Department of Defense
Legacy Resource Management Program

PROJECT 10-416

USING BLACK EARTH AND REMOTE SENSING OF INDICATOR PLANTS FOR IDENTIFICATION OF PREHISTORIC ARCHAEOLOGICAL SENSITIVITY AND POTENTIAL SITE INTEGRITY IN THE EASTERN WOODLANDS:

Black Earth Protocol: Soil Analysis, Methods and Guidelines

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Black Earth Creation

- Direct: Soil amendments over time for the purpose of increasing soil fertility to support agriculture
- Indirect: Midden creation at sites inhabited for long enough for wastes to build up significantly, maybe as little as a few weeks (and these areas would probably be visited yearly)

Black Earth Soils

- Found all over the world where man has fertilized the soil with household wastes and manure
- “Kitchen soils“
- Deep, black surface horizons formed in layers of kitchen refuse (mainly oyster shells, fishbones, etc.) from early Indian habitation

Terra Preta de Indio

Left - nutrient-poor oxisol; Right – oxisol transformed into terra preta through organic amendment

Amendments

- Smothered burning of agricultural and human waste, as well as plant biomass (low or no oxygen prevents combustion) creates biochar
- Biochar, human refuse, kitchen waste, etc. used as amendments
- These human-related activities increase the amount of calcium, carbon, phosphorous, and nitrogen occurring in soil strata (Skinner 1986)

Pre-settlement Agriculture in the Eastern US

- Maize-based agriculture introduced in AD 700; grown in raised beds with beans, squash, and tobacco (south)
- Agricultural amendments:
  - Wampanoag tribe, coastal NE: fish remains and organics
  - Slash and burn, charcoal production
- Indirect amendment: middens (refuse piles)
- *Signal of amending soils can be used as an indicator of Native American agricultural activity*

Black Earth Field Sampling Methods

1.) Take GPS waypoint at each location

2.) Take soil core to layer of occupation

3.) Remove top 10 cm and organic layer

4.) Take *soil color reading* (Munsell 10YR system)

5.) Sift samples for organic materials and rocks and search for soil charcoal

6.) Dry, and bag cores in plastic Ziploc bags

Sampling a midden recorded with traditional archaeological techniques on the “Calendar Site” (prehistoric ceremonial site), Ft. Drum, NY (2009).

Soil color reading example procedure with using the Munsell system (10YR) color guide (Cheatham Annex, 2009).

Example of the color difference between midden and non-midden soils (Calendar Site midden soil on left; soil above midden (deposited via wind erosion) on right, Fort Drum 2009).

Laboratory Methods

- Obtain baseline soil fertility and characteristics of dominant soil series
- Basic testing of samples for the following characteristics: nutrient content in parts per million (ppm) of phosphorous, potassium, magnesium, and calcium
- Calculate compiled soil fertility for the Baseline and Samples
  - Addition of nutrient content values (ppm) for all tested nutrients
- Sample Fertility – Baseline Fertility
  - Resulting positive values indicate areas where the sample fertility is higher than baseline

How to Utilize Sampling Results

- Spatial Interpolation (Inverse Distance Weighting); see following slides
- ArcGIS Spatial Interpolation tools used here for creation of interpolated surface
- Interpretation of patterns from resulting surface

Spatial Interpolation

- Assigning values to unknown points using values from a set of known points
  - Multiple types: natural neighbor, inverse distance weighting, kriging
- *Inverse Distance Weighting* (IDW) works well for environmental variables that fluctuate relatively slowly across a landscape
- Unknown points are assigned a value equal to the weighted average of nearby sampled points
  - Weight given each point is an inverse proportion to the distance to the unknown point

Using Spatial Interpolation Tools in ArcMap

1. Open ArcMap and add any required base layers (elevation, roads, boundaries, etc)

2. Add archaeological site boundary shapefile, if available (if not available, digitize an accurate boundary)

3. Load soil sample waypoints and edit the attribute table to add the index soil fertility values (sample fertility – baseline fertility)

