Survey methodology for assessing geographically isolated wetlands map accuracy

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RTI INTERNATIONAL

Objectives

- To create a GIS Isolated Wetland prediction map using existing geodatabases
- To design and implement a sampling design that applied to the Study Area will serve as a foundation for precise and reliable assessment of map accuracy
  - Field visits to selected sites to ground truth readings from prediction map
- Produce design- based accuracy assessment estimates to evaluate the GIS Isolated Wetland map accuracy

Isolated Wetlands

- Wetlands that have no surface water connection to downstream waters are usually called Isolated Wetlands (IW) by the U.S. Army Corps of Engineers (USACE)
- They are often small which has resulted in less attention on understanding their ecological and environmental functions in space and time.

Isolated Wetlands

- Isolated wetlands are prominent ecological features of landscapes on the U.S. Southeastern Coastal Plain, covering up to 30% of the land area in some coastal counties of North and South Carolina (Tiner et al.,2002)

Isolated Wetlands

- Tiner (1984) and Dahl (1990) estimated that 50% to 55% of the original wetland area in the conterminous United States has been lost since pre-settlement times.
- This loss has not ceased, and some 15% of current wetlands are estimated to be in a state of transition to other land uses (Moorhead and Cook, 1992).

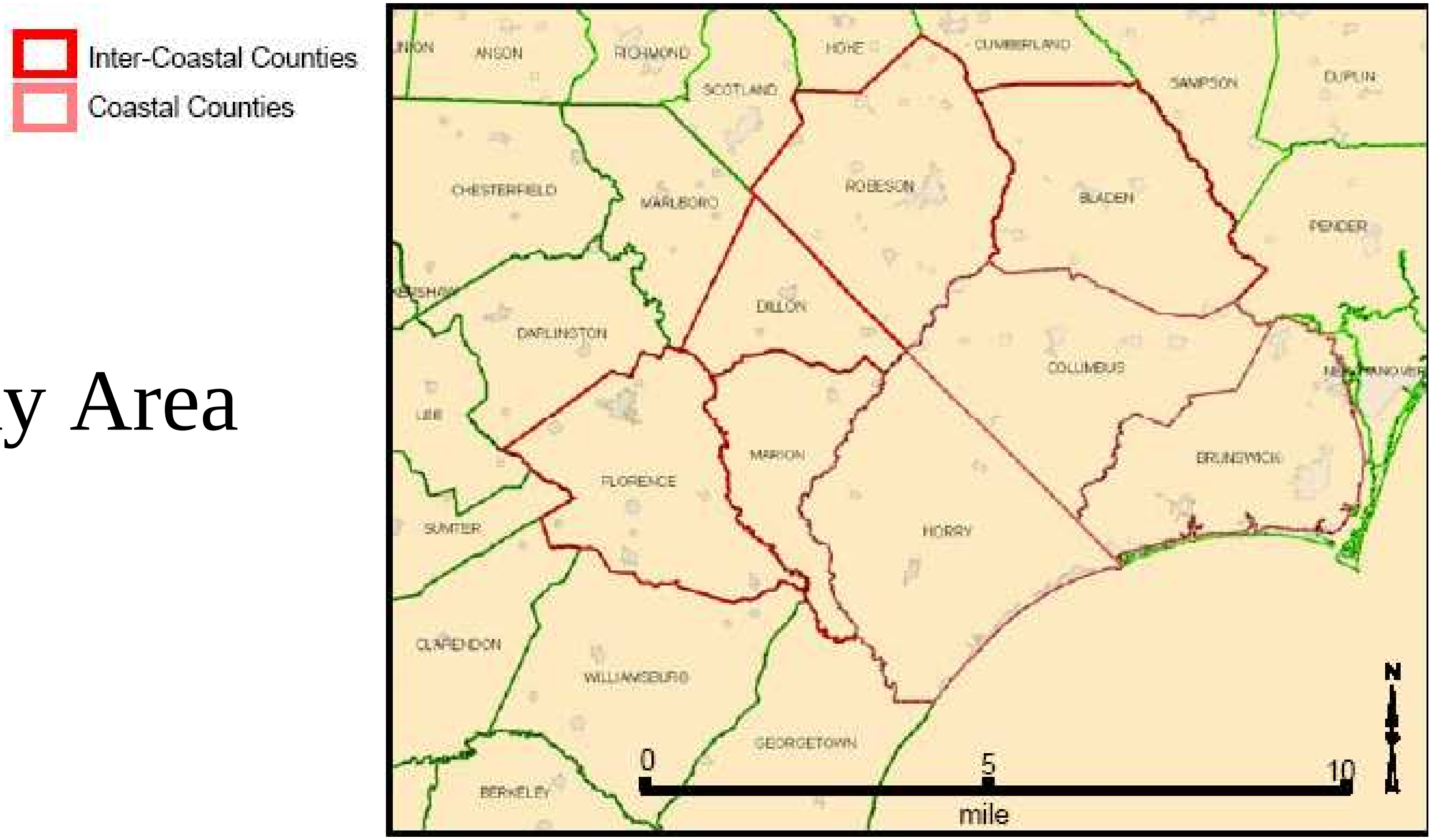
Isolated Wetlands

- Isolated Wetlands (IW) provide significant environmental benefits: assimilation of pollutants, flood water storage, ground water recharge, and fish and wildlife habitat.
- They are more vulnerable to losses from urbanization and agriculture because they are geographically isolated and have varying amounts of regulatory protection.

Isolated Wetlands

- IW occupy 15% and 24% of North Carolina and South Carolina landscapes (Hefner et al.,1994), respectively.
- In addition, 27% and 29% of the wetland system in North Carolina and South Carolina, respectively, are considered to be isolated wetlands (Comer et al., 2005; Dahl, 2000).
- The richest variety of isolated wetlands found in North and South Carolina includes Carolina bays, limesinks, pocosins, gum ponds, cypress domes, oxbows, and forested depressions.

Study Area



The Study Area consists of eight counties in North and South Carolina. Two counties (Brunswick County, NC, and Horry County, SC) are coastal counties, and the remaining six counties (three in each state) are inter-coastal counties

Isolated Wetlands Map

- Currently, there is not a dependable method to accurately map IW:
  - Sending field scientists into the field to perform surveys, or
