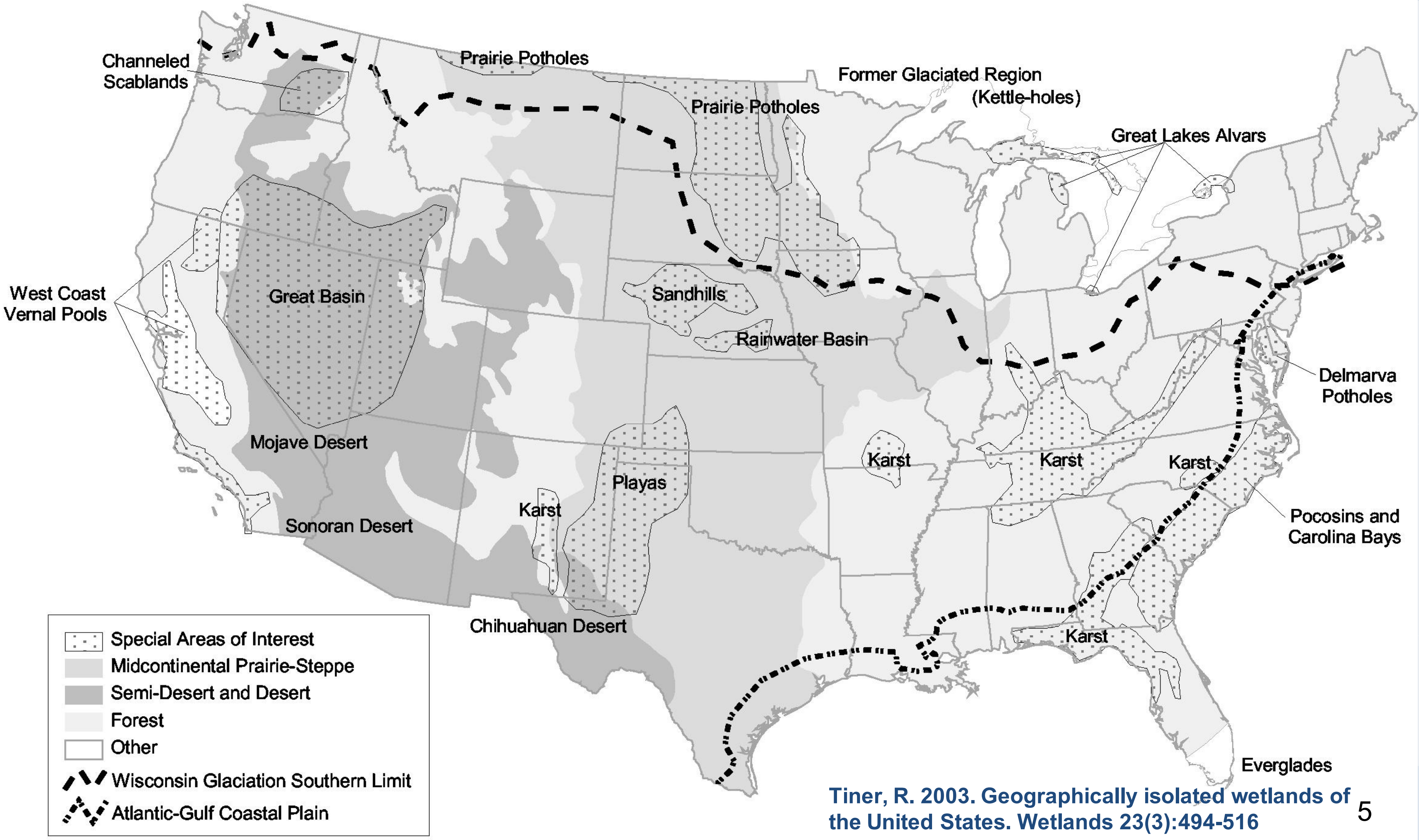


- SWANCC (2001)
- Rapanos (2006)
  - “*Significant nexus*”
  - “[W]etlands possess the requisite [significant] nexus, and thus come within the statutory phrase ‘navigable waters,’ if the wetlands, either alone or in combination with similarly situated lands…**significantly affect the chemical, physical, and biological integrity of other covered waters**”

Likens et al. (2000): <20% wetland area of continental USA geographically isolated (~10 million hectares!)

Comer et al. 2005: 81/276 (29%) wetland types in USA were "geographically isolated"

Isolated Wetlands: Context



Tiner, R. 2003. Geographically isolated wetlands of the United States. Wetlands 23(3):494-516

Synthesis of the Scientific Literature

- ORD conducted DRAFT review and synthesis of scientific literature
- Will inform upcoming joint EPA/Corps rulemaking to clarify Clean Water Act jurisdiction
- Over 1000 peer-reviewed publications reviewed
- In independent Scientific Advisory Board review

Major Draft Conclusions

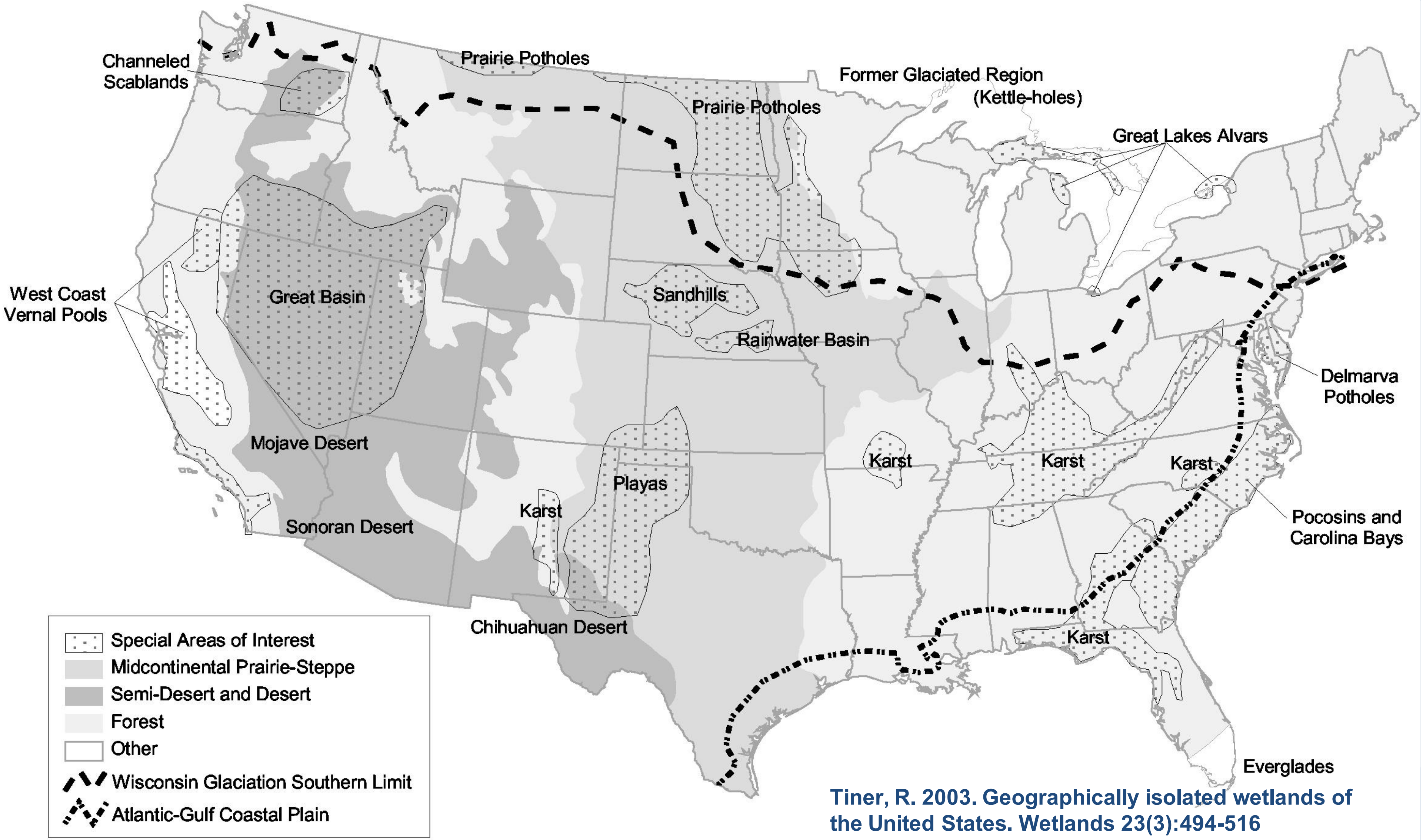
1. Streams, regardless of their size or how frequently they flow, are connected to and have important effects on downstream waters.