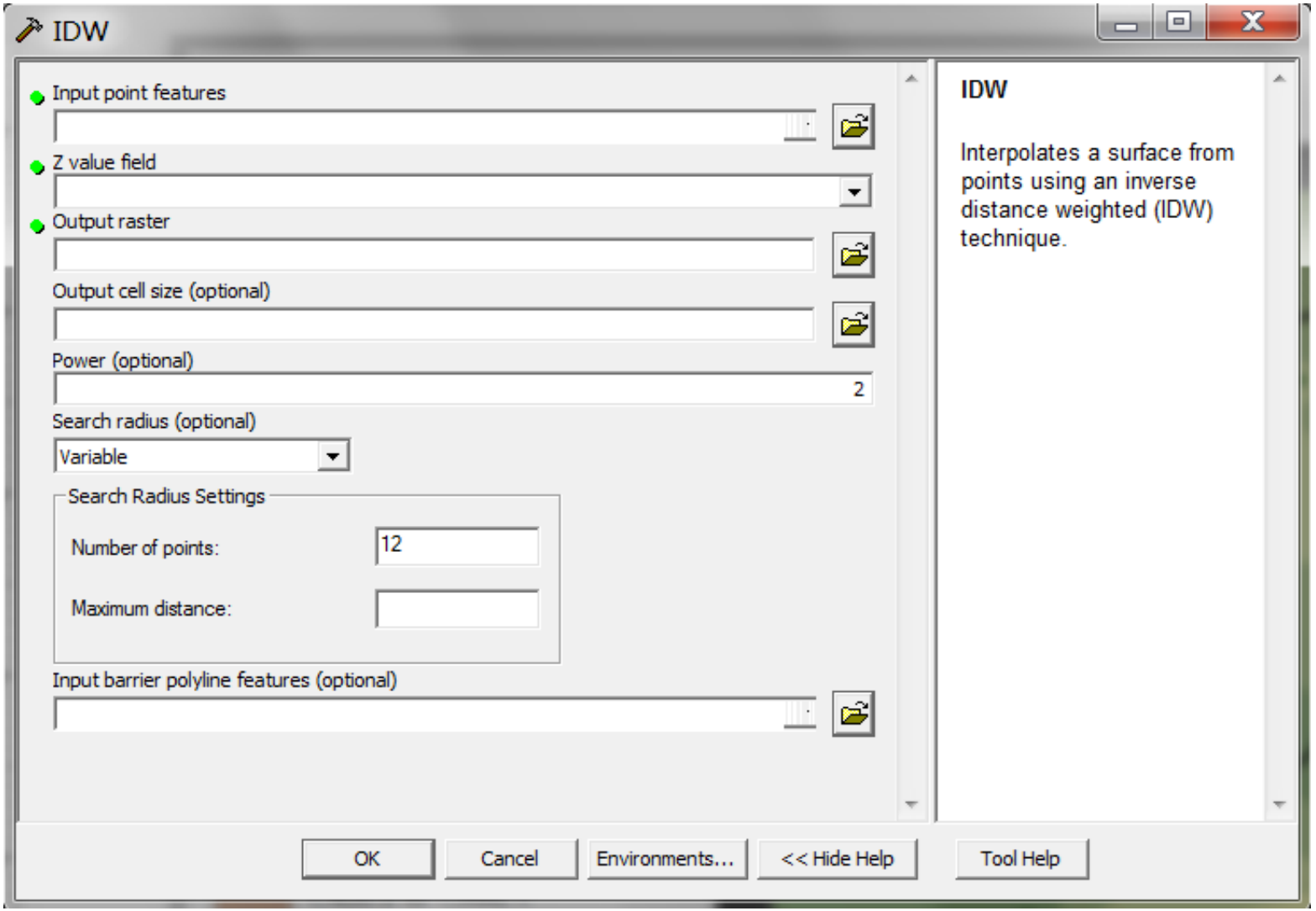
4. Go to: ArcToolbox>Spatial Analysis> Interpolation and select the tools for Kriging or Inverse Distance Weighting (IDW)