  - requiring that image technicians perform heads-up digitizing from vast archives of aerial photography.
- A GIS approach is a cost effective solution.

Challenges in Creating IW GIS Map Model

- Resolution of most satellite imagery used in previous landcover classification projects may not capture the small areas covered by IW.
- High-resolution imagery, such as aerial photography, contains far too much detail to use traditional landcover classification methods.
- The vegetation and cover of IW vary so much that we anticipate that multiple layers of GIS data may be needed (e.g. Carolina Bays have several cover types that include water, agriculture, and many types of vegetation.)

Construction of the GIS IW map

- Specialists on wetlands will identify the relevant physical, hydrologic, and biological criteria to categorize a land area as an isolated wetland.
- There are a variety of different types of coastal and inter-coastal IW:
  - e.g. Carolina bays, floodplain and sinkhole depressions, drained ponds, vernal pools, dune swales, and deflation plain wetlands
- Although many of these types may have common characteristics (e.g., hydric soils), other characteristics, e.g. spatial extent, may be quite different.

Construction of the GIS IW map

- GIS and image analysts will work with the wetlands specialists to identify the existing geospatial data layers that best meet these criteria
  - land-cover coverages
  - soils
  - elevation data
  - water data
  - the National Wetland Inventory (NWI)
  - delineation maps from environmental consultants
- The result will be a polygon data layer identifying the predicted location and extent of isolated wetlands.

Construction of the GIS IW map

- Several strata within the Study Area will emerge, ranging from areas where IW are very unlikely to be found (e.g., in a floodplain), to areas where IW are very likely to be present.
- Intermediate areas of IW potential are also expected where most, but not all, operational criteria are met.
- Different GIS IW mapping tools may be created for each stratum of the Study Area.

Sampling Units

- Well-defined sampling units (e.g., a polygon of specified minimum size, quadrangle, pixel, etc.) will be proposed to best characterize the spatial characteristics of the IWs
- For example, pixels (the smallest identifiable unit on the map) or small-size polygons may constitute an appropriate sampling unit for selecting very small IW types, such as vernal pools, which range in size from small puddles to shallow lakes.
- For areas in the study regions where larger IW are located (e.g., pocosins, which range in size from less than 1 acre to several thousand acres), a larger sampling unit may be considered.