2. Wetlands and open-waters in floodplains of streams and rivers and in riparian areas (transition areas between terrestrial and aquatic ecosystems) are integrated with streams and rivers.

Major Draft Conclusions

3. There is insufficient information to generalize about wetlands and open-waters located outside of riparian areas and floodplains and their connectivity to downstream waters.

Geographically Isolated Wetland Extent



Tiner, R. 2003. Geographically isolated wetlands of the United States. Wetlands 23(3):494-516

Research Needs

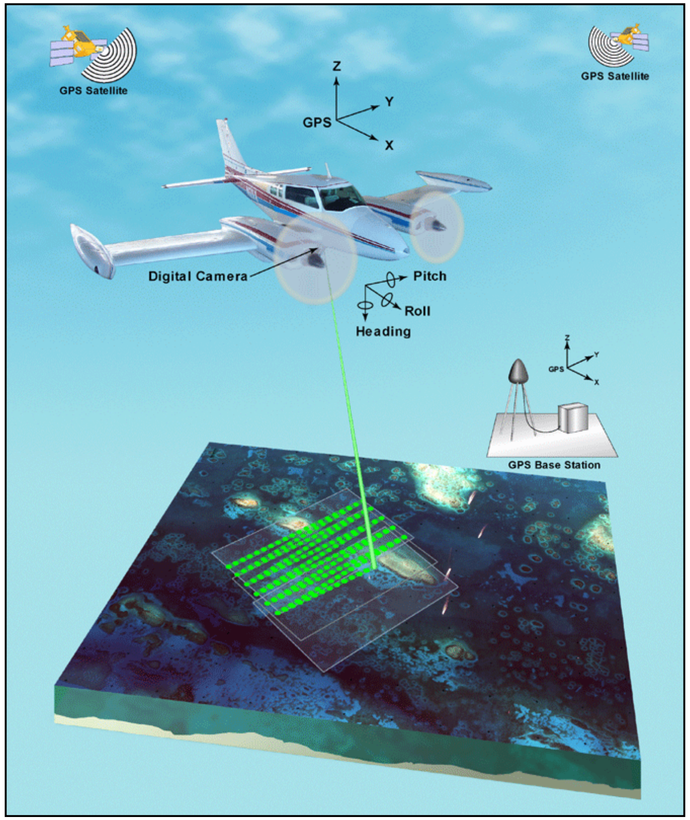
1. Identify the extent of the resource
2. Quantified functional measures of geographically isolated wetlands
   - Biogeochemical
   - Hydrological
   - Biological
3. Connectivity measures of isolated wetlands

Research Approach

1. Identify the resource
   - "…a first step…is to identify the frequency of their occurrence, distribution on the landscape, and characteristics such as size and wetland type." McKinney & Charpentier 2009
2. Quantify the function(s)
   - Hydrological / Biogeochemical / Biological
3. Quantify the effects

