



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:**

Protocol: Methods and Guidelines for Analysis of Indicator Species
Distribution Using Remote Sensing

SARAH JOHNSON, MARC D. ABRAMS, AND LAURIE RUSH

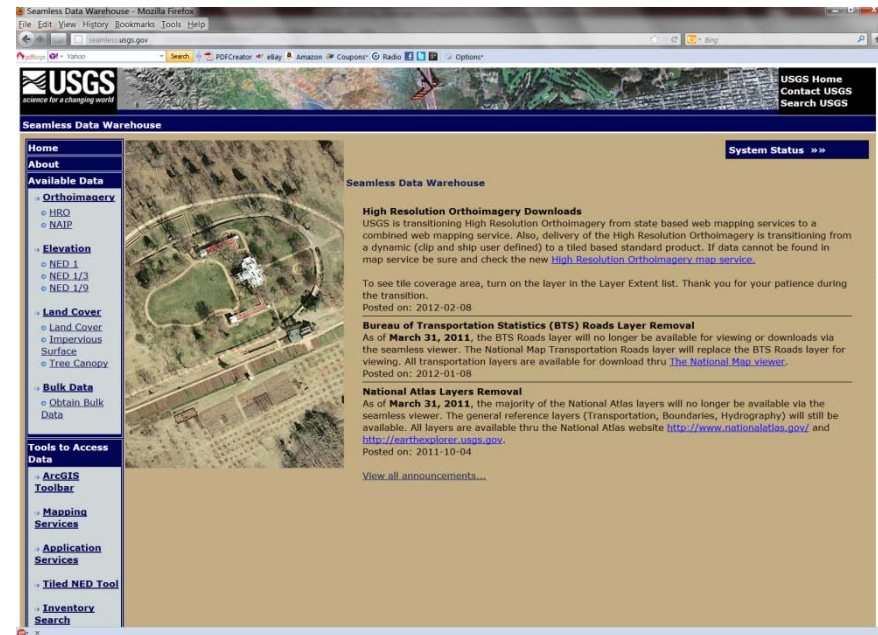
May 2012

Methods and Guidelines for Analysis of Indicator Species Distribution Using Remote Sensing

- Remote sensing: Measuring or recording information about an object or phenomena without contacting the object
- Two types:
 - *Active* - sensors that generate their own radiation (Radar, Lidar)
 - *Passive* - sensors that measure signals already present in the environment (aerial photography, satellite imagery)
- **Remotely sensed data can be used to assess land cover type and patterns in dominant vegetation. When combined with archaeological site data, cover type analysis can indicate the dominant vegetation association where cultural resources are most likely to be found.**

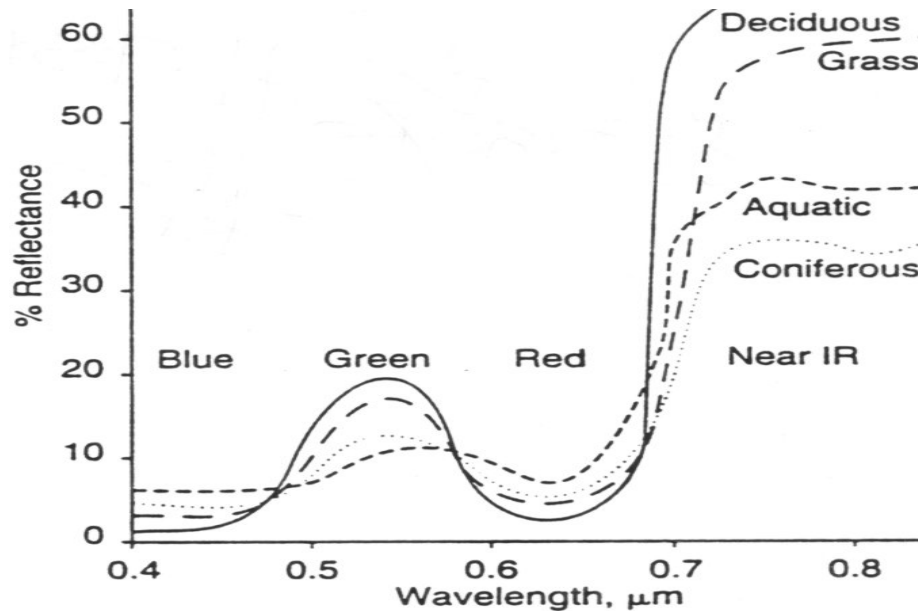
Aerial Imagery

- The imagery used here is from the National Agricultural Imagery Program (NAIP) and is available on the USGS Seamless Data Distribution System (<http://seamless.usgs.gov/>)
- Four bands available for display: red, green, blue, and near infrared (NIR)
- High resolution: 1 m x 1 m cell size

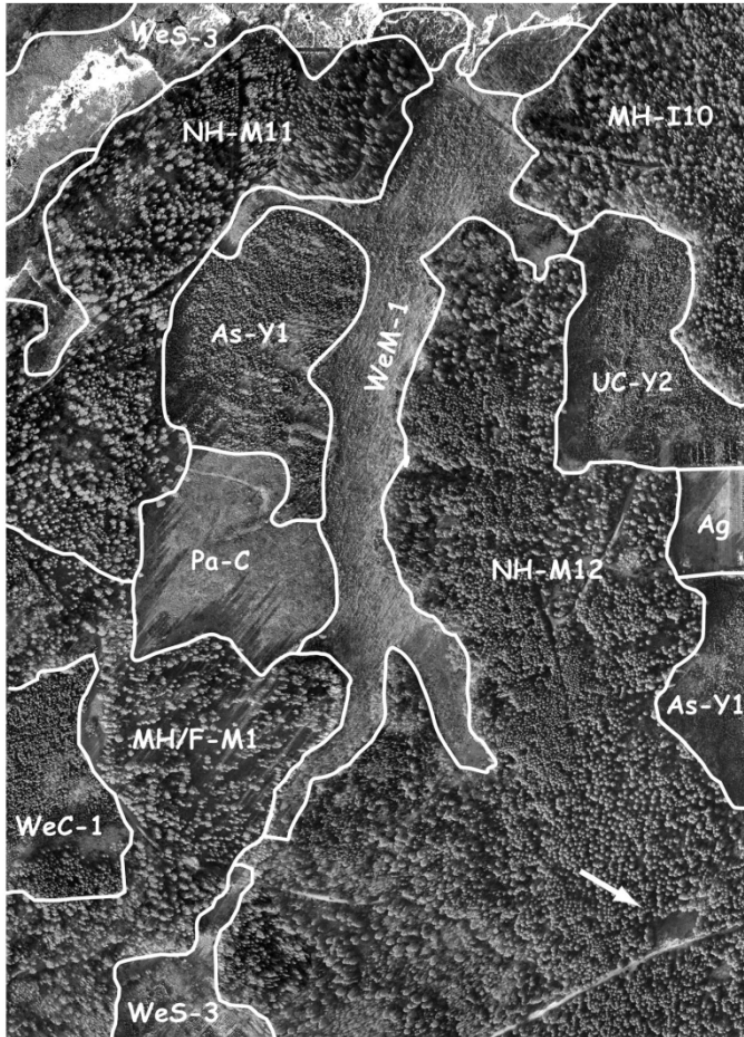


Remotely Sensed Image Interpretation

The combination of percentage reflectance values across all bands or wavelengths of the visible and infrared spectrum provides a “spectral signature” for different land cover types or land uses, which results in different characteristics that we can detect visually.



Photointerpretation

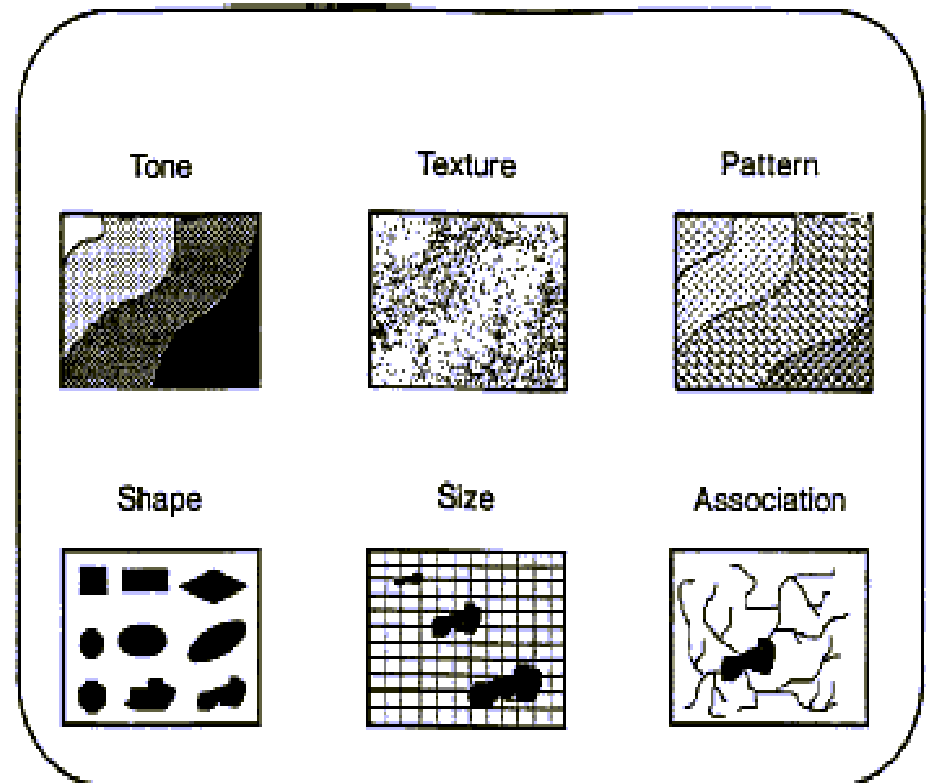


“The act of examining photographic images for the purpose of identifying objects and judging their significance.”

For detection and measurement of trends and patterns on the landscape.