Sampling Design

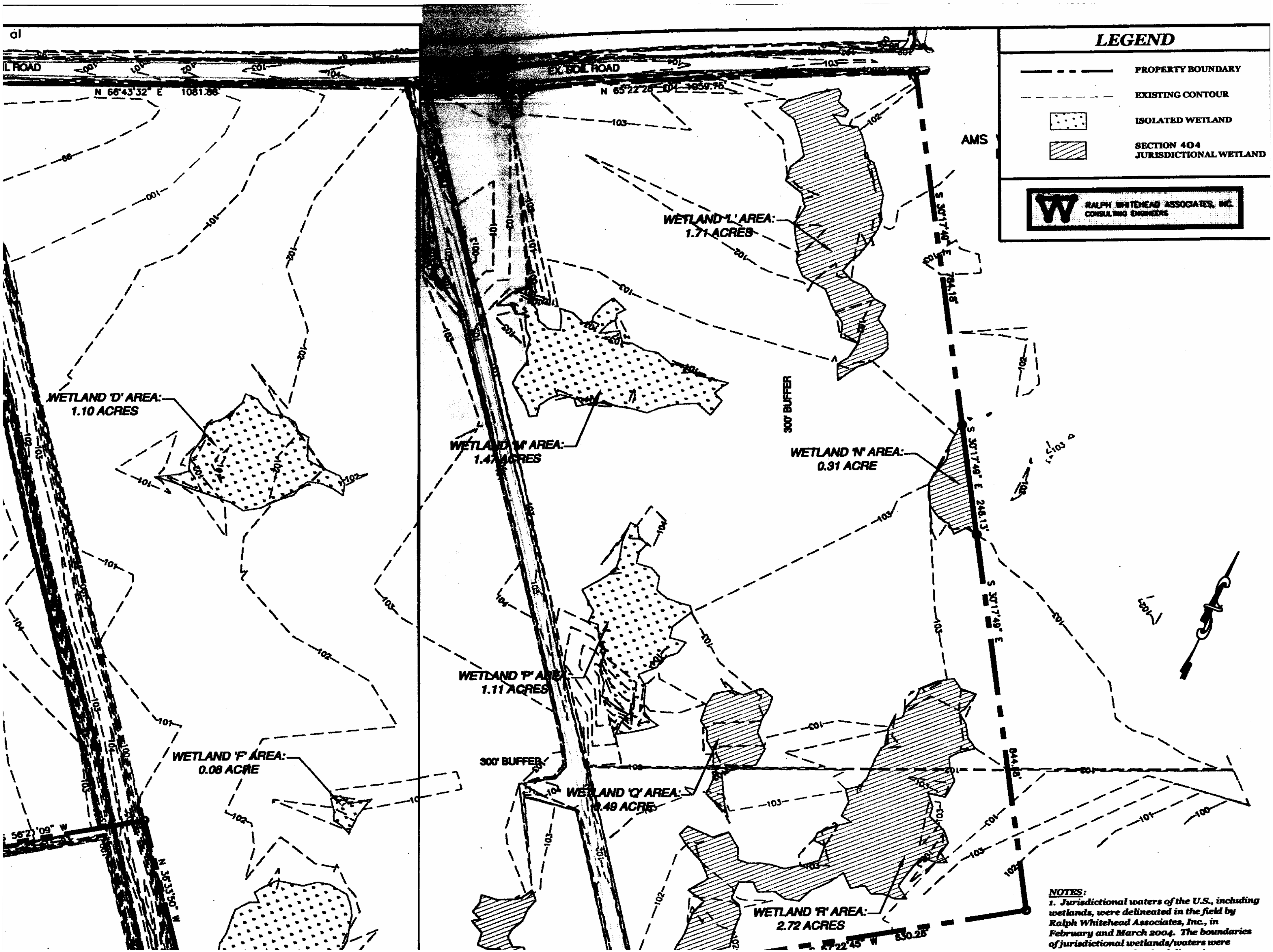
- Stratification and Sampling intensity:
  - reducing (but not entirely eliminating) the effort in IW unlikely areas
  - Intensifying in those areas where isolated wetlands are most likely to exist.
- Because available map resolution may not capture all the existing IW, we will define separate strata containing those areas not capturing IW and those areas where expert opinion suggests IW may exist.