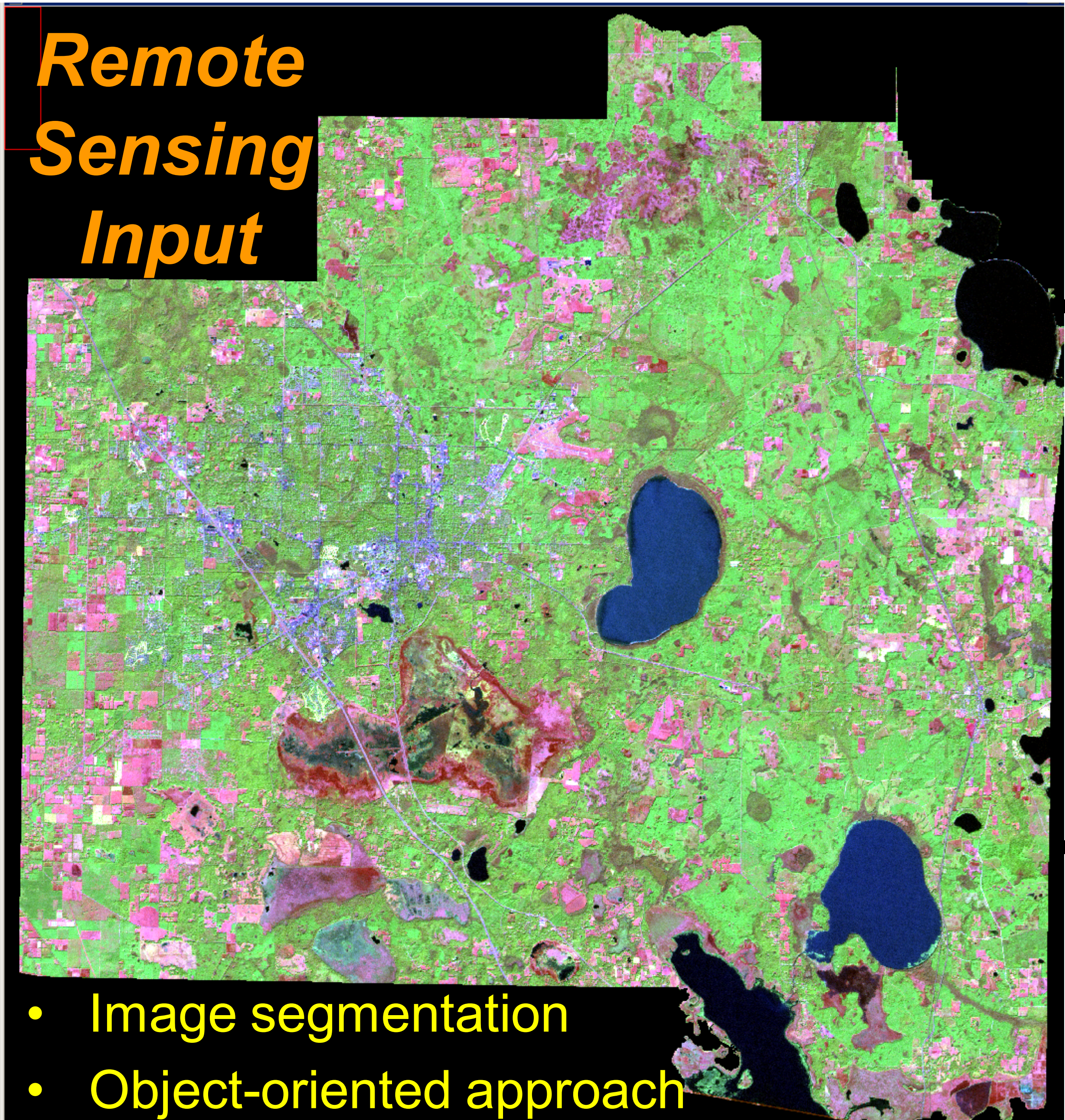
Mapping the Resource

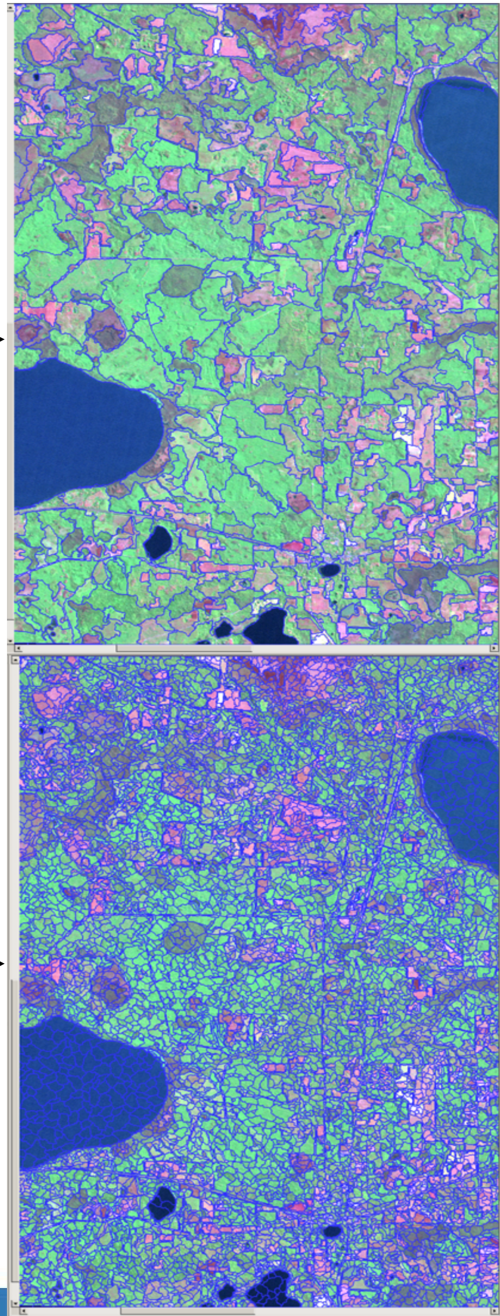
- Remote Sensing Approach
  - Multiple existing and emerging platforms
  - Confounded by scale and mixed pixels
- GIS and Analytical Approach
  - NWI and NHD
  - Confounded by resource age