Basic elements of Photointerpretation

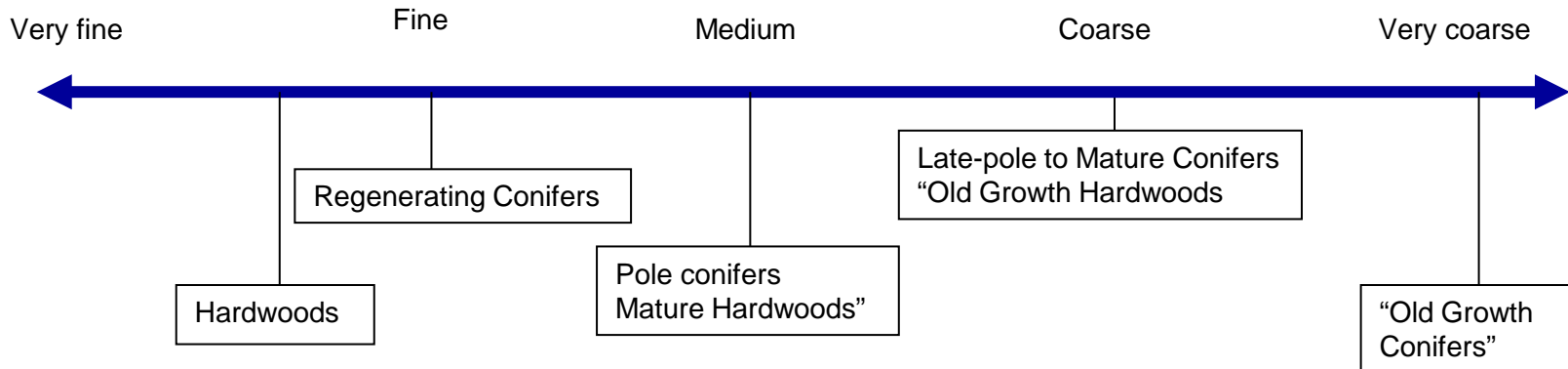
- Tone or Color
- Size (relative or absolute)
- Shape
- Texture
- Pattern/arrangement
- Shadow
- Association/location



Source: Paine and Kiser 2003

Texture

- The impression of "smoothness" or "roughness" of image features
- Grasslands have very fine textures
- Shrublands have medium textures
- Forests exhibit spectrum of textures:



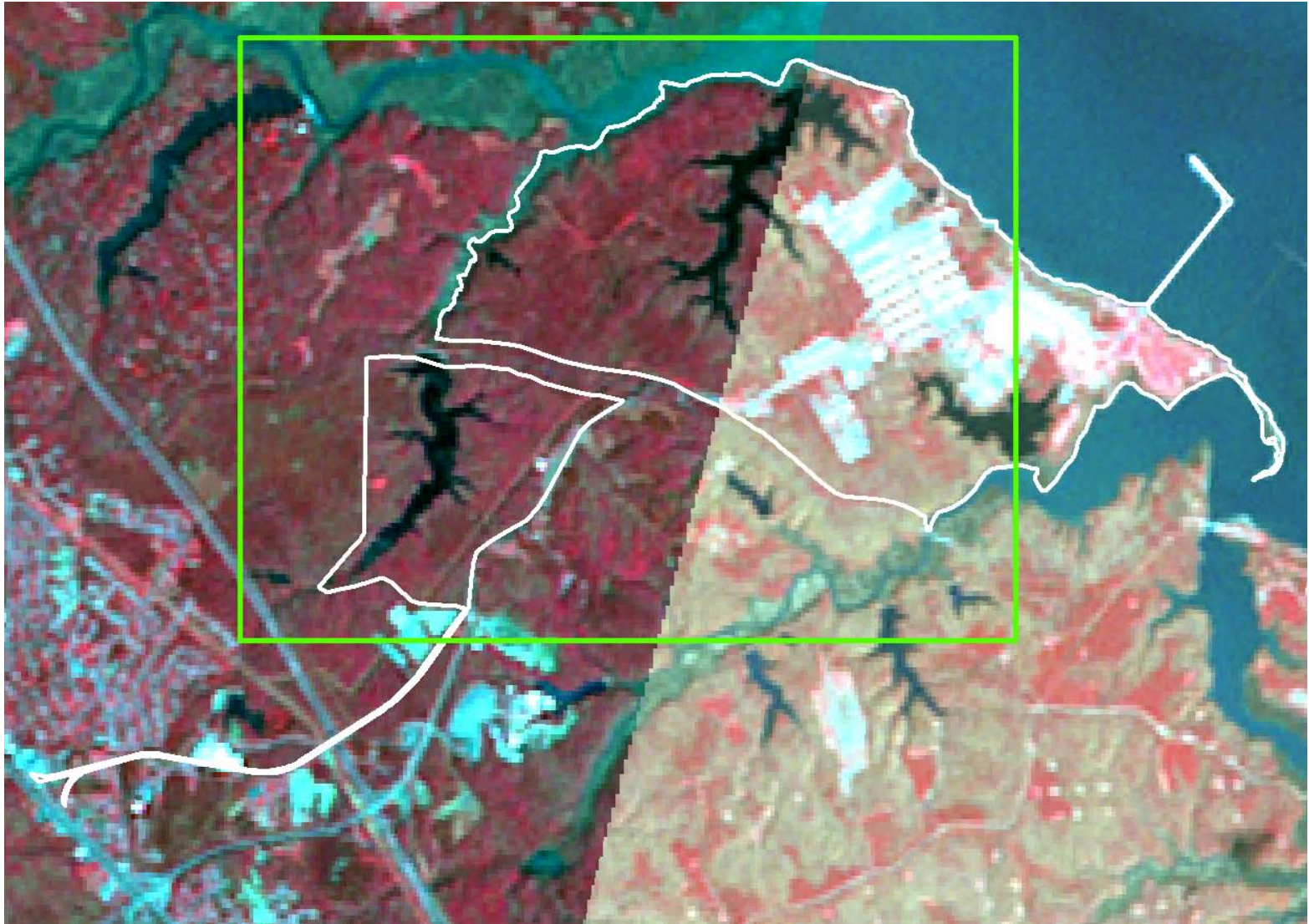
Color Infrared Display and Interpretation

- Color infrared (CIR) is often used to map vegetation due to differences of radiation reflected by different trees
 - *To display an image in CIR, assign the red channel to the infrared band (4), the green channel to the red band (1), and the blue channel to the green band (2). Do not use the blue band.*
- In leaf-off imagery, conifers will be very noticeable
- Conifers appear very dark in IR when compared with deciduous trees

Method

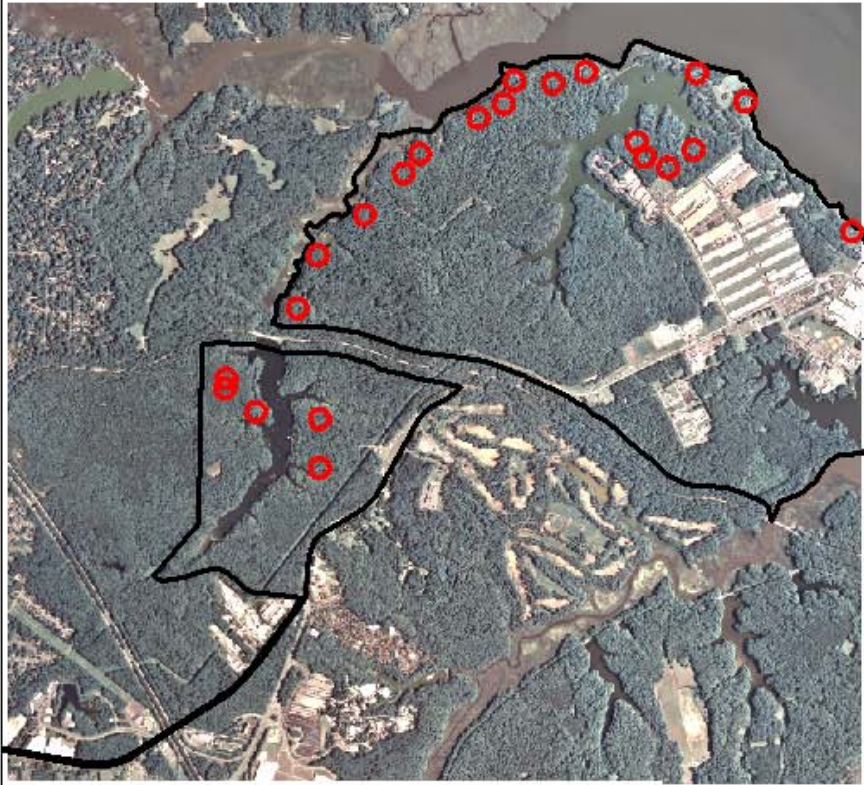
- *Because of the high resolution of the imagery and consequent increase in storage capacity and file size, only small pieces of each site are used here as an example analysis. Therefore, this analysis would need to be conducted for the entire area of the base to reduce bias in the type of sites that are inspected.*
1. Load aerial imagery into ArcGIS and overlay archaeological site buffers/boundaries
 - In ArcMap, use Buffer tool (ArcToolbox>Analysis Tools>Proximity>Buffer) to assign a buffer of specified width (60 meters is used here) around archaeological sites that are contained in point shapefiles
 2. Identify the major and secondary vegetation types within each site buffer/boundary using visual inspection of tone, brightness, and texture of pixels in both natural color and color infrared (CIR) renderings.

