Application of GIS and Statistical Tools for Identifying and Assessing Isolated Wetlands on the Southeast Coastal Plain

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1. Background and Purpose

The Southeast Isolated Wetland Assessment (SEIWA) explored the extent, condition, and significance of the isolated wetland (IW) resource in an 8-county portion of the coastal plain of North and South Carolina. IWs are wetlands that have no surface connection to downstream waters via a stream, ditch, or continuous wetlands. SEIWA, funded by a U.S. EPA REMAP grant, was conducted because of

- Court decisions on the lack of surface connectivity to navigable waters leading to varying degrees of regulatory protection for IWs in NC, SC, and elsewhere (Dorney et al., 2012),
- The need for scientifically based estimates of IW extent to understand how SWANCC and other court decisions may affect wetland resources (Liebowitz and Nadeau, 2003),
- Recent increases in development pressure on wetlands along the southern Atlantic coast, and
- Little study of IW extent, condition, and function on the southeast coastal plain.

2. Study Area – Southeast Atlantic Coastal Plain (NC and SC)

Eight counties (approximately 6,500 mi²) in North and South Carolina were selected due to:

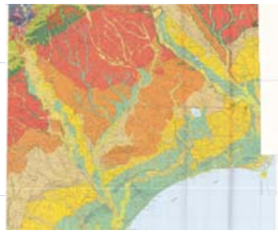
(1) Numerous wetlands, with many unidentified IWs (Tiner et al., 2002; Comer et al., 2005) ;

(2) Direct applicability to regulatory programs in two states;

(3) Common issues, geology, biology = extensible methodologies for Region 4;

(4) Sharp development gradient: coastal counties with rapid development and inland rurall counties with little or no growth but active land conversion for silviculture and agriculture;

(5) Large enough area to have a large number of IWs, yet small enough to be accessible.



Geology: IWs mainly occur as depressions on elevated marine terraces in study area.

3. Study Methods - Overview

SEIWA combined a statistical sampling design with remote (Level 1) and field (Level 2 and Level 3) wetland assessment methods to estimate, with a known degree of certainty, the extent, condition, and relative function of IWs in the NC and SC study area.

Level 1 - Geodatabase evaluation defines initial population frame of candidate IW polygons.

Probabilistic sampling frame randomly selects Level 1 candidate IWs for Level 2 field work. - - *Stratified random sample ensures extensible results.*

Level 2 rapid field assessments verify IWs and determine their size, condition, and stressors*.

Level 3 intensive assessments of selected IWs develop detailed methods*.

Level 1: Landscape Assessment and Sampling Design

- Review existing geospatial data and define criteria for identifying IWs.
- Define sampling unit and construct sample frame for predictive mapping tool.
- Develop probabilistic sampling design and predictive mapping tool.

Level 2: Ground-truthing & Rapid Assessment

- Conduct site visits to determine accuracy of mapping tool (isolated. not isolated and why, historical isolation status).
- Evaluate the wetland's relative functioning and condition with rapid assessments (NCWAM and ORAM).
- Collect soil samples.
- Determine storage capacity and average and/or deepest depth.

Level 3: Intensive Assessment

- Conduct quantitative field sampling to determine pollution absorption capacity and hydrological connectivity of clusters of isolated wetlands in the landscape.
- Characterize amphibians, aquatic macroinvertebrates and plant communities of typical examples of isolated wetlands in the study area

3. Study Methods - Level 1 GIS

The GIS process started with deriving topographic depressions (or sinks) from LIDAR (5m) or hypsography (30m) elevation data using an ArcGIS fill algorithm (Gritzner, 2006); resulting sink rasters were converted to vector polygons.

Sinks directly connected to water bodies, in developed areas, and in floodplains were removed as connected – the remaining sinks represent candidate IW polygons which defined the sampling frame.

Wetland likelihood was scored by overlaying sinks with available wetland and soil data layers.

- Wetland layers included NC CREWS (most NC counties), NWI (SC Counties), and "blackspots" feature-extracted from from State DOQQ infrared imagery; correlated features are more likely to be wetlands.
- Soils were extracted from SSURGO - wetlands are more likely to be found on hydric soils and soils subject to ponding, and are less likely to be isolated on riverine soils in a floodplain.