http://gulfsci.usgs.gov/tampabay/data/1_bathymetry_lidar/images/Eaarl1.gif

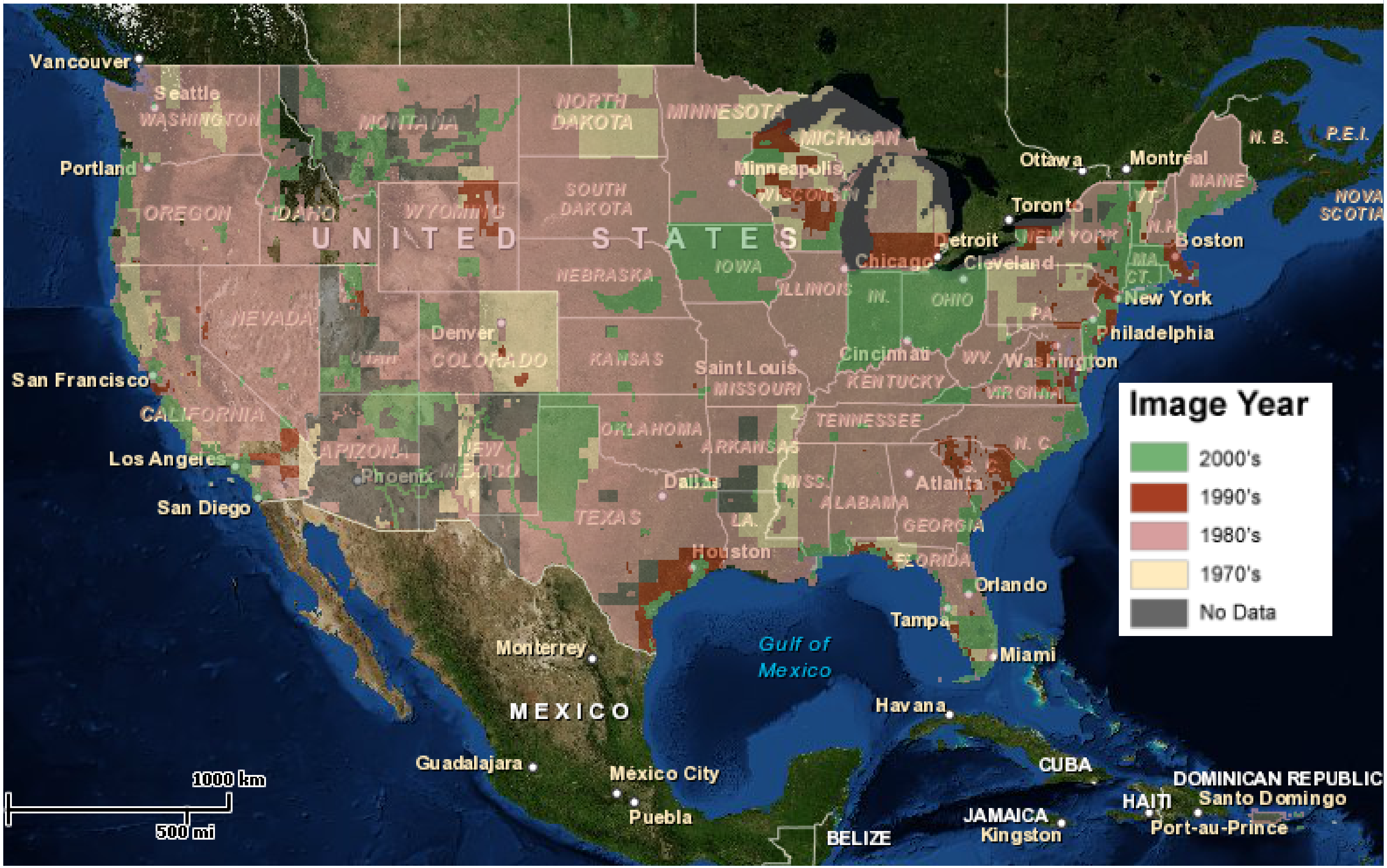
Remote Sensing Input

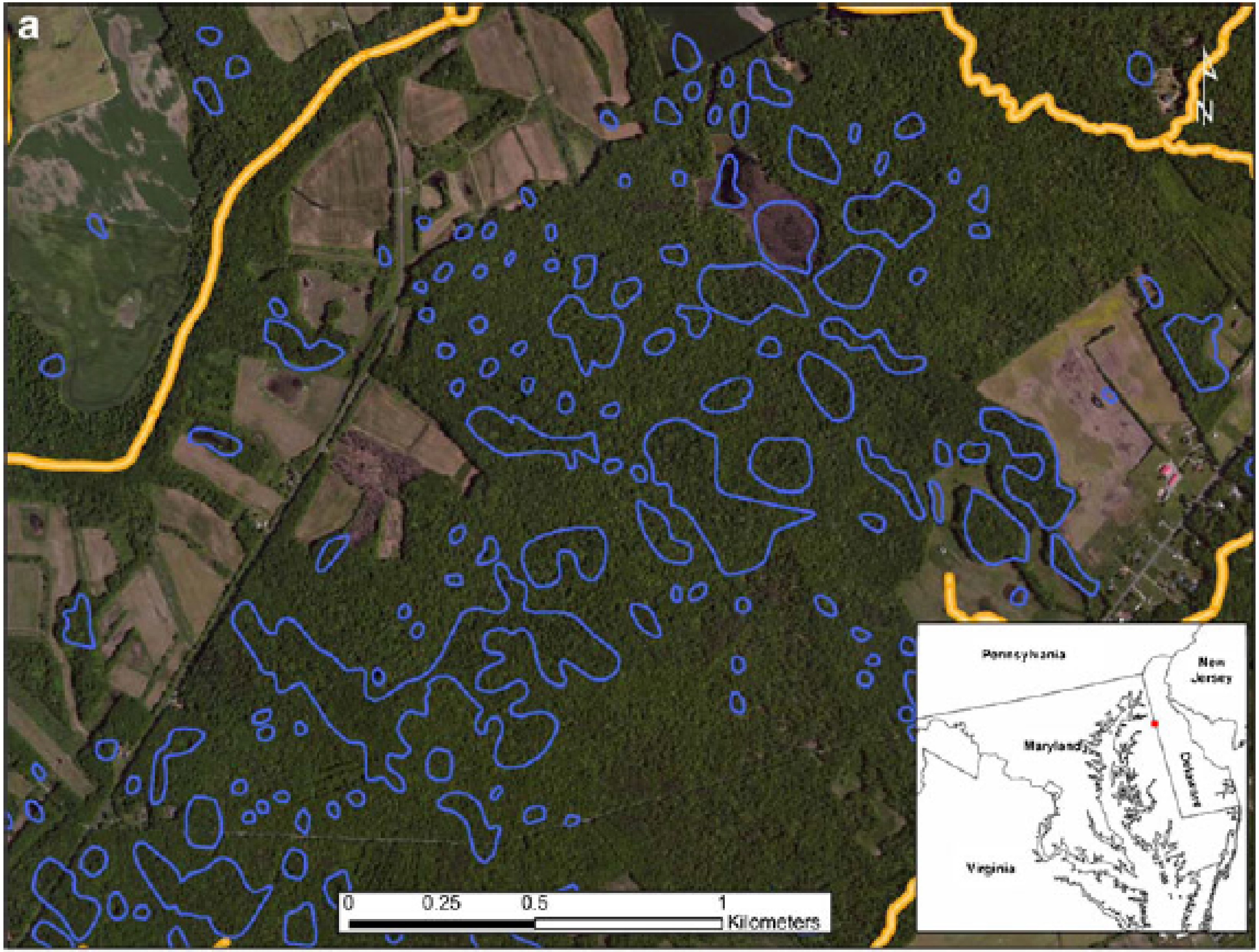




- Image segmentation
- Object-oriented approach

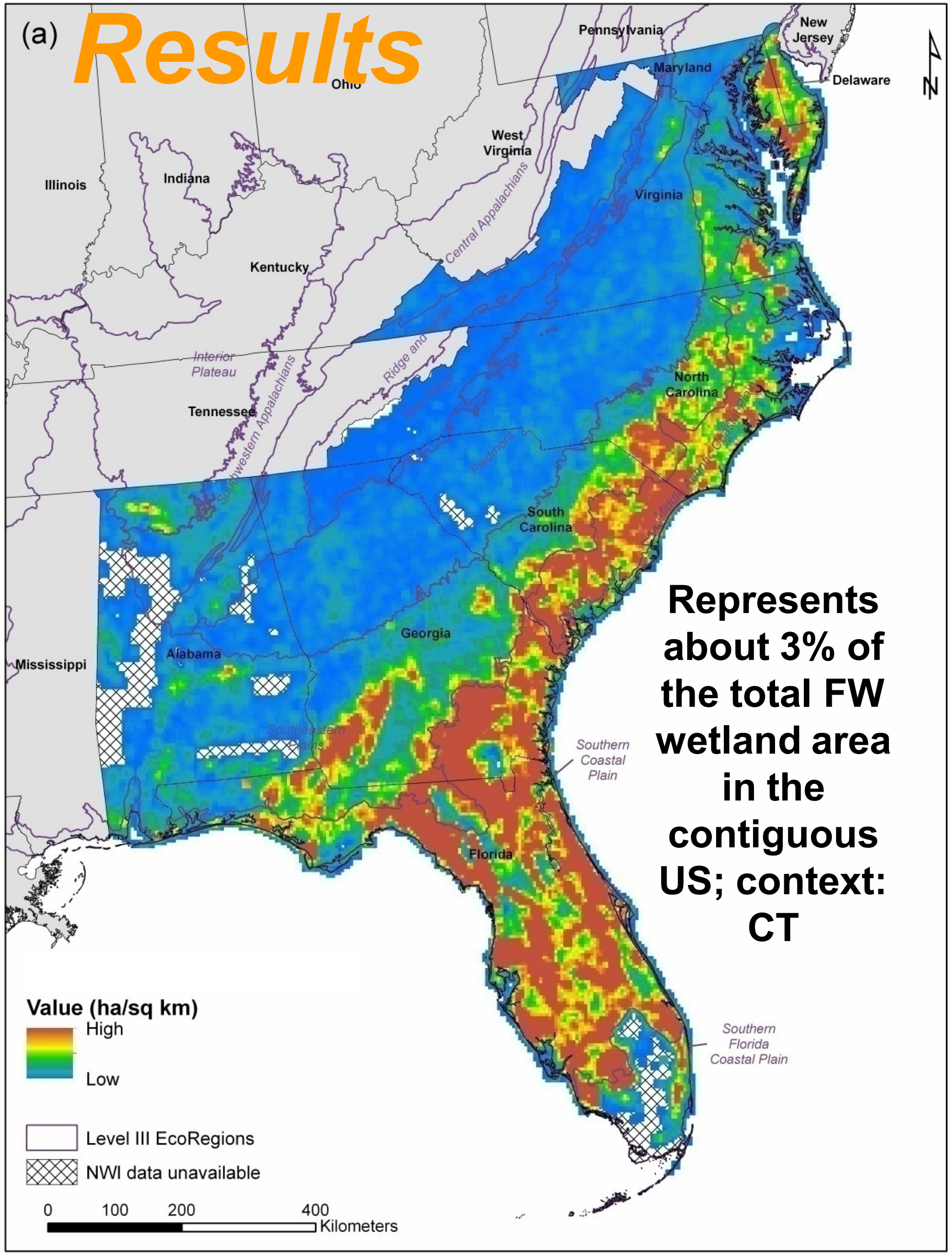
US FWS Wetlands Mapper





Lane et al. Wetlands 32(4): 753-767.