Cheatham Annex

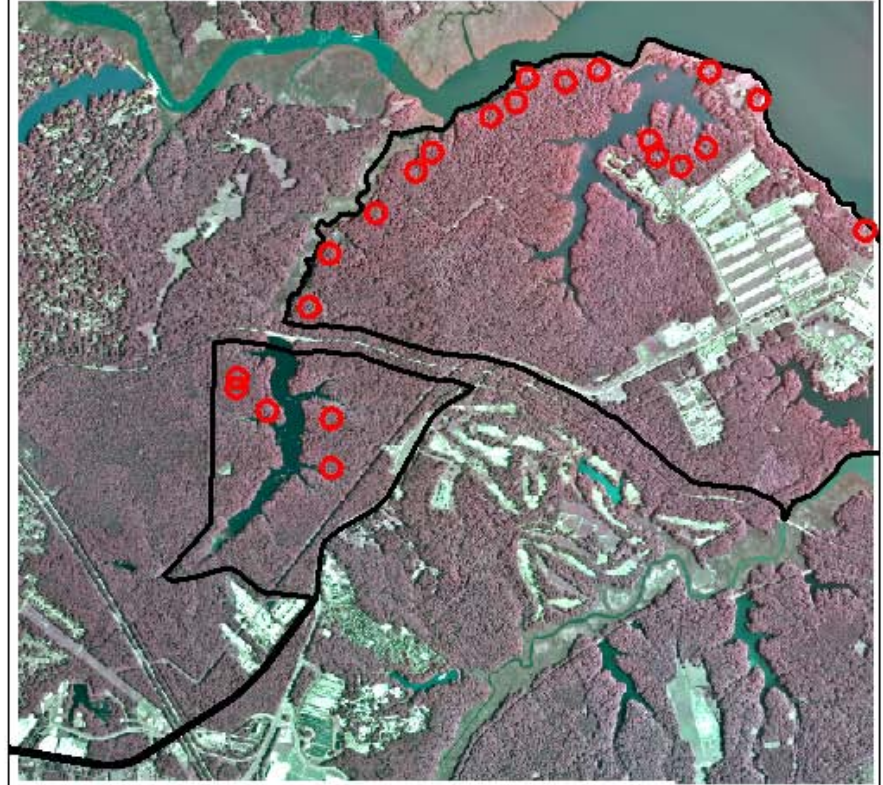


Installation is indicated by the white outline, and the area of interest considered here is indicated with the green box.



Natural Color rendering



Color Infrared (CIR) rendering

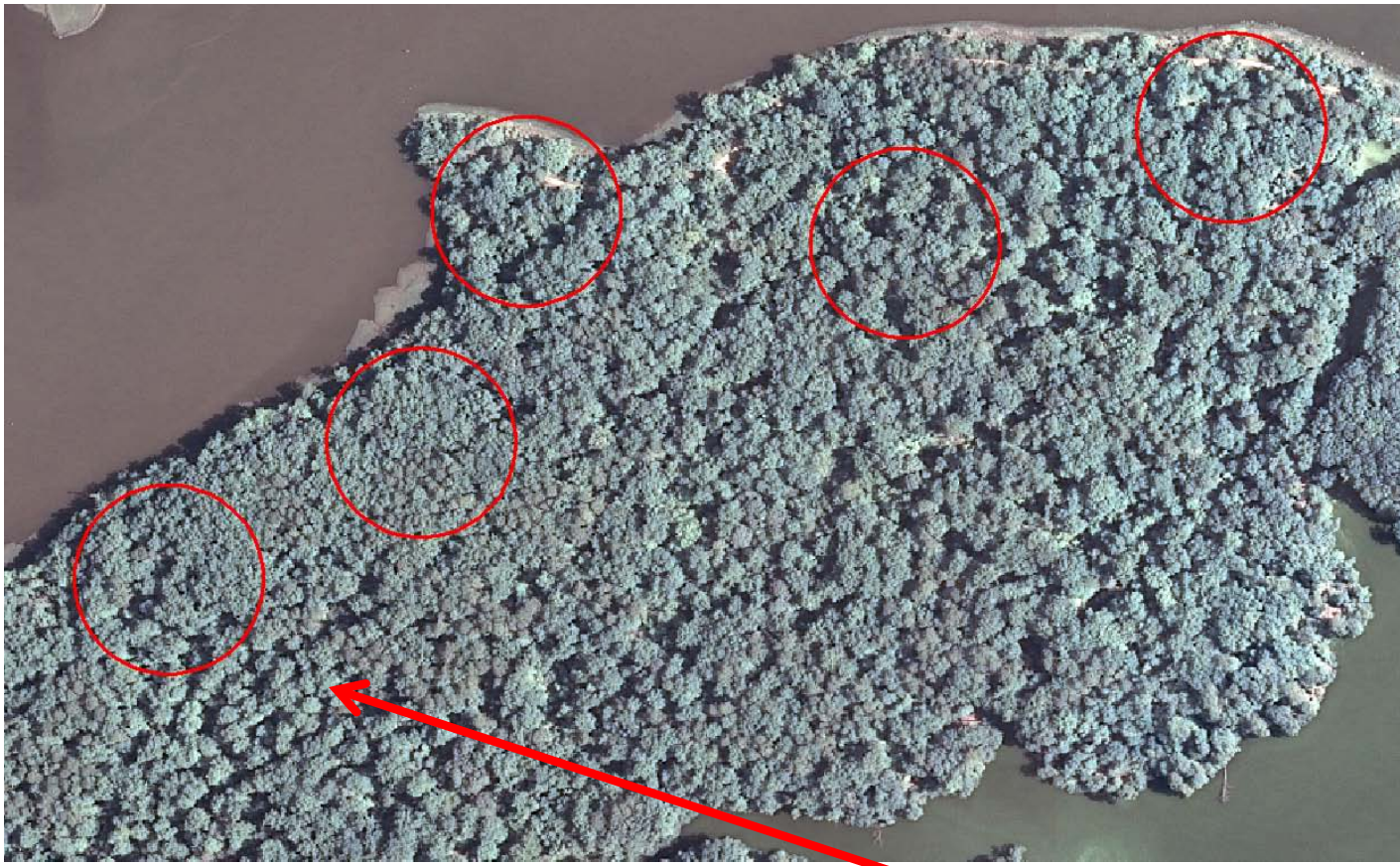


Legend

-  Prehistoric Cultural Sites
-  Cheatham Annex Boundary

0 650 1,300 2,600 Meters

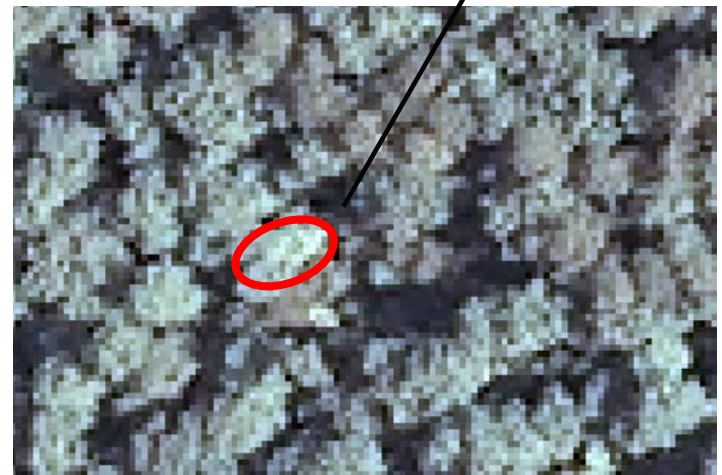




Deciduous crown

Image Interpretation:

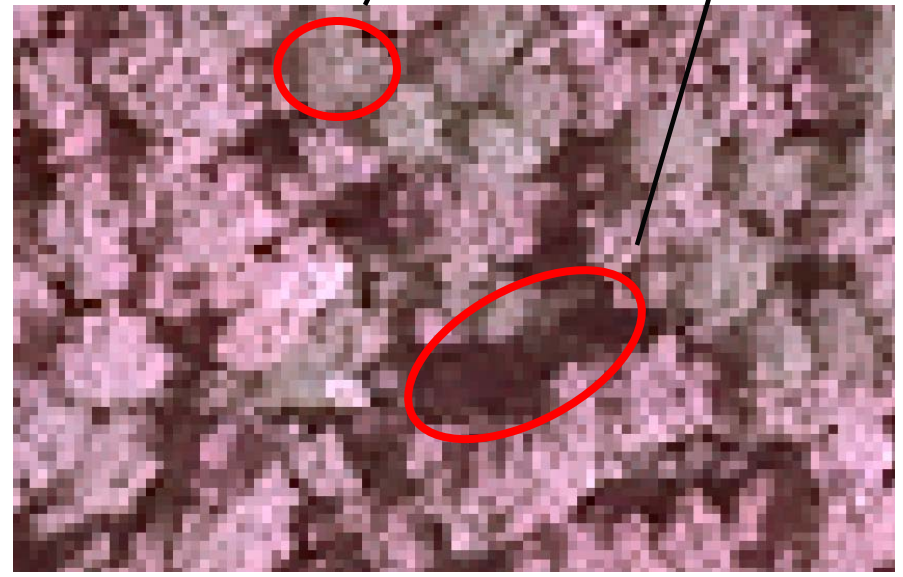
Conifer and deciduous trees exhibit differences in tone and texture in aerial photographs, while open and closed forest habitats are distinguishable through the identification of areas of short versus tall vegetation.