Using the tools, continued

5. Input the waypoint shapefile and select the field in the attribute table to run the interpolation on (the index soil fertility field)

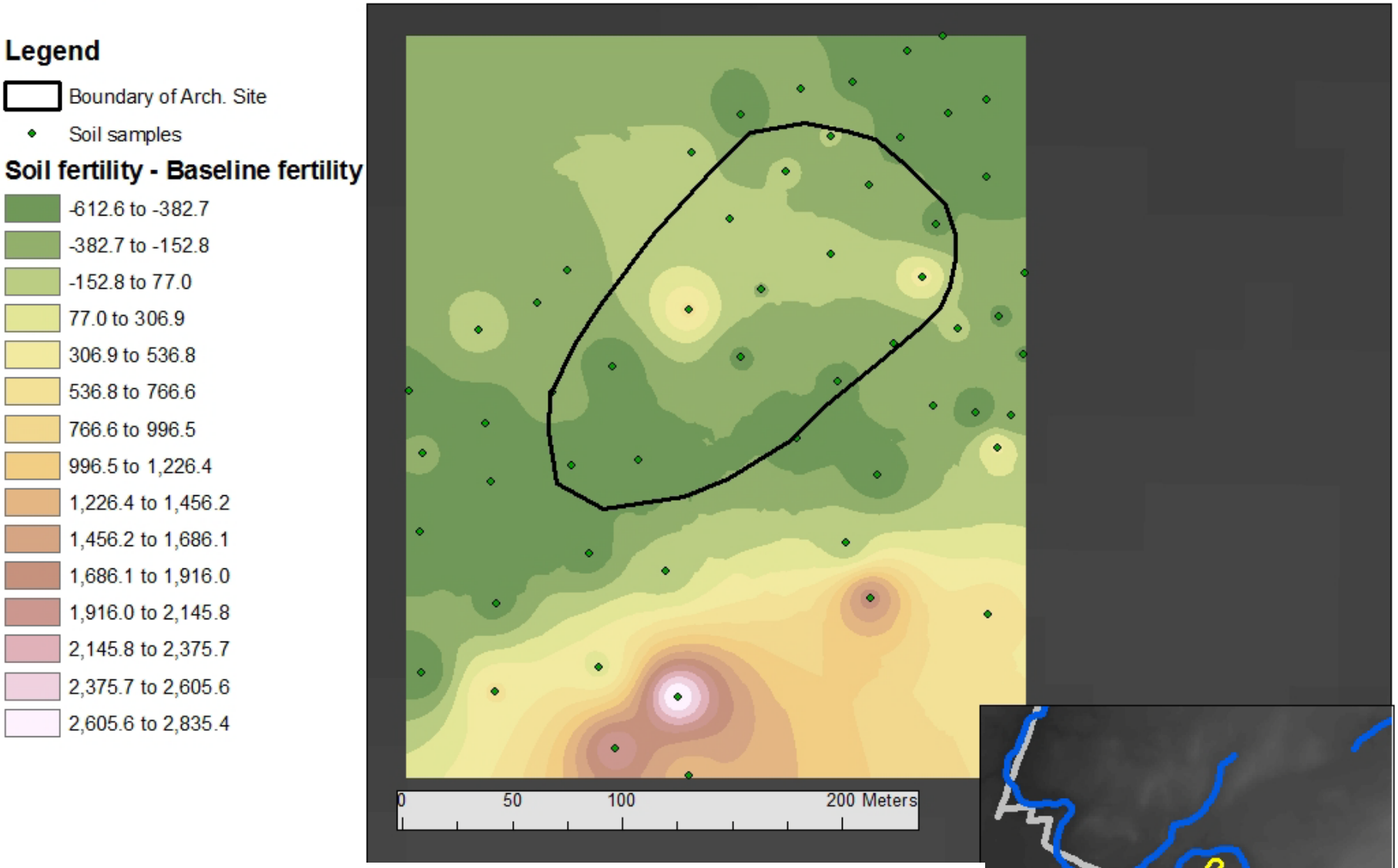
6. Select a folder and file name to save the output raster grid file to