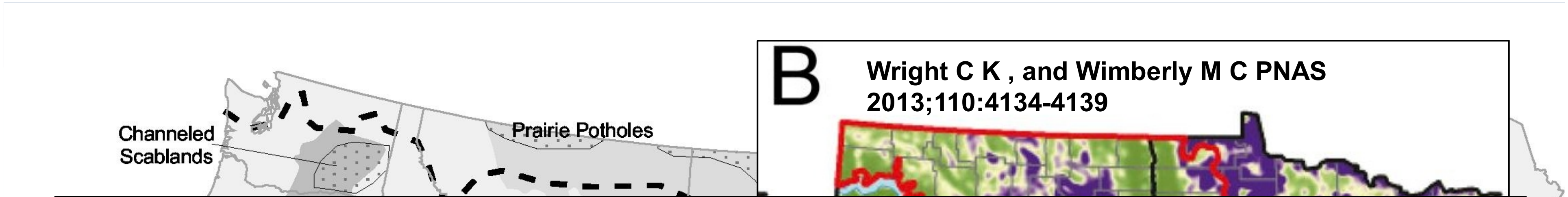
Results

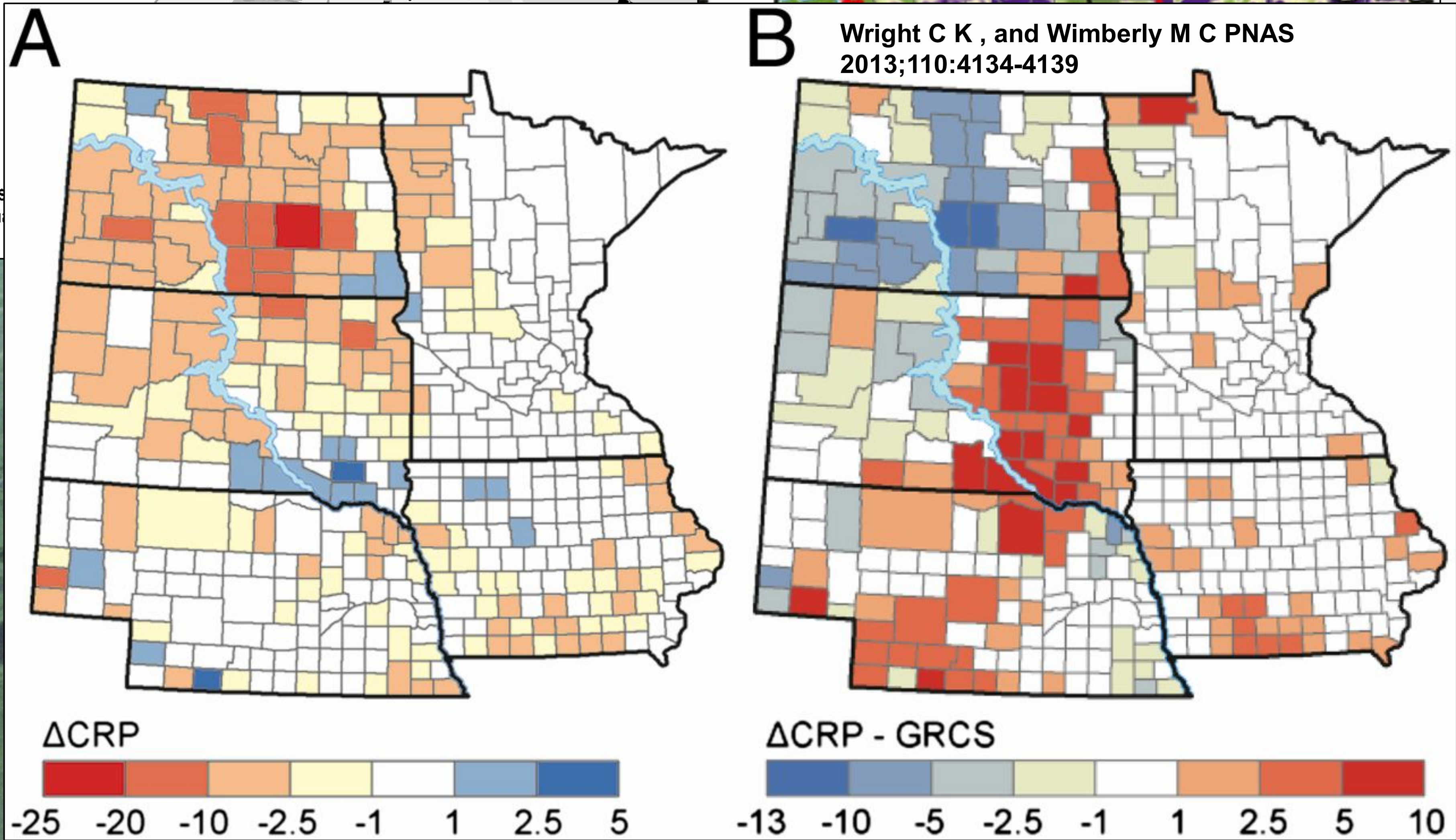


Represents about 3% of the total FW wetland area in the contiguous US; context: CT

State	Count of PIW	Area of PIW (ha)
AL	61068	45500.4
DE	8166	10750.9
FL	317424	535116.8
GA	153526	240974.3
MD	24895	27706.2
NC	76604	126994.3
SC	100413	153279.8
VA	71067	44700.0
Total	813163	1185022.6

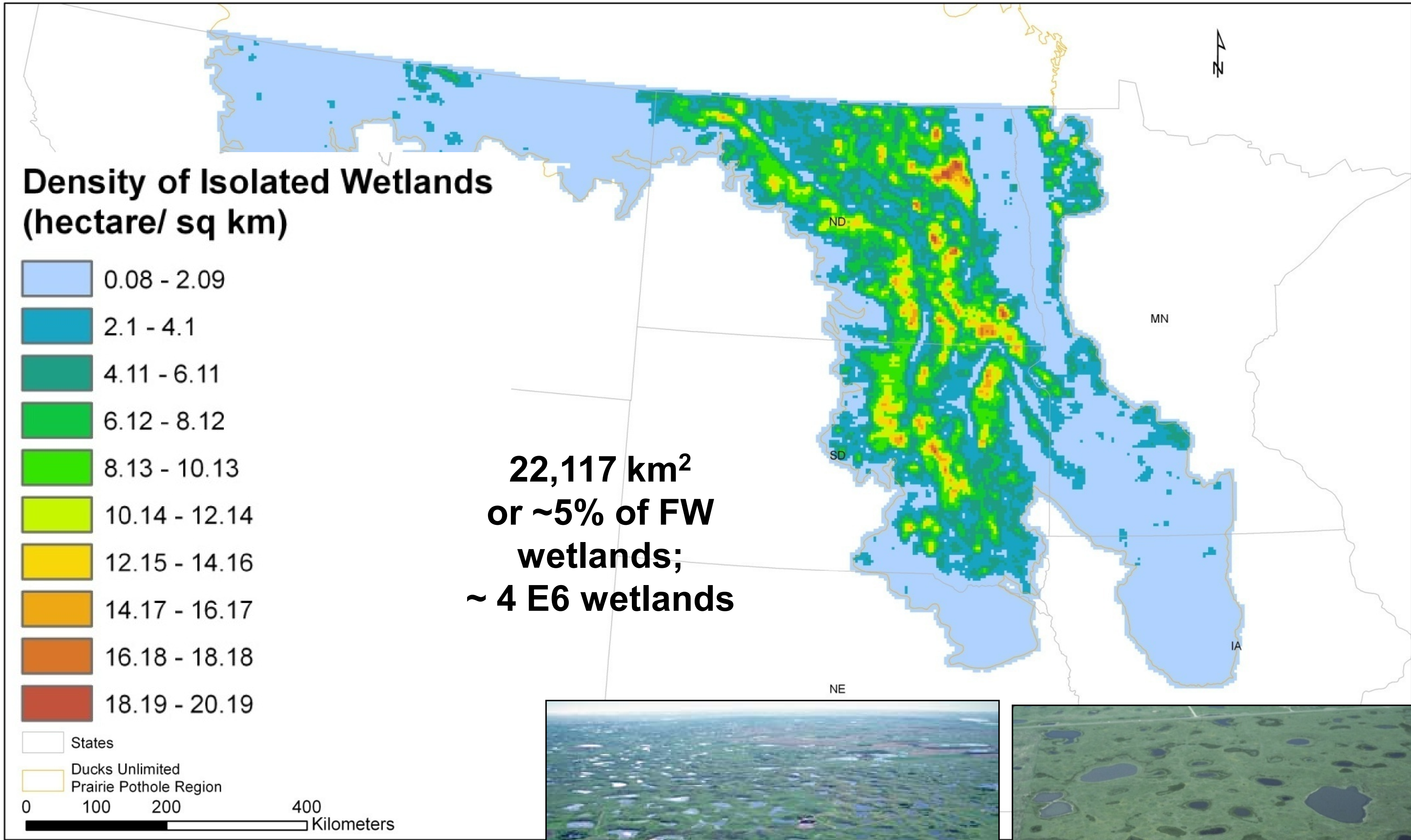
State	PIW % of palustrine area	PIW % of Total Freshwater Habitat	PIW % of Total Wetland Habitat
AL	4.4	3.6	2.1
DE	10.7	9.5	0.9
FL	12.4	11.0	6.6
GA	10.9	9.9	7.1
MD	12.1	10.2	1.2
NC	7.7	6.8	3.2
SC	10.7	9.5	6.2
VA	9.0	6.8	1.3
Total	10.4	9.0	4.4