Sampling Design

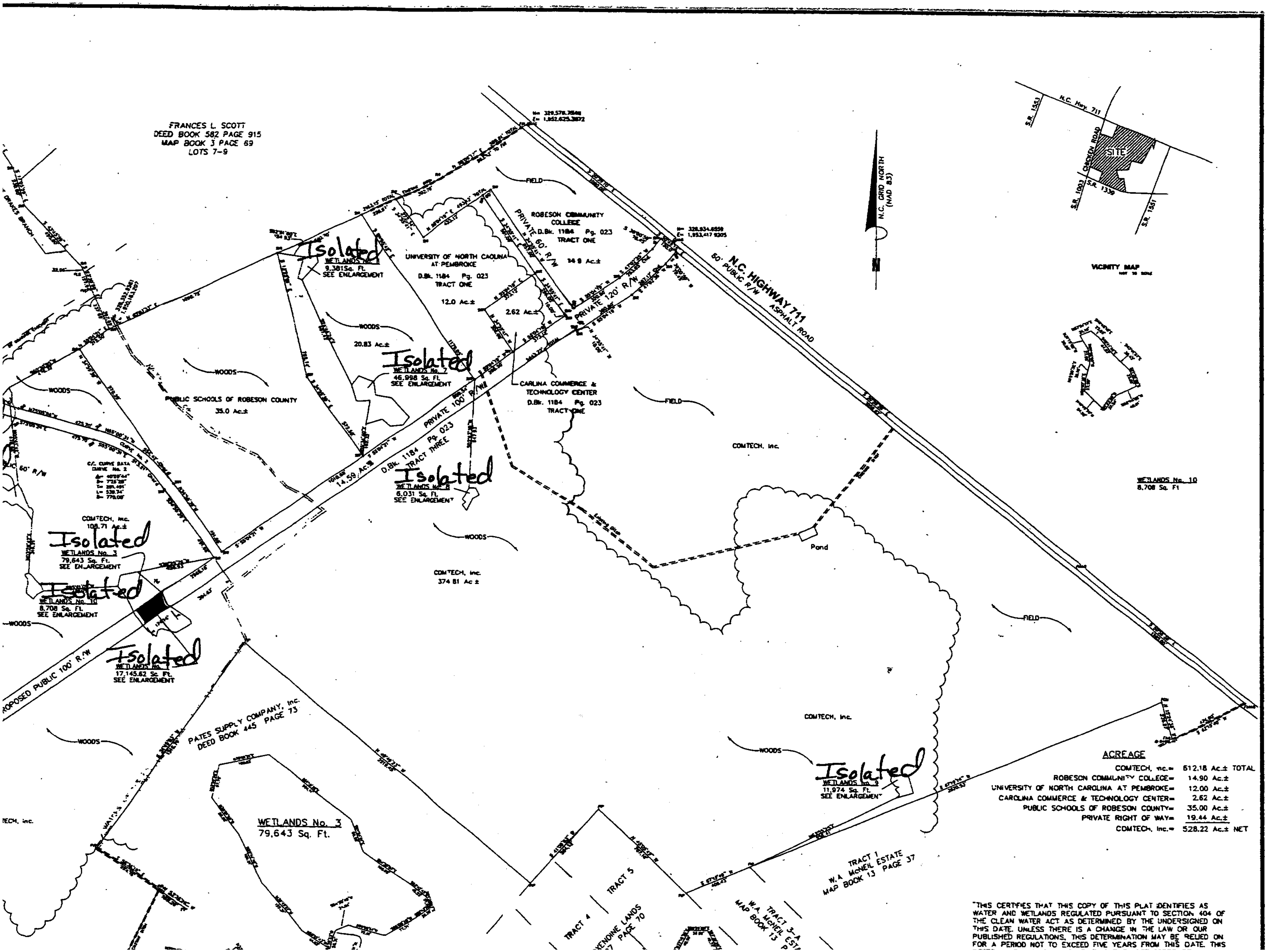
- The quality (e.g., resolution, accuracy) of the reference data, the travel costs for ground truth visits suggest that the sampling design should incorporate stratification and clustering strategies.
- A hierarchical structure can be developed by partitioning the counties in the Study Area using measures of area and knowledge about the spatial distribution of isolated wetlands within each county in the Study Area.