Conifer crown

Canopy gap



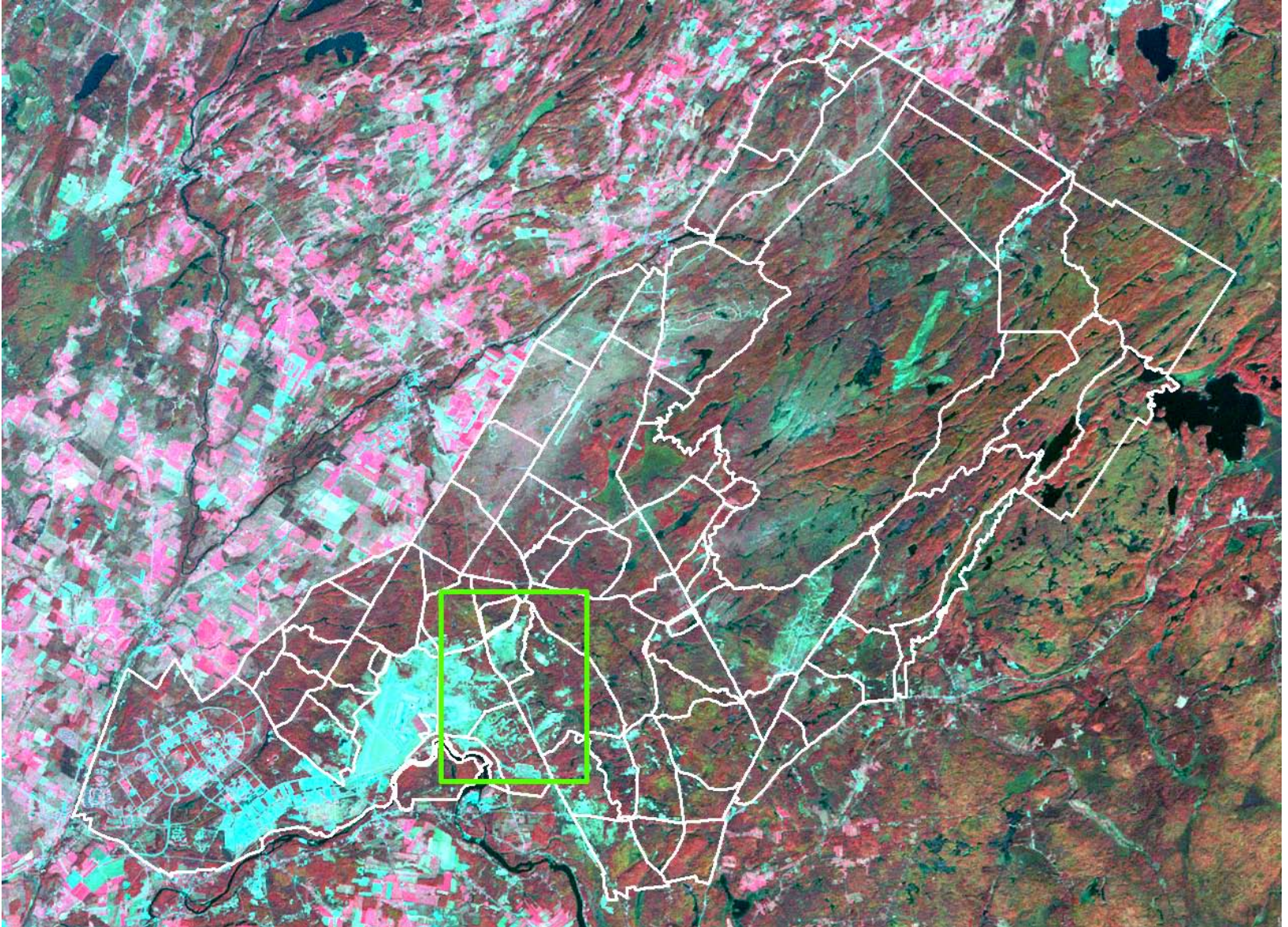
Photointerpretation Results

- **22** total sites within the area of interest
- Percent land cover composition of archaeological sites:
 - Pine and hardwood, pine dominant: **32%** (7/22)
 - Pine and hardwood, equally dominant: **32%** (7/22)
 - Hardwood (maple, sweetgum, poplar) dominant: **23%** (5/22)
 - Pine and hardwood, hardwood (oak) dominant: **14%** (3/22)
 - **41%** of all sites (9/22) were within 60 meters of a river bank

Cheatham Annex Summary

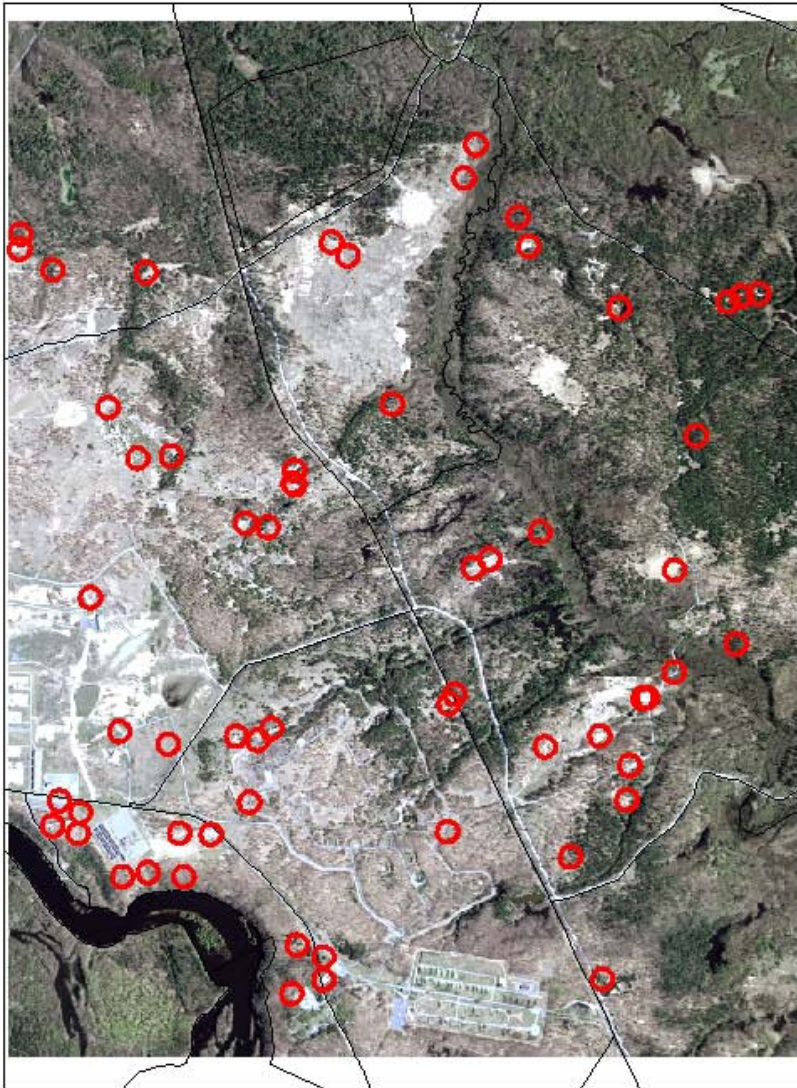
- Pine-dominated closed forest contained the majority of archaeological sites in the Cheatham Annex, and 41% of sites were within 60 meters of a waterway
- Pine trees require well-drained soils, which are also ideal for habitation
- Further, the pine-dominated woodlands on the Annex populate elevated bluffs along the south side of Queen Creek, an important source of food (shellfish) and transportation

Ft. Drum

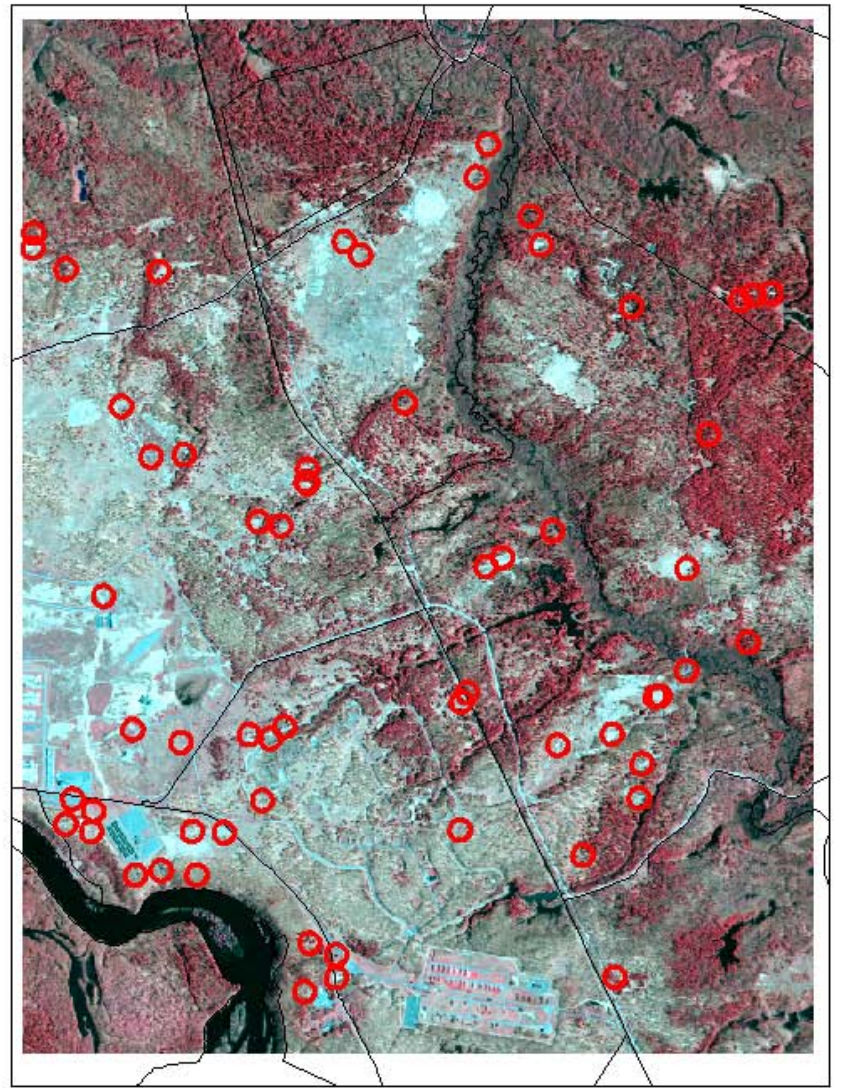


Installation is indicated by the white outline, and the area of interest considered here is indicated with the green box.



Natural Color



CIR rendering



Legend

-  Prehistoric Cultural Sites
-  Training Area Boundaries

0 600 1,200 2,400 Meters



Several examples of cover on archaeological sites in the area of interest on Ft. Drum. The area within the 60 m radius buffer zone is assessed for species (hardwood, pine) and density (bare, open, or closed forest) of cover.