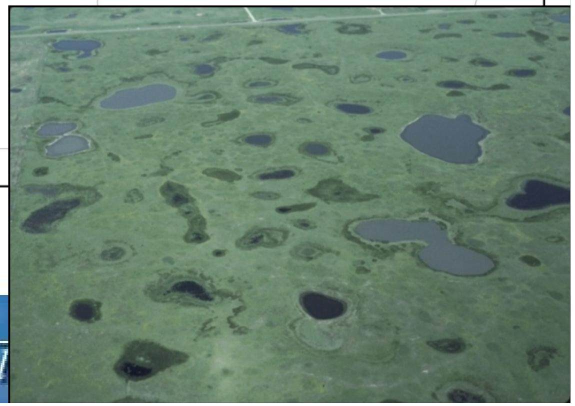


d States. Wetlands 23(3):494-516

mental decisions



22,117 km^2
or ~5% of FW
wetlands;
~ 4 E6 wetlands



http://www.usgcrp.gov/usgcrp/

Research Needs

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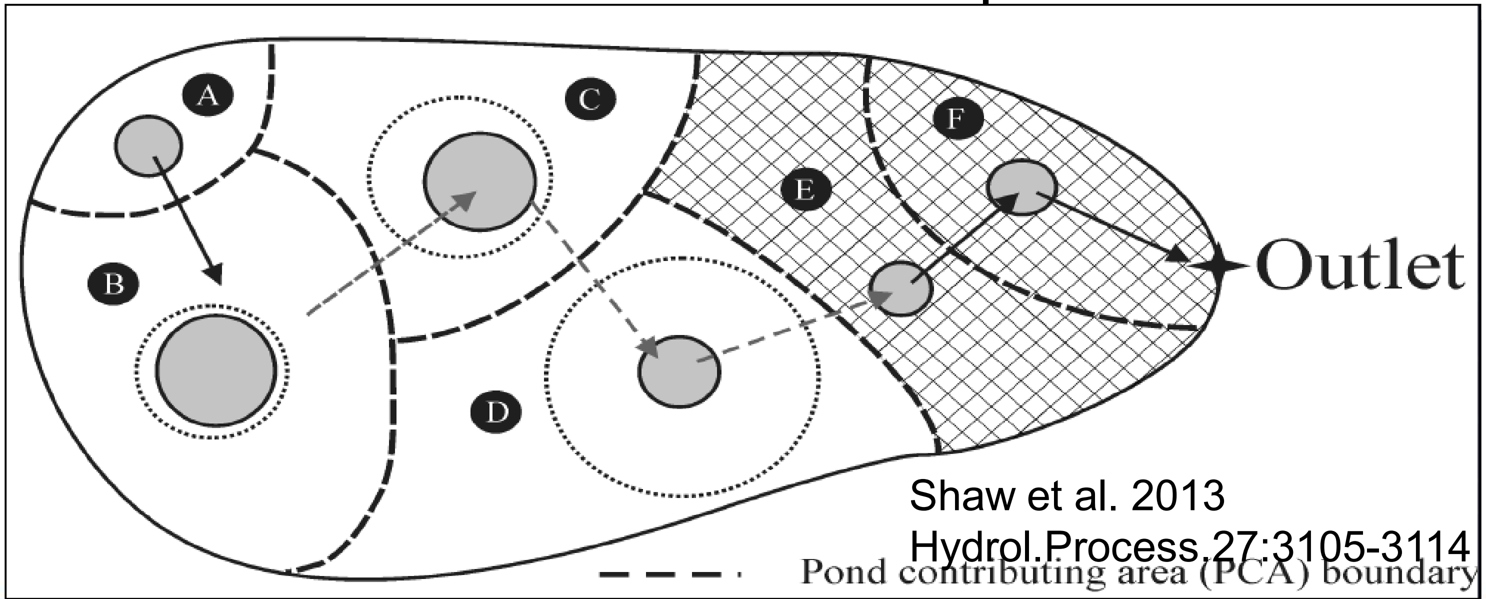
Hydrological Functions of Isolated Wetlands

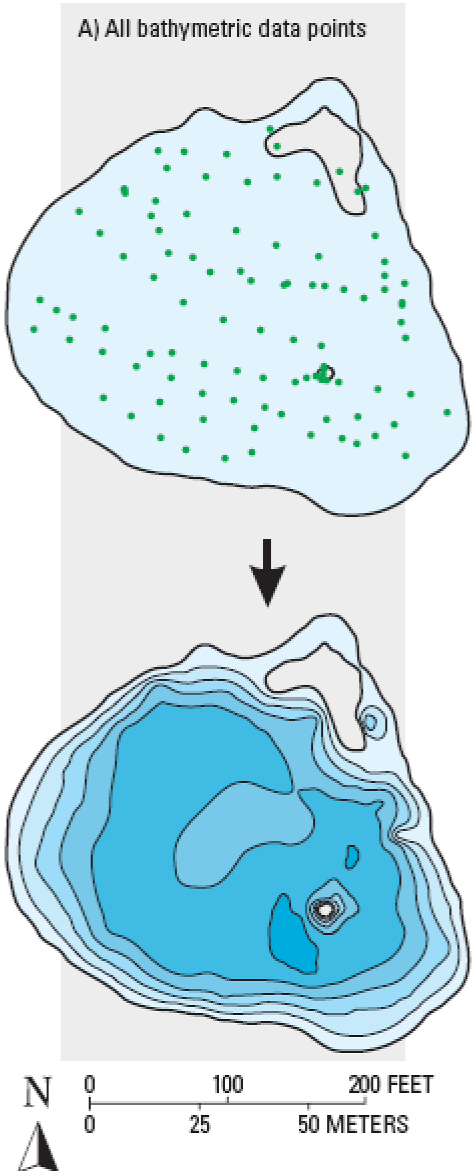
- Hydrology conveys material and energy to other waters
- Isolated wetlands may affect other waters
  - Maintain baseflow & decrease stormflow
  - Modification can short-circuit processes