Accuracy Assessment

- Accuracy reflects the precision at which the GIS isolated wetland predictive mapping tool correctly classifies the sampling units (IW or not)
- Each of the selected sampling sites will be visited, appropriate observations made, and field data collected.
- Each selected sampling unit will be verified as to whether the site is or is not an isolated wetland



LEGEND
PROPERTY BOUNDARY
EXISTING CONTOUR
ISOLATED WETLAND
SECTION 404 JURISDICTIONAL WETLAND
RALPH WHITEHEAD ASSOCIATES, INC. CONSULTING ENGINEERS
EX. SOIL ROAD
N 66°43'32" E 1081.88'
N 65°22'28" E 1059.76'
WETLAND 'D' AREA: 1.10 ACRES
WETLAND 'F' AREA: 0.08 ACRE
WETLAND 'L' AREA: 1.71 ACRES
WETLAND 'M' AREA: 1.47 ACRES
WETLAND 'N' AREA: 0.31 ACRE
WETLAND 'P' AREA: 1.11 ACRES
WETLAND 'Q' AREA: 0.49 ACRE
WETLAND 'R' AREA: 2.72 ACRES
300' BUFFER
300' BUFFER
S 30°17'49" E 784.18'
S 30°17'49" E 246.13'
S 30°17'49" E 844.88'
N 36°33'50" W
S 56°21'09" W
630.25'
AMS
NOTES:
1. Jurisdictional waters of the U.S., including wetlands, were delineated in the field by Ralph Whitehead Associates, Inc., in February and March 2004. The boundaries of jurisdictional wetlands/waters were


FRANCES L. SCOTT
DEED BOOK 582 PAGE 915
MAP BOOK 3 PAGE 69
LOTS 7-9
N.C. GRID NORTH (NAD 83)
N.C. Hwy. 711
S.R. 1553
CHICKEN ROAD
SITE
S.R. 1003
S.R. 1339
S.R. 1551
VICINITY MAP
ROBESON COMMUNITY COLLEGE
D.Bk. 1184 Pg. 023
TRACT ONE
UNIVERSITY OF NORTH CAOLINA AT PEMBROKE
D.Bk. 1184 Pg. 023
TRACT ONE
12.0 Ac.±
2.62 Ac.±
PRIVATE 60' R/W
PRIVATE 120' R/W
N.C. HIGHWAY 711
60' PUBLIC R/W
ASPHALT ROAD
FIELD
WOODS
Isolated
WETLANDS No. 1
9,381Sq. Ft.
SEE ENLARGEMENT
20.83 Ac.±
Isolated
WETLANDS No. 7
46,998 Sq. Ft.
SEE ENLARGEMENT
CARLINA COMMERCE & TECHNOLOGY CENTER
D.Bk. 1184 Pg. 023
TRACT ONE
PUBLIC SCHOOLS OF ROBESON COUNTY
35.0 Ac.±
PRIVATE 100' R/W
D.Bk. 1184 Pg. 023
TRACT THREE
14.59 Ac.±
Isolated
WETLANDS No. 8
6,031 Sq. Ft.
SEE ENLARGEMENT
COMTECH, Inc.
60' R/W
COMTECH, Inc.
109.71 Ac.±
Isolated
WETLANDS No. 3
79,643 Sq. Ft.
SEE ENLARGEMENT
Isolated
WETLANDS No. 10
8,708 Sq. Ft.
SEE ENLARGEMENT
WETLANDS No. 10
8,708 Sq. Ft
COMTECH, Inc.
374.81 Ac.±
Pond
Isolated
WETLANDS No. 1
17,145.62 Sq. Ft.
SEE ENLARGEMENT
PROPOSED PUBLIC 100' R/W
PATES SUPPLY COMPANY, Inc.
DEED BOOK 445 PAGE 73
COMTECH, Inc.
Isolated
WETLANDS No. 9
11,974 Sq. Ft.
SEE ENLARGEMENT
WETLANDS No. 3
79,643 Sq. Ft.
TRACT 4
TRACT 5
TRACT 3-A
W.A. MCNEIL EST.
MAP BOOK 13
TRACT 1
W.A. MCNEIL ESTATE
MAP BOOK 13 PAGE 37
ACREAGE
COMTECH, Inc.= 612.18 Ac.± TOTAL
ROBESON COMMUNITY COLLEGE= 14.90 Ac.±
UNIVERSITY OF NORTH CAROLINA AT PEMBROKE= 12.00 Ac.±
CAROLINA COMMERCE & TECHNOLOGY CENTER= 2.62 Ac.±
PUBLIC SCHOOLS OF ROBESON COUNTY= 35.00 Ac.±
PRIVATE RIGHT OF WAY= 19.44 Ac.±
COMTECH, Inc.= 528.22 Ac.± NET
"THIS CERTIFIES THAT THIS COPY OF THIS PLAT IDENTIFIES AS WATER AND WETLANDS REGULATED PURSUANT TO SECTION 404 OF THE CLEAN WATER ACT AS DETERMINED BY THE UNDERSIGNED ON THIS DATE. UNLESS THERE IS A CHANGE IN THE LAW OR OUR PUBLISHED REGULATIONS, THIS DETERMINATION MAY BE RELIED ON FOR A PERIOD NOT TO EXCEED FIVE YEARS FROM THIS DATE. THIS