Photointerpretation Results

- **62** total sites within the area of interest
- Percentage of archaeological sites containing each vegetation type as a major or secondary type:
 - Open hardwood and shrubs: **42%** (26/62)
 - Mixed hardwood/pine: **29%** (18/62)
 - Bare ground: **16%** (10/62)
 - Closed hardwood: **6%** (4/62)

 - Human-modified: **35%** of all sites (22/62, 18 of these sites had no other cover type)
 - River or creek bank: **2%** (1/62; this site also contained a forest cover type)

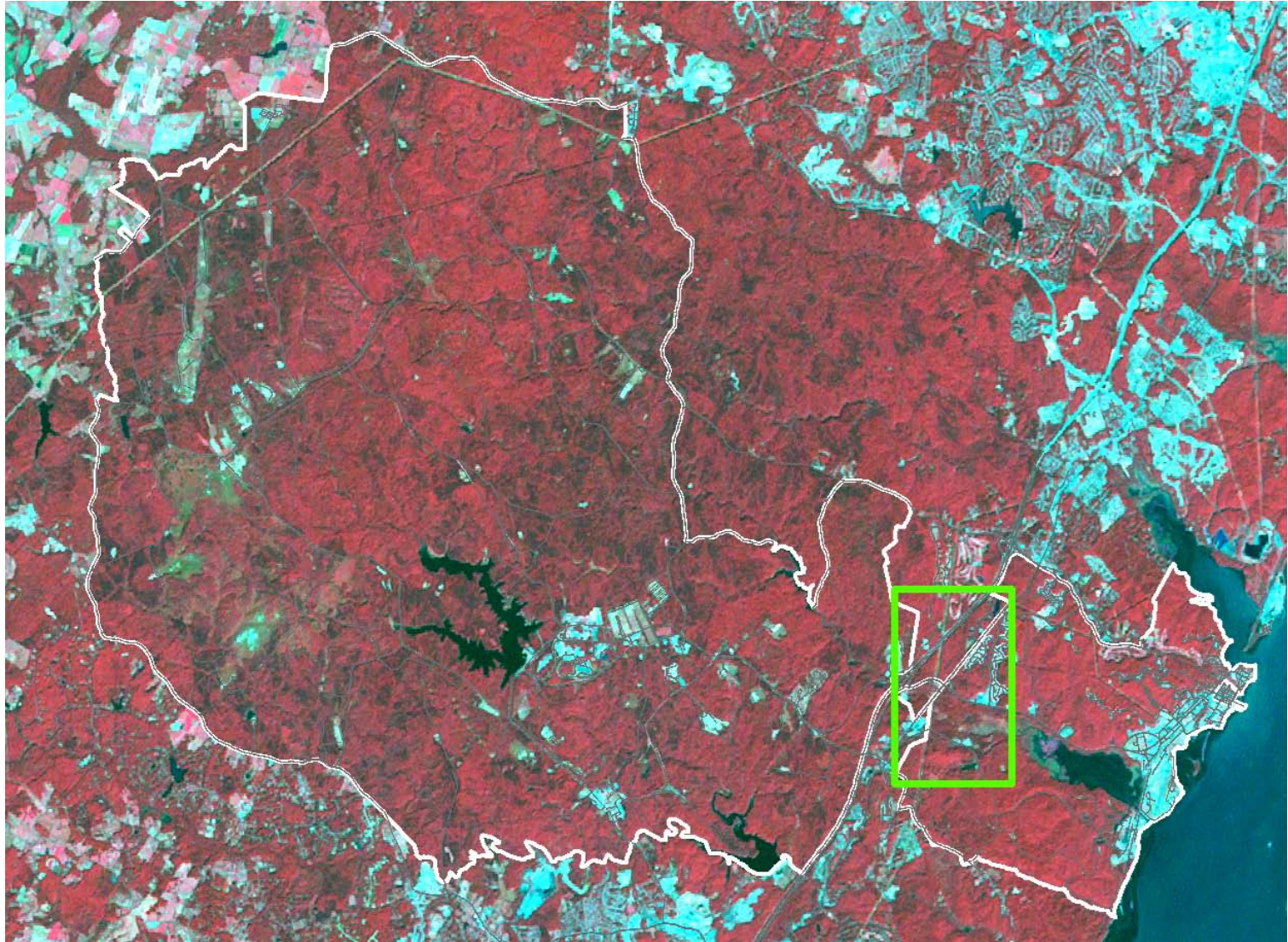
Ft. Drum Summary

- 42% of archaeological sites in the area of interest were covered by open hardwood forest.
 - Some small component of pine may be secondarily important
- There is a large amount of human-modified ground in the chosen area; this type of analysis may return more accurate results in an area less impacted by military activities on the surface
- Only 2% of sites are within 60 m of a waterway; this may be because many of the smaller waterways are surrounded by low-lying areas where habitation is not desirable

Ft. Drum Summary (Continued)

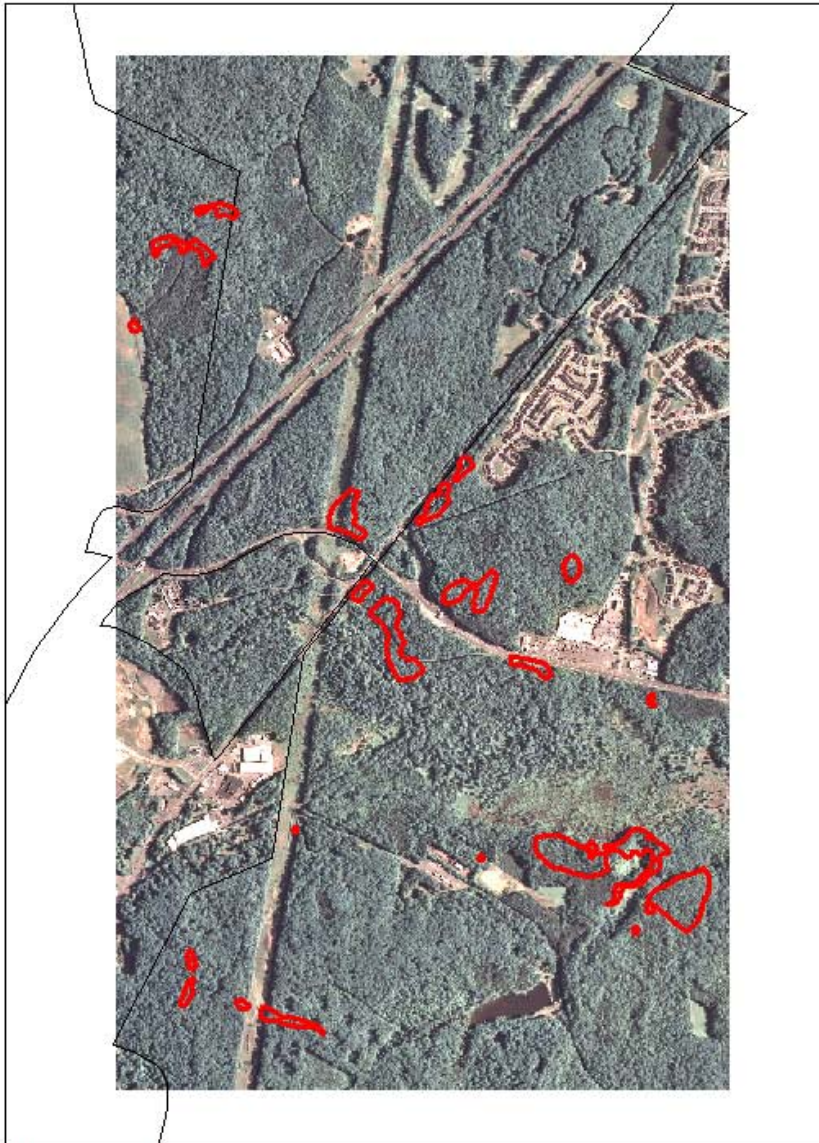
- Prevalence of open or partially-open ground on archaeological sites leads to:
 - Open Areas Hypothesis: Use for many years by Native Americans (and many times subsequent use by European settlers because that land was already cleared) caused a slowing of succession due to decreased soil fertility, erosion and de-vegetating associated with constant traffic and use.
- Areas of sparse *hardwood-dominated open woodland* (mast orchard) are important, especially if they are almost exclusively oak
- Oak-dominated Forest Type:
 - Indicator vegetation
 - Heavily utilized for mast production (for both game animal and human consumption)
 - Important to Native American groups throughout the eastern US
 - **Remote sensing can help to quickly identify areas of this species association that have not been previously tested.**