Shaw et al. 2013
Hydrol.Process.27:3105-3114

Isolated Wetland Hydrology

- Couple monitoring and modeling approaches
  - Wetland-shed
  - Watershed
- Challenge: Quantifying the influence (i.e., signal:noise)
  - Improved parameterization
  - Temporal considerations



Haag et al. 2005

Biogeochemical Functioning in Isolated Wetlands

- Denitrification
- Phosphate sorption
- Mercury methylation & other metals
- Carbon mineralization & processes
- Assimilation of other pollutants

Wetlands (2013) 33:887–894
DOI 10.1007/s13157-013-0447-4

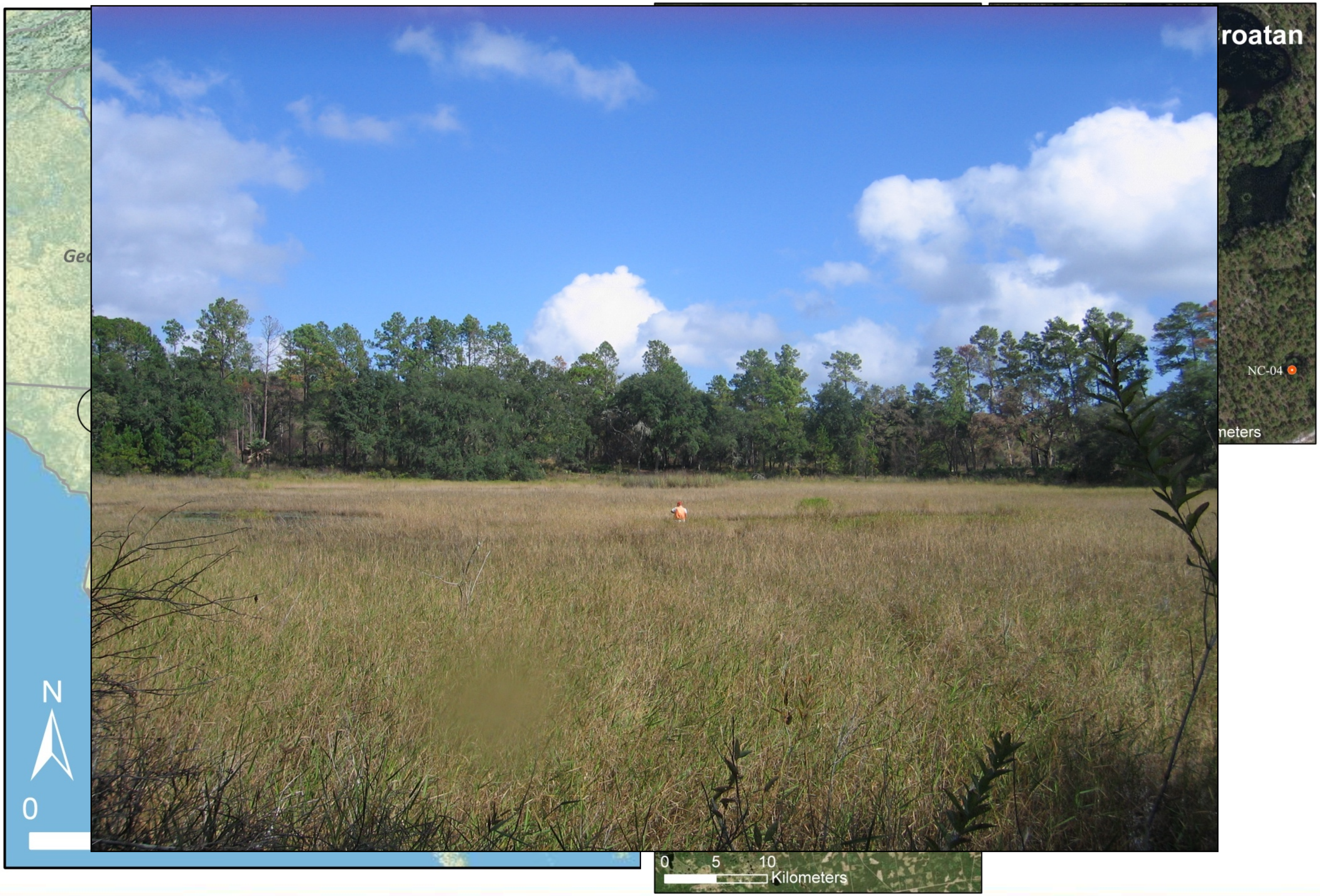
ARTICLE

Seasonal Mercury Dynamics in a New England Vernal Pool

Janina M. Benoit · Deborah A. Cato ·
Katherine C. Denison · Amy E. Moreira

Denitrification Potential in Isolated Wetlands

- Wetlands possess requisite conditions for high rates of denitrification
  - Labile carbon
  - Abundant microbes
  - Anoxic conditions
- Analyzed ambient and amended denitrification rates



roatan
NC-04
N
0
0 5 10
Kilometers

Denitrification Results

- **Ambient:** 6.9 (± 5.0) µg N kg DW^{-1} hr^{-1}
- **N amended:** 188.2 (± 221.7) µg N kg DW^{-1} hr^{-1}
- **C amended:** 5.7 (± 4.2) µg N kg DW^{-1} hr^{-1}
- **N + C amended:** 253.2 (± 272.8) µg N kg DW^{-1} hr^{-1}

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Journal of Environmental Quality TECHNICAL REPORTS
WETLANDS AND AQUATIC PROCESSES

Functional Differences between Natural and Restored Wetlands in the Glaciated Interior Plains

John M. Marton,* M. Siobhan Fennessy, and Christopher B. Craft

We measured soil properties, carbon and nutrient (nitrogen, phosphorus) pools, ambient and potential denitrification, and phosphorus sorption index (PSI) in natural depressional wetlands and depressional wetlands restored through the U.S. Department of Agriculture (USDA) Wetland Reserve Program. We measured the same suite of variables in natural and USDA Conservation Reserve Program–restored riparian buffers and in agricultural fields adjacent to both systems to determine the degree to which ecosystem services are being provided through restoration in different hydrogeomorphic settings. Organic carbon and nutrient pools, PSI, and denitrification were greater in natural than in 5- to 10-yr-old restored depressional wetlands. In riparian soils, carbon and nutrient pools, PSI, and denitrification were comparable between restored and natural systems, suggesting that these services develop quickly after restoration. Restored depressional wetlands had lower soil organic C, N, and P relative to agricultural soils, whereas the opposite trend was observed in restored riparian soils. Four-year-old restored riparian buffers achieved equivalence to natural riparian buffers within 4 yr, whereas restored depressional wetlands took longer to provide these ecosystem services (i.e., PSI, denitrification, C storage) at levels comparable to natural wetlands. Restored depressional wetlands and riparian buffers provide ecosystem services lost through previous conversion to agriculture throughout the Midwest; however, the development of these services depends on hydrodynamics (pulsed versus nonpulsed), parent material, soil texture (sand, clay), and disturbance regime (prescribed fire) of the site. As restoration continues throughout the region, C sequestration and nutrient removal in these systems is expected to increase water quality at the local and regional levels.