Accuracy Assessment

- After all sampled sites have been field-visited and assessed as to whether or not they meet the isolated wetland definitional criteria, an accuracy assessment will be performed.
- The standard result of the accuracy assessment will be a series of design-based accuracy measures (producer's accuracy, user's accuracy, and overall accuracy of the map derived from the "accuracy matrix")

		Is Site Verified as an Isolated Wetland?	
		Yes	No
Does GIS Mapping tool Predict Site as an Isolated Wetland?	Yes		
	No		

Design-based Accuracy Estimates

- Inclusion probability π_{ijk}
- Need to adjust weights $w_{ijk} = 1/\pi_{ijk}$ by the area of map land where IW are located for the entire study area and the Horvitz-Thompson estimate of the surface area for map coverage (A)

$$A = \sum_{i} \sum_{j} \sum_{k} \frac{1}{\pi_{ijk}} I(s_{ijk})$$

$$I(s_{ijk}) = 1 \text{ if IW and } 0 \text{ otherwise}$$

$$s_{ijk} = \text{sampling site}$$

Design-based Accuracy Estimates

Overall Accuracy rate = percentage of study area for which map and field were consistent

$$OA = 100 \frac{\sum_i \sum_j \sum_k w_{ijk} I_{ijk}(s)}{\sum_i \sum_j \sum_k w_{ijk}}$$

$$I_{ijk}(s) = 1 \text{ if field and map agrees, 0 otherwise}$$

Design-based Accuracy Estimates

Producer's Accuracy rate = percentage of field area for which map and field were consistent

$$PA(t) = 100 \frac{\sum_i \sum_j \sum_k w_{ijk} I_{ijk}(s=t)}{\sum_i \sum_j \sum_k w_{ijk} J_{ijk}(t)}$$

$$J_{ijk}(t) = \begin{cases} 1 & \text{if site is classified as IW (t = 1) or not (t = 0)} \quad \text{(from field visit)} \\ 0 & \text{otherwise} \end{cases}$$

Design-based Accuracy Estimates

Users's Accuracy rate = percentage of map area for which map and field were consistent

$$PA(t) = 100 \frac{\sum_i \sum_j \sum_k w_{ijk} I_{ijk}(s = t)}{\sum_i \sum_j \sum_k w_{ijk} J_{ijk}(t)}$$

$$J_{ijk}(t) = \begin{cases} 1 & \text{if map classifies site as IW } (t = 1) \text{ or not } (t = 0) \\ 0 & \text{otherwise} \end{cases}$$

Simulation

- Using data from the Robeson county we generated a stratified sample of size 100 using GRTS design
- . For the ground truth I modified the original data by eliminating some sites were wetlands were located and adding an IW indicator to other sites.
- Overall accuracy was estimated to be 61%

Comments

- We are very optimistic about using a GIS prediction map and our probabilistic approach to assess map accuracy
- We know the limitations that data accuracy, data costs and availability for the whole study region imposes in our population frame.
- We may not be able to detect smallest IW but we can provide an estimate of our non-detection rate with results from the accuracy assessment