MCB Quantico

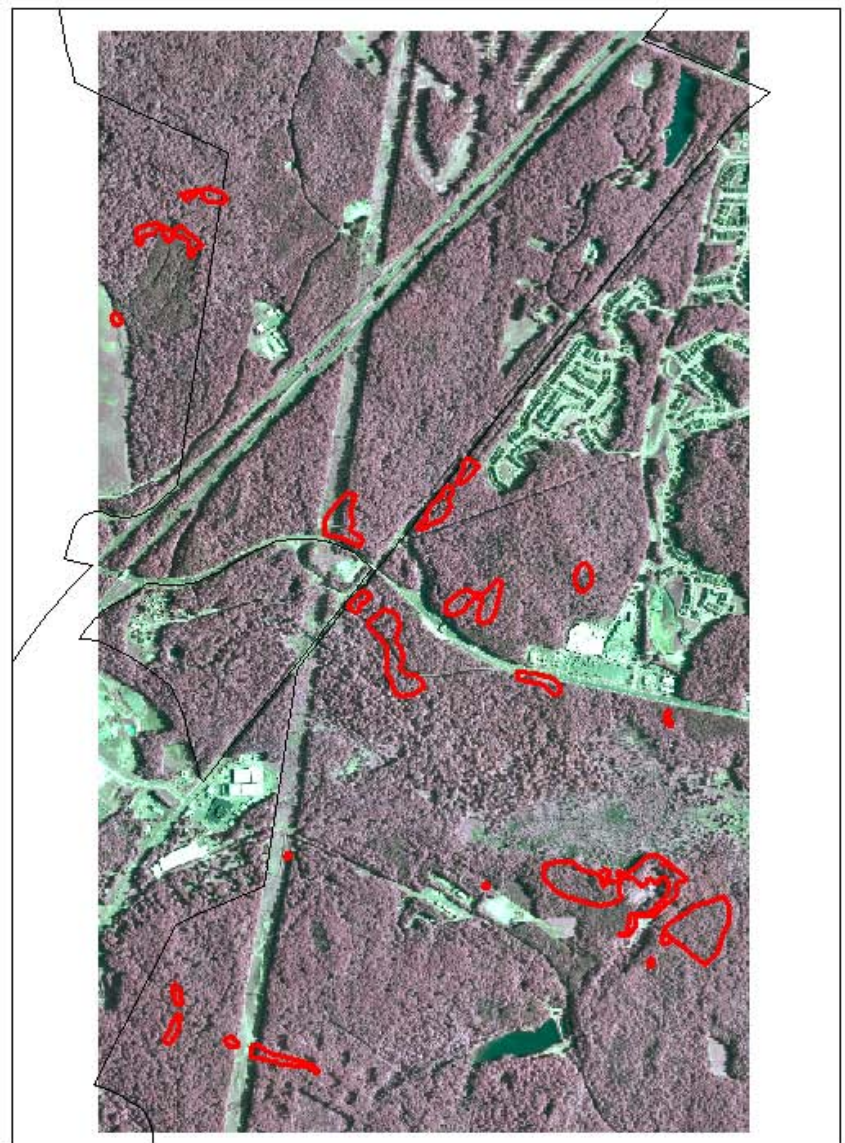


Installation is indicated by the white outline, and the area of interest considered here is indicated with the green box.



Natural Color



CIR rendering



Legend

-  Prehistoric Cultural Sites
-  InstallationArea

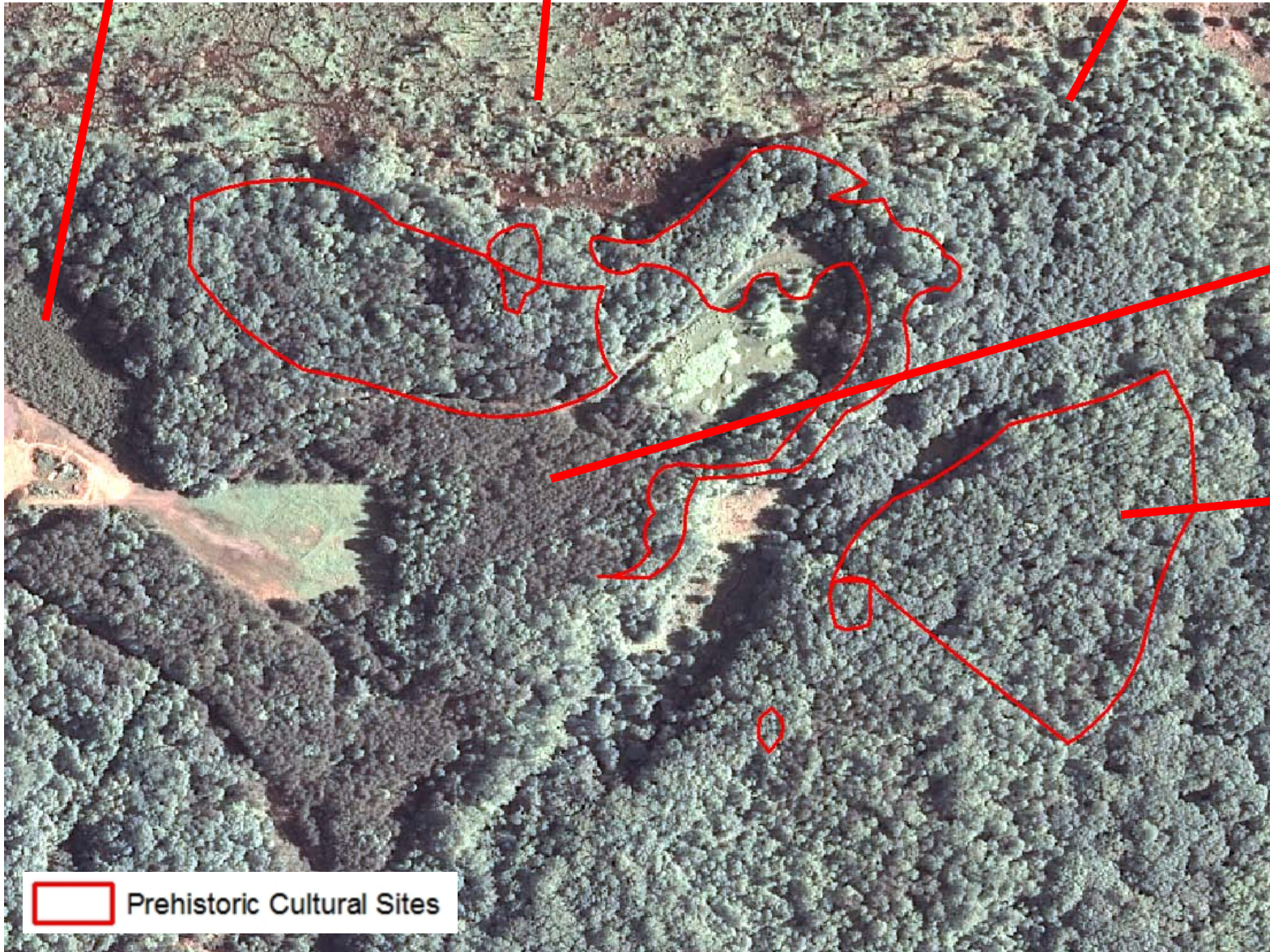
0 375 750 1,500 Meters



Shrubs and low trees


Marshy, low shrubs and emergent
vegetation

Open forest, low-lying



Closed
conifer
forest

Closed
hardwood
forest

 Prehistoric Cultural Sites

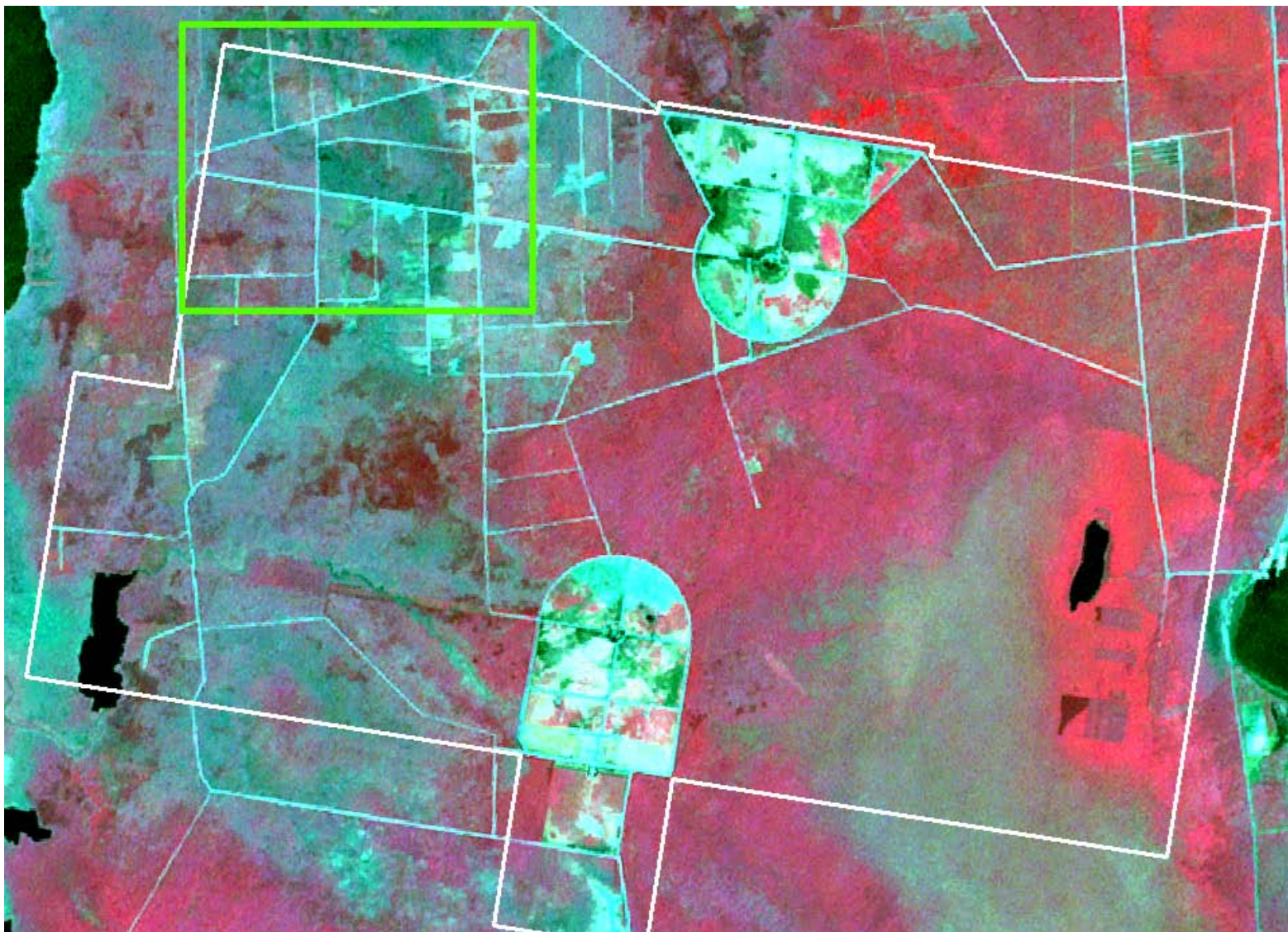
Photointerpretation Results

- **25** total sites within the area of interest
- Percent land cover composition of archaeological sites:
 - Pine and hardwood, hardwood (oak) dominant: **48%** (12/25)
 - Closed hardwood forest: **28%** (7/25; 3 share cover with closed pine)
 - Closed pine forest: **12%** (3/25; all share cover with closed hardwood)
 - Pine and hardwood, pine dominant: **12%** (3/25)
 - Low-lying mesic forest (maple and red oak dominant): **4%** (1/25)