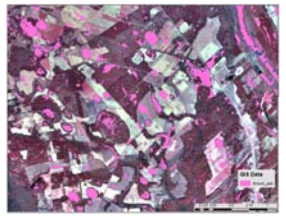
Wetland connectivity was scored based on hydrologic layers and floodplains (for proximity to waterbodies) and roads and agricultural landcover (for ditching).

- Floodplain maps were used as a filter (i.e., no IWs on floodplains)
- Hydrologic layers included NHD (1:24k) and elevation-derived hydrography; waterbodies were buffered to 10 meters to determine and remove connected sinks.
- For ditching likelihood we used NLCD 2001 landcover data for "Open Field" classes (cultivated, herbaceous/ grassland, pasture/hay) and road data from state DOTs.

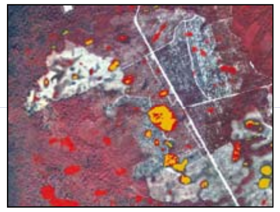
After filtering for bogus polygons and masking for floodplains, connected waterbodies, and development, remaining candidate IW polygons were each scored for every criteria from 1 to 10, with 10 being more likely to be an IW.

- For example, a candidate IW polygon on "all-hydric" soil would get a 10, "partially hydric" would get a 5, and not hydric would score a 1.
- Scores were grouped and totaled to estimate overall IW likelihood per candidate IW polygon. (Score groupings included the likelihood of a feature being a wetland, having ditching connectivity, or having water-drainage connectivity).
- Overall scores were ranked to classify each candidate IW polygon as having a low, medium, or high likelihood of being an IW.

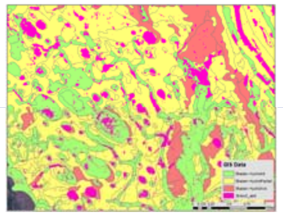
Level 1 result: Over 130,000 scored candidate IW polygons as sample frame for Level 1 field verification and Level 2 assessments.



Sinks derived from 5m LIDAR data

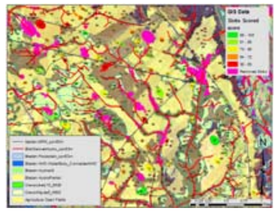


Wetland "Blackspots" (orange) correlated with sinks (red)



Hydric Soils (green-yellow-pink) shown with sinks (magenta)

Agricultural landcover and roads for likely ditching connectivity



Total score derived from geospatial relationship with GIS layers

3. Study Methods - Statistical Sample Design

A stratified, two-stage sampling design was developed to randomly select candidate IW polygons for Level 2 field visits to confirm identification and assess condition and function.

- *Stage 1*: Study area was stratified by counties, candidate IW polygons were clustered by 14-digit HUCs, and HUCs were selected with probability proportional to count of polygons in each. 7 to 8 HUCs were selected per county, depending on sample size.
- *Stage 2*: Within each HUC, IW polygons were stratified by low, medium, and high IW likelihood from the Level 1 analysis and IW polygons were selected at random within each stratum for the Level 2 field assessments. The number of selected sites per HUC varied from 3 to 5 and was allocated as 50% to high, 25% to medium, and 25% to low IW likelihood. Final sample: ~90 sites per state, ~21 sites per county .

The stratified random sample design enabled Level 2 results to be extended across counties, states, and the entire study area. 93% of the selected sites were accessible.

4. Results – Level 1 Method Accuracy

- Elevation data resolution made a great difference in the number and area of delineated sinks; the 30m hypsography data used in 3 SC counties produced 22 to 27 sinks/mi² while the 4–5m LiDAR data produced 322 to over 1,500 sinks/mi².
- Masking reduced the number of candidate IW sinks by about 10-fold in most counties
- Overall only 22% of the candidate IW polygons predicted to be IWs were IWs, but 69% were correctly predicted to be wetlands. Also, 75% of the medium or low likelihood polygons were correctly predicted to be non-IWs.
- For NC 35% of the candidate IW polygons were correctly predicted to be IWs, suggesting that using LiDAR data improves accuracy. However, the LiDAR data often missed the small drainage structures found to connect many potential IW features.