7. Other options are available for the execution of the interpolation such as search radius and the number of surrounding points to use for interpolation of unknown points; manipulate these options as necessary



Example window for Inverse Distance Weighting spatial interpolation tool in ArcMap; optional settings allow the user to manipulate the influence of points at different distances on the unknown point, and choose the number of surrounding points to use in the interpolation of the unknown point.

Camp Drum 1 Soil Analysis



Example of spatial interpolation IDW results showing areas of increased fertility in and to the south of the archaeological site (designated with black outline).

Interpretation & Use

- Where index of soil fertility is positive, indicates higher fertility than baseline
- These areas may correspond to *middens* if they are isolated patches, or *agricultural fields* if they are broader areas
  - Both would indicate where cultural resources are likely to be found, or where artifacts are likely to occur
- **Soil color** can be used as an indicator of nutrient status
  - Darker soil has more nutrient-holding capacity
  - No testing required; more efficient

Example of dark soil color on an archaeological site from a soil core on Fort Drum (2009). Site is associated with the bluff the north side of the Black River, an ideal habitation site. The soil in the occupation layer is black (2/1 with Munsell 10YR system), indicating high organic content and nutrient-holding capacity.

Color comparison between archaeological site (right) and off-site (left) soils (Fort Drum 2010, FDP 1272 LeRay Site); archaeological site is much darker and has higher nutrient status than off-site soils.

Integration of Indicators

- Using vegetation, black earth, and soil color in combination to more accurately and efficiently predict the presence of cultural resources.
- Soil charcoal is less useful as a definitive indicator
  - Results variable across cultural and control sites
  - A possible legacy of broadcast burning by Native Americans

Ft. Drum Army Installation, NY

- Key indicator species are lamb's quarters, oak species, and blueberry
  - Combination of oak species and blueberry very indicative
  - Combination of lamb's quarters and black to dark brown soil color possibly indicative of Native American agriculture

Soil (ppm) Parameter	Cultural	Control
pH	5.09 ± 0.15	5.00 ± 0.15
Phosphorous	38.44 ± 7.68	25.44 ± 3.77
Potassium	69.80 ± 15.76	37.68 ± 4.61
Magnesium	65.88 ± 11.87	39.76 ± 7.14
Calcium	522.16 ± 112.81	368.57 ± 104.07
Total Nitrogen	2194.07 ± 207.51	1890.31 ± 213.24
Soil color	very dark brown	yellowish brown

	Site Occurance		Average % cover/canopy
Indicator Species	**Cultural**	**Control**	**Cultural**
Lamb's quarters	9	3	25
Oak species	22	6	40
Blueberry	20	7	30 (variable, some 60+)

Blueberry underneath a canopy of almost 100% oak species (both white and northern red oak) at FDP 1021, north of Black River (2009). This species association is also present on FDP 1161, The Calendar Site and surrounding area, and FDP 1267.

Large blueberry patch near the “Boat Building” site on Ft. Drum. Blueberry was in a stand of oak and pine species, and soil samples were positive for soil charcoal. However, associated control soil samples were also positive for charcoal, which leads us to believe that broadcast burning was occurring in this area to facilitate the growth and regeneration of these key indicator species (2008).

[Above] Very thick lamb's quarters in herbaceous layer of FDP 1021.

[Below] Lamb's quarters was an important wild-gathered source of grain for the Iroquois. This picture was taken on FDP 1 where black earth soil testing in grid format was also conducted (2011).

Field to the northeast of FDP 1 containing large amounts of lamb's quarters; possible site of Native American agricultural fields. Soil samples were taken here as part of a grid analysis (2010; see spatial interpolation methods and implementation).