Quantico Summary

- Previous work has found hardwood-dominated upland areas and areas along waterways to be important
- 48% of sites in the area of interest are dominated by upland hardwood forest that contains scattered pines, which supports the previous conclusion
- Untested areas of this vegetation type should have the highest potential for discovery of new cultural sites

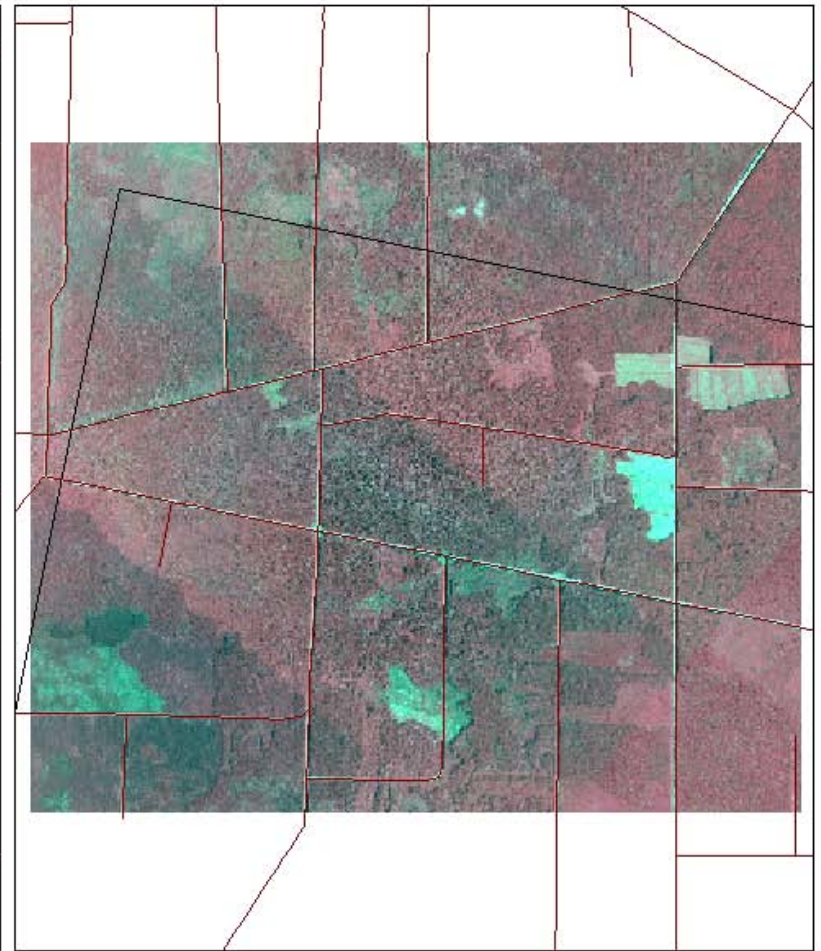
Dare County Bombing Range



Installation is indicated by the white outline, and the area of interest considered here is indicated with the green box.

Natural Color

CIR rendering



Legend

- DCBR Roads
- DCBR Boundary

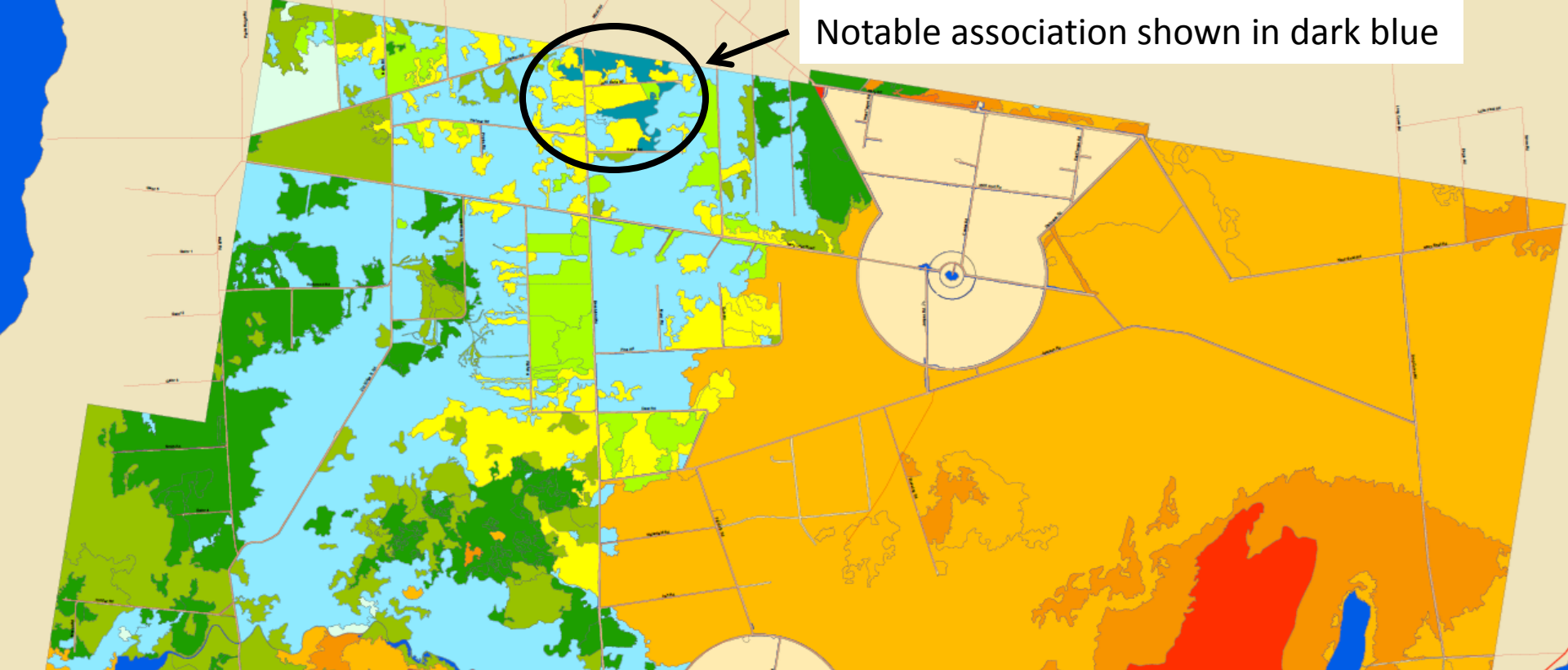


Analysis

As there are no identified archaeological sites within the Dare County Bombing Range, aerial imagery was instead used to determine the identifying characteristics of a notable vegetation type (the Diamondleaf oak-Swamp blackgum association) that occurs on the range. We focused on this forest type because of its occurrence on more upland soils with a loam component, where traditional archaeological testing can be most effective.

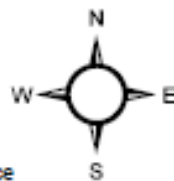
The boundary of the association was digitized and aerial photography within the polygon of the association was analyzed for patterns and compared to patterns of other forest types.

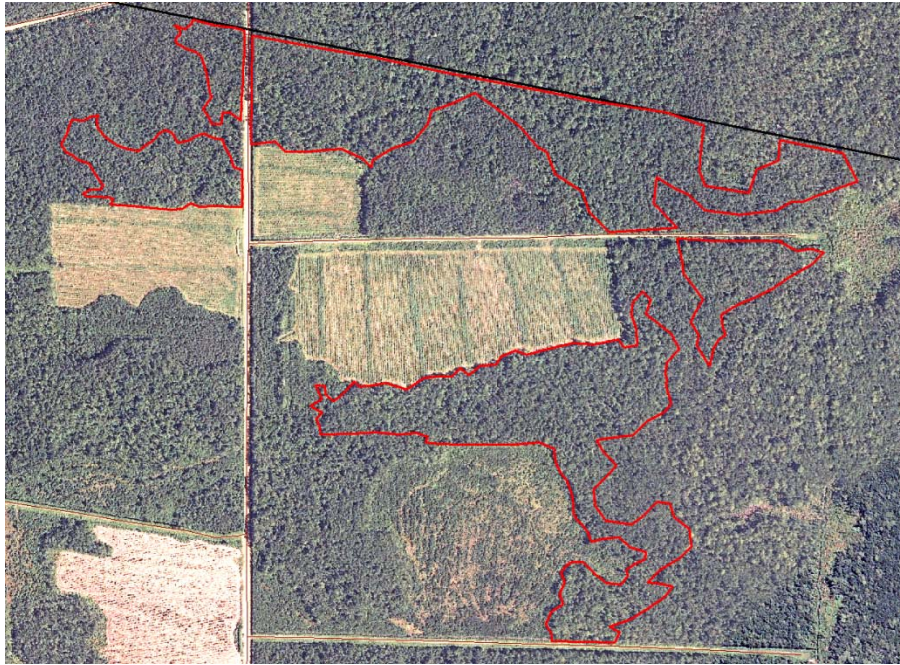
Notable association shown in dark blue



Dare County Range Vegetation Classification National Vegetation Classification System Alliance

-  Administrative
-  Surface Hydrology
-  Bald-cypress - Swamp Blackgum - (Water Tupelo) Saturated Forest Alliance
-  Swamp Blackgum - Red Maple - (Tuliptree) Saturated Forest Alliance
-  Diamondleaf Oak - Swamp Blackgum Saturated Forest Alliance
-  Atlantic White-cedar Saturated Forest Alliance
-  Loblolly Pine - Atlantic White-cedar - Red Maple - Swamp Blackgum Saturated Forest Alliance
-  Loblolly Pine - Sweetgum - Red Maple Saturated Forest Alliance
-  Loblolly Pine Saturated Forest Alliance
-  Pond Pine Saturated Woodland Alliance
-  Sweetbay - Swampbay Saturated Forest Alliance
-  Shining Fetterbush - Little Gallberry Saturated Wooded Shrubland Alliance
-  Honeycups - Shining Fetterbush - (Big Gallberry, Little Gallberry) Saturated Shrubland Alliance
-  Saltmeadow Cordgrass - (Saltgrass) Tidal Herbaceous Alliance