Wetlands and riparian buffers provide ecosystem services such as water storage and flood protection, biodiversity support, carbon (C) storage and sequestration, and water quality improvement benefits (Mitsch et al., 2001; Zedler, 2003; Fennessy and Craft, 2011). However, more than half of the wetland area in the United States at the time of European settlement (~90 million ha) has been cleared for agriculture and urban development (Dahl, 2000). Between the 1950s and 1970s, nearly 200,000 ha of wetlands were lost annually. Annual losses slowed between the mid-1980s and mid-1990s to around 24,000 ha each year, primarily due to wetland protection measures such as decreased incentives for wetland drainage and increased wetland restoration and creation (Dahl, 2006). The most recent inventory indicated an overall loss of over 25,000 ha between 2004 and 2009 (Dahl, 2011).

Historically, the agricultural Midwest experienced drastic wetland drainage for conversion to agriculture, with statewide wetland losses of up to 90% between 1780 and 1890 (Dahl, 1990). High agricultural density and loss of wetland ecosystem services in this region has led to increased nutrient and sediment delivery to the Mississippi River, contributing to water quality degradation of downstream water and to hypoxia in the Gulf of Mexico (Goolsby et al., 1999; Rabalais et al., 2002; Zedler, 2003; Fennessy and Craft, 2011). Reintroduction of nutrient and sediment removal, through practices such as changing inflow rates and water retention times (Jordan et al., 2003) or wetland restoration, can provide long-term benefits to local and regional water quality.

The Glaciated Interior Plains (GIP) of the midwestern United States, also known as the Corn Belt, has >1 million wetland conservation projects totaling ~110,000 ha, including wetland restoration, creation, and enhancement through conservation programs initiated under the Farm Bill and programs such as the Wetland Reserve Program (WRP) and Conservation Reserve Program (CRP) through the USDA Natural Resources Conservation Service. These programs are used to restore wetlands and riparian buffers in the agricultural landscape of the GIP and elsewhere (Fennessy and Craft, 2011).

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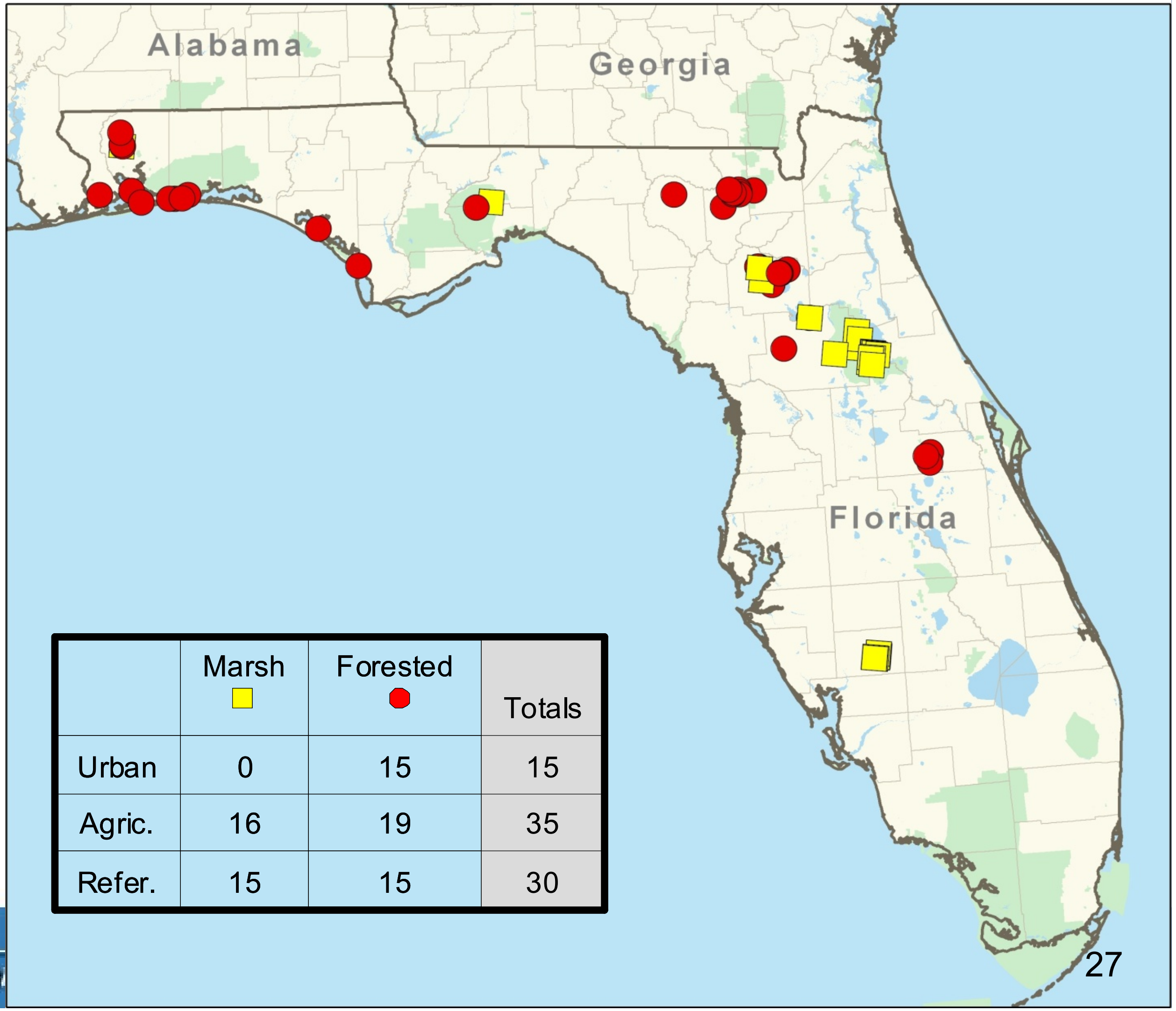
Abbreviations: CRP, Conservation Reserve Program; OM, organic matter; PSI, phosphorus sorption index; SOM, soil organic matter; TNC, The Nature Conservancy; WRP, Wetland Reserve Program.

Phosphorus Sorption

- Sampled 80 sites throughout Florida
- Isolated wetland soils provide pollutant sorption sites (clays, organic matter, Fe/Al/Ca oxides)



	Marsh (yellow square)	Forested (red circle)	Totals
Urban	0	15	15
Agric.	16	19	35
Refer.	15	15	30

Sorption Capacity

- Phosphorus:
  - Equilibrium Phosphorus Concentration (EPC_0): a measure of wetland capacity to act as source/sink for P (Reddy and DeLaune 2008).
  - Differences between wetland classes (i.e., forested or emergent marsh)
    - PFO: EPC_0 910.7 µg/L ± 775.9
    - PEM: EPC_0 482.0 µg/L ± 532.5



Research Needs:

1. Identify the resource
   - "…a first step…is to identify the frequency of their occurrence, distribution on the landscape, and characteristics such as size and wetland type." McKinney & Charpentier 2009
2. Quantify the function(s)
   - Hydrological / Biogeochemical / Biological
3. Quantify the effects

Conclusions

- Better understanding the influence of geographically isolated wetlands on other systems
  - Location, setting, extent
  - Functional Quantification
    - Hydrological
    - Biogeochemical
- Challenging
  - Type, hydroperiod, hydropattern
  - Spatial location, size, shape

Acknowledgements: EPA ORD Terri Jicha, Colleen Elonen, Lindsey Seifert

The views represented here are my own and do not necessarily represent those of the US Environmental Protection Agency.

Charles Lane, US EPA/ORD

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