Cheatham Annex, VA

- Key Indicators:
  - Shell midden evidence
  - High oak species importance versus maple, sweetgum, and tulip poplar in interior forest
  - Topographic position – on bluffs near brackish waterways
- All beta test sites had evidence of both shell middens and oak presence

Distinct shell midden seen from road cut (black circles indicate shell fragments in the soil), adjacent to the south bank of Queen Creek in the Wilderness Area on the Cheatham Annex (2008). Overstory trees visible in the background are almost exclusively oak and pine species.

Soil core for nutrient analysis and soil color analysis taken in the Wilderness Area on the Cheatham Annex, with shell midden evidence, at Beta Test Site #2 (2009).

High white oak importance in the area of an identified cultural site in the Wilderness Area (2008). White oak is an important mast producer for humans and wildlife, and is in association with the south bank of Queen Creek. Shell midden evidence and dark soils were also present here.

MCB Quantico

- Key indicators:
  - Oak and hickory species in the canopy
  - Tuckahoe along waterways

- Fifteen of fifteen archaeological sites surveyed had a high percentage of oak in the canopy, and eight of fifteen had a high percentage of hickory in the canopy

	Site Occurance		Average % cover/canopy
Indicator Species	**Cultural**	**Control**	**Cultural**
Oak species	15	1	20 to 45
Hickory species	8	1	15

Late Woodland archaeological site in Training Area 6B on Quantico (2010); high importance of white oak in the forest canopy. This site is located on a hilltop which could have been a fortified settlement during a time of warfare.

Blueberry in archaeological site in Training Area 6B (Quantico 2010); also a highly utilized species by Native Americans.

Large patch of tuckahoe along the north bank of Chopawamsic Creek in association with an archaeological site consisting of a “hamlet” style settlement; dwelling of a small family group (Quantico 2010).

A grove of paw paw (utilized for fruit production) and spicebush (a medicinal small tree) in an archaeological site along the north bank of Chopawamsic Creek, (site 1-2, 2010).

Dare County Bombing Range, NC:
Limitations

1. Landscape consists of a peatland, continually building organic material
2. Whole range tested negative for cultural resources; though many artifacts are probably buried under the organic peat mat
3. No cultural tests possible because of the lack of exact locations of archaeological sites
4. No soil samples were taken for Black Earth analysis on the Bombing Range because almost the entirety of the Range is muck or hydric soils

However, relevant conclusions are possible based on indicator species inventory and analysis of soil and vegetation types on the Range.