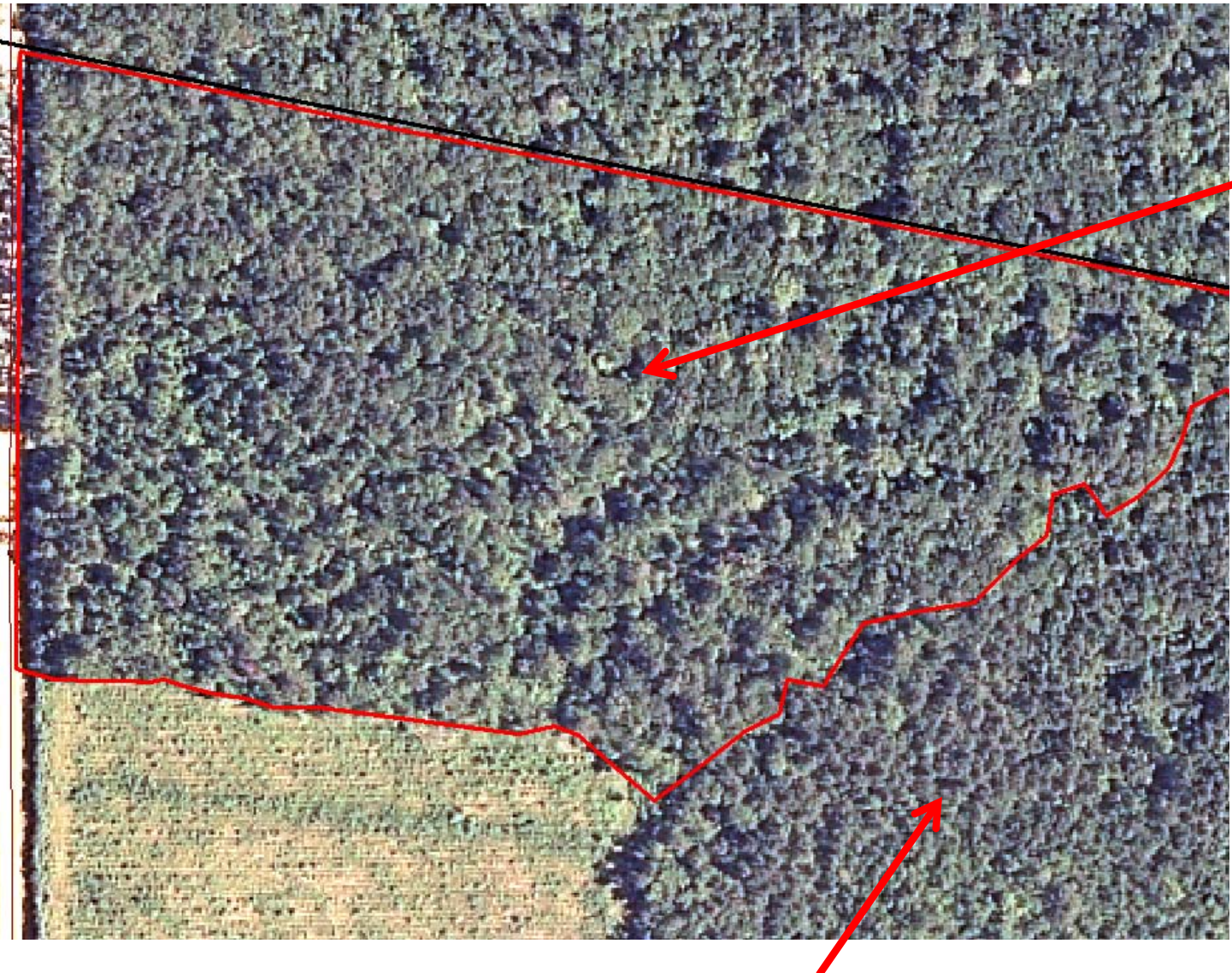
Natural color rendering

Texture and tone differences exist between the association containing diamondleaf oak and surrounding associations.

Both renderings are useful in determining boundaries between different vegetation types.

CIR rendering

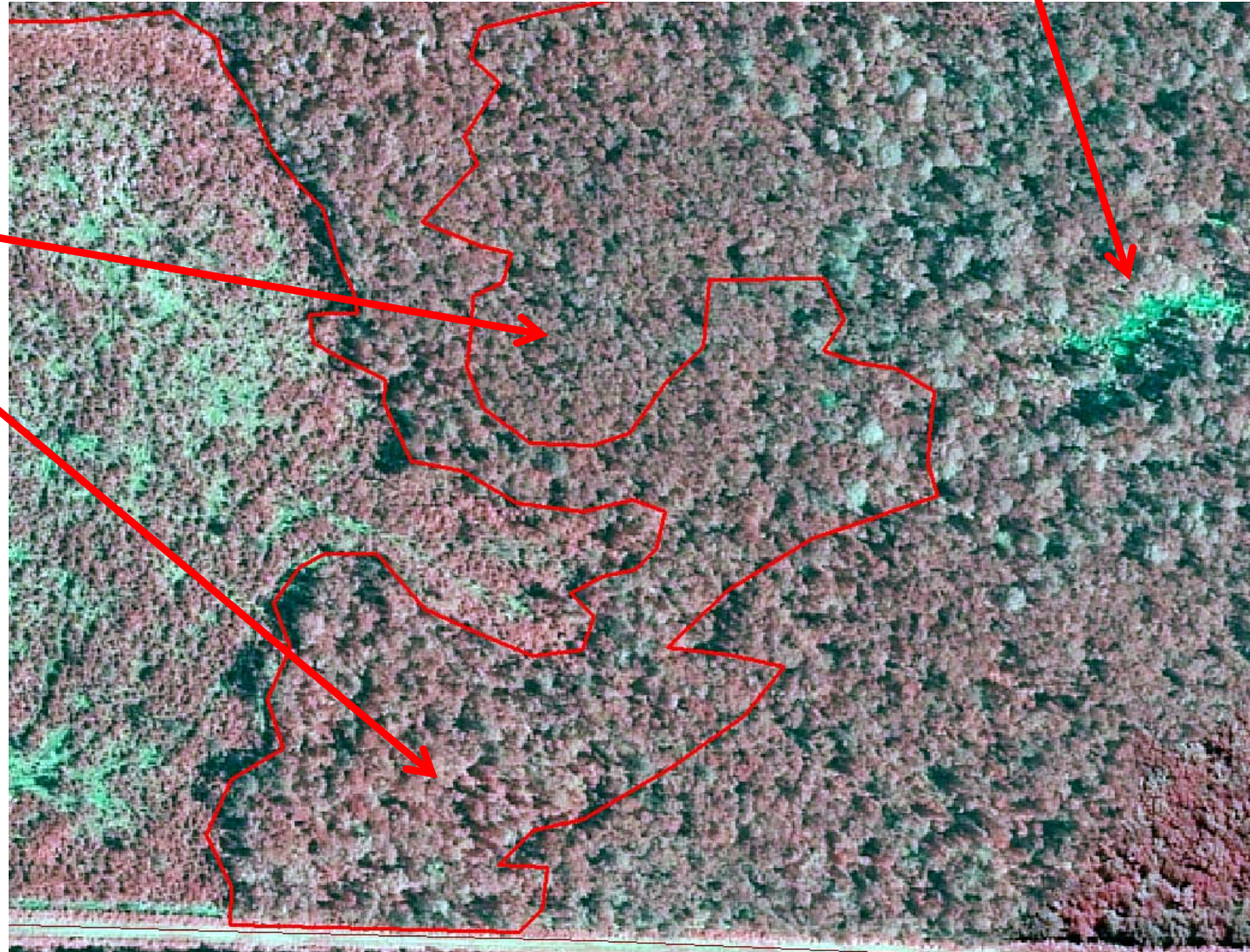


An aerial photograph of a forest. A red line outlines a large area on the left and bottom. A black line runs diagonally across the top. Two red arrows point to specific spots within the forest canopy. The top-left area is darker and more textured, while the bottom-right area is lighter and more uniform in color.

A few conifer crowns are apparent in the diamondleaf oak association (indicated by arrow), however the difference in composition is apparent.

Textural and tone differences exist between the association containing more hardwood species and the association containing more pine (loblolly pine, indicated by arrow). The differences are due to the darker color of the conifers and the variation in canopy species between the two associations.

More saturated, patchy areas are easily distinguishable from the closed canopy of the oak association.



The CIR rendering shows a slight textural difference between pine associations (top arrow) and the oak association (bottom arrow), due to differences in crown shape.

Photointerpretation Results

- Differences apparent in natural color rendering:
 - Appears more 'uneven' in texture when compared with surrounding vegetation which is dominated by loblolly pine
 - Texture changes in more saturated forest types because patches where the water is too deep for tree establishment appear as gaps
- Differences apparent in CIR rendering:
 - The association containing diamondleaf oak shows a darker red color than the loblolly pine surrounding it
 - Color changes between more saturated areas that have more lower vegetation such as shrubs appearing through canopy gaps (higher reflectance of the vegetation in these patches)

DCBR Summary

Archaeological sites cannot be identified on the Range because of the very thick layer of organic peat in highly saturated areas.

These conditions resulted in limited archaeological testing at the Range.

However if further testing were to be conducted, more upland sites containing an oak component could be targeted.

Overall Conclusion

- The vegetation types containing high density of archaeological sites should show the highest potential for discovery of previously unknown cultural sites.
- Untested areas can be examined for these vegetation types to prioritize shovel testing.
- Remote sensing, especially high-resolution aerial imagery, is also useful in efficiently identifying potentially human-modified features on the ground (e.g., mounds with regular shapes or edges).