GIS methods based on LiDAR data are useful in finding potential IWs, but field work is needed to confirm whether the wetland is connected or isolated.

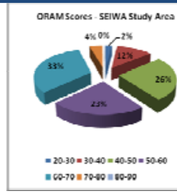
4. Results – Isolated Wetland Numbers, Extent, Size, and Type

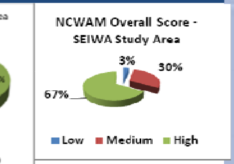
IWs are numerous, small, and spread across the study area.

- Overall the study area contains about 52,000 IWs, with 22,000 in SC and 30,000 in NC, and a total acreage of about 30,000 acres. Average density is about 8 IWs per square mile. 99% of the IWs occur on the marine terraces that define the area's geomorphology.
- IWs are generally small with a median size of 0.41 acres and a range from 0.002 to 21 acres. Large isolated wetlands appear to be rare because as size increases they are more likely to be connected. IWs are smaller in coastal (0.38 acres) than in inland counties (1.5 acres), perhaps reflecting development density.
- Most IWs are small forested/shrub ecosystems in shallow depressions on the uplifted costal plain marine terraces, and are mainly 3 general types: forested flats (50%), forested ponds (33%), and small pocosins (16%) [*see Poster 370 for details by state]*.

4. Results – Isolated Wetland Condition and Hydrology

- About 90% of IWs are in fairly good condition, with medium to high ORAM scores; NC WAM relative function scores were medium to high for hydrology, water quality, and habitat.
- IWs in the study area can store 3,900 or more acre-feet of water, and flow to downgradient waterbodies through surficial aquifers [*see posters 245, 246, and 232 for related hydrology studies*]

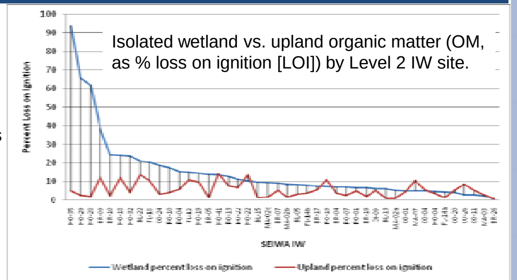




SEIWA Ohio Rapid Assessment Method (ORAM) condition scores and North Carolina Wetland Assessment Method (NCWAM) function scores

4. Results – Carbon Sequestration Estimates

- Because some IWs contain peat, the average IW soil carbon content is over 190 tons/acre (almost 430 Mg/hectare)[1], intermediate between non-peat wetlands and peatlands.
- We estimate that IW soils in the study area contain over 5.2 million metric tons of organic carbon[1]. IWs with peat (with up to 92% LOI) sequester significant amounts of fossil carbon.



[1] Assumptions include (1) % LOI = % OM; (2) soil OM decreases with depth exponentially, and (3) 58% of soil OM is carbon.

5. Discussion and Conclusions

The SEIWA project applied geospatial, statistical, and field methods to successfully characterize and assess the condition of a previous uncharacterized IW resource on the southeast Atlantic coastal plain. In addition to identifying and showing how to overcome challenges and data limitations in remote wetlands assessment, the Level 1 and Level 2 SEIWA effort provided valuable, quantitative information about IWs that can be extended to other areas in the southeast U.S. and beyond.

The Level 3 SEIWA effort , which was limited to a few sites in this study, has been extended through separate grants to a greater number of sites. These efforts are providing a more in-depth understanding of IWs in the study area, including a detailed habitat assessment and evidence that many of these IW features are hydrologically connected through surficial aquifers to navigable waters [*see Posters 232, 245, 246*].

The SEIWA project continues to be relevant to the regulation and protection of IWs in NC and especially SC, where there is a perennial interest in IWs and their regulation; for example, recent legislation has called for an inventory of IWs in SC.

References

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**For detailed discussions of Level 3 activities see related posters: 379 (V. Baker), 245 (D. Tufford), 246 (A. Keyworth), and 232 (R. Vander Vorste).*

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