Dare County Bombing Range, NC

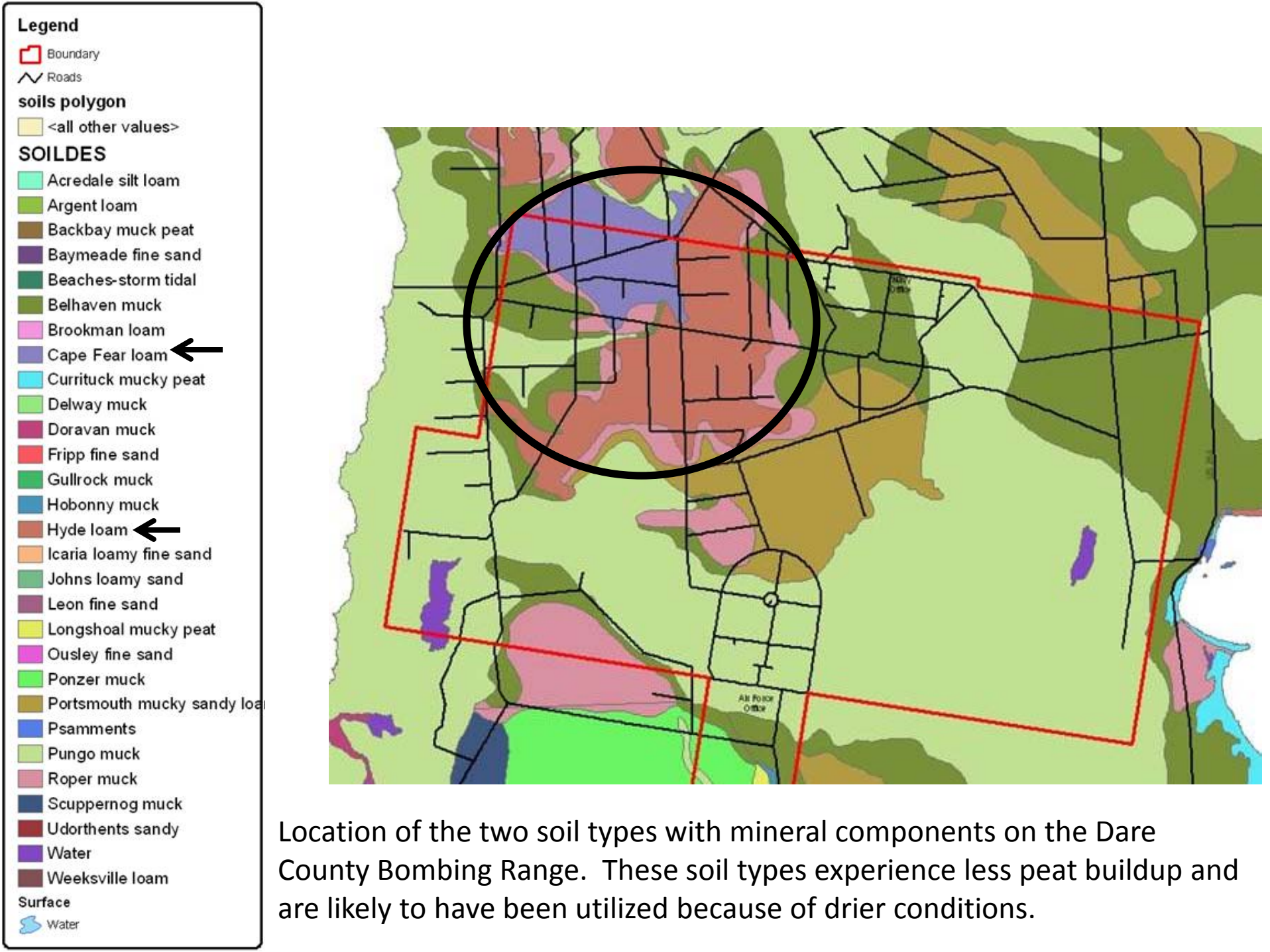
- Key Indicators are the presence of mineral soils and oak species in the canopy

- Mineral soil types present on the Range:
  - Hyde Loam
  - Cape Fear Loam
- Presence of oak species is both indicative of a mineral soil component and also very heavily utilized by Native Americans

Live oak and black walnut trees, both heavily utilized by Native Americans for mast, at Late Woodland site in Ft. Raleigh, Roanoke Island (2010). Although this Native American archaeological site is not on the Dare County Bombing Range itself, these other sites can be used to gain knowledge of the indicator species occurring in areas of Native American activity in coastal North Carolina.

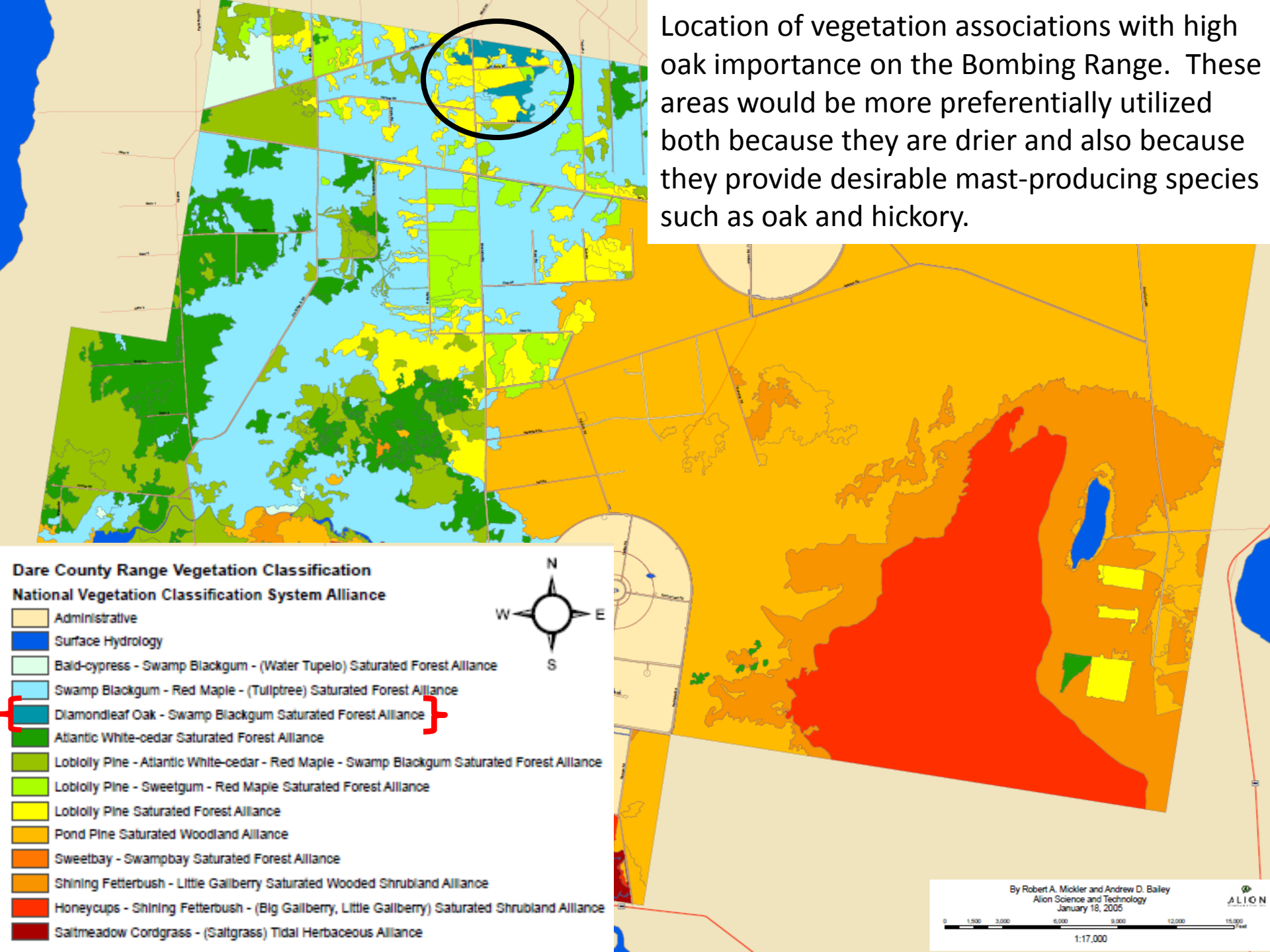
Live oaks on Roanoke Island at a Late Woodland Native American site near Ft. Raleigh (2010).

Leaf of water oak (*Quercus nigra*); occurs frequently in mineral soils of the Dare County Bombing Range.



Location of the two soil types with mineral components on the Dare County Bombing Range. These soil types experience less peat buildup and are likely to have been utilized because of drier conditions.

Location of vegetation associations with high oak importance on the Bombing Range. These areas would be more preferentially utilized both because they are drier and also because they provide desirable mast-producing species such as oak and hickory.



Conclusion

- An integration of the use of vegetative indicator species and black earth has more predictive power than either alone.

- General Hierarchy:
  - Physical evidence (shell middens)
  - Vegetation (indicator species)
  - Soils (soil color first, then nutrient analysis)