

How to Prepare Vegetation Overlays as Accomplished at Harpers Ferry

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Harpers Ferry National Historic Park (HFNHP) is in the process of developing an extensive spatial database for its geographic information system (GIS). Aerial photography of the park and adjacent lands was obtained for the purpose of developing a vegetation overlay. Personnel in the Department of Forestry at Virginia Tech (VT), stereoscopically examined aerial photographs in order to identify and delineate vegetation types and prepare the vegetation overlays necessary for entry into the GIS. The purpose here is to describe the process we used to develop this vegetation information, and what we learned about this process for those who will perform similar tasks in the future.

Creation of Vegetation Overlays

The first step in any mapping project is to define a classification system. Seven classes were defined, covering forested and non-forested land. The Non-Forested classes included non-vegetated developed land, vegetated developed land, agricultural land, and water. The Forested classes included hardwoods, conifers, and mixed hardwoods and conifers. A Five (5) acre minimum mapping unit was specified. The selected classes are shown in Table 1.

The creation of the 37 vegetation overlays involved a number of steps. First, photo interpretation of the 1:24,000 scale normal color aerial photographs was performed. We had four sets of aerial photos available to

create the vegetation overlays: 1:24,000 scale normal color leaf-off, 1:3,000 scale normal color leaf-off, 1:12,000 scale CIR leaf-on, and 1:12,000 scale leaf-off. Only the 1:24,000 scale normal color photos, however, provided complete coverage of the entire region of interest. Of the 17 normal color photos in the set, 6 were chosen that covered the area of interest. For each of 6 photos, mylar overlays were photo interpreted using an Old Delft Scanning Stereoscope. Photo mylar overlays are vegetative classifications traced on mylar over the photographs of the region of interest. Color, texture, shadow pattern, size, and shape of the region of interest were used to assist in classification.

Ground Survey

Next, a preliminary ground survey was conducted to evaluate the photo interpretation. From this initial ground survey, there appeared to be some error in the original interpretation of the photos, particularly in the differences between P and MIX and between MIX and UPH. Very little of what was initially called MIX on the photo appeared to be MIX on the ground. Most of what was called MIX was in fact UPH. Where available, additional CIR photo information was then used to re-examine these cover types.

The initial ground survey and examination of the CIR photos showed the need for a more extensive ground survey. A second field check

was performed to re-evaluate the photo interpretation after the changes made following the first field check. During the field check, we concentrated mainly on areas that were classified as either P or MIX to determine their accuracy. The second field check resulted in changing a great deal of P and MIX areas on the photo mylar overlays to UPH. We determined that our errors in classification were due to a misinterpretation of hardwood (deciduous) species that had already leafed-out as MIX and P. In addition, some ground cover that had leafed out in the hardwood regions may have caused us to interpret some UPH regions as MIX. Changes in photo interpreted information were made according to the results of the second field check.

The photo interpreted information was then transferred to base maps of the park. A Bausch and Lomb Zoom Transfer Scope (ZTS) was used to assist in the transfer of the classified aerial photos onto the base maps. The ZTS was used because the transfer from the normal color 1:24,000 scale aerial photos involved both a change in scale and image geometry. The ZTS uses mirrors, back-lit screens, variable lighting, and optics to allow the user to superimpose and trace the vegetation overlay onto the desired base map. The vegetation overlays contain the same information as the photo mylar overlays at the scale of the base maps. The "zoom" and "skew" controls on the ZTS were used to match to scale of the photo mylar overlay with the scale of the base map and to account for geometric distortion in the photographic image.

Distortion Causes

Geometric distortion is the combined result of optical distortion from inferior lenses, tilt, aircraft motion; and relief displacement. Campbell (Campbell, James, B., "Introduction to Remote Sensing," The Guildford Press, 1987.) states that "the most important source of positional error [geometric distortion] in vertical photography is probably relief displacement." Relief displacement causes objects to appear to lean away from the center of the photograph as one moves towards the photo's edge. Uneven terrain, such as encountered at HFNHP, significantly increases relief displacement making the matching of vegetation overlays and bases maps difficult at times.

The ZTS used by Virginia Tech was slightly modified by raising the instrument approximately 6" on stable wooden blocks to increase the areas that could be transferred at

Table 1. Selected Classes

Class	Definition	Appearance on Normal Color Photo
DVC	Developed with Vegetative Cover	Some roads interspersed among the green textured areas. Some buildings visible as white rectangles.
DVN	Developed without Vegetative Cover	Interspersed with white lines and blocks representing roads and buildings. Little vegetation.
AGR	Agricultural Land	Regular patches of green and light brown, smooth in texture.
WAT	Water Areas	Dark, smooth textured areas. Sometimes bright or sparkled because of sunlight reflection.
UPH	More than 70% upland hardwood Species	Overstory brown or a light pale green. Coarse textured. Most prevalent category.
P	More than 70% Conifer	Dark green vegetative overstory. Coarse textured and irregular in shape.
MIX	Less than 70% of Conifers or Deciduous	Interspersed dark green, and brown overstory. Coarse textured and irregular in shape.

one time. This modification did not appear to increase distortion. Very little of the ZTS's "stretch" function was used in the transfer of the image as stretching did not appear to help in matching the two images. Manual alignment of the base map and the aerial photo followed by slight adjustments with the ZTS's controls worked best. Usually, one or two distinct man-made features such as a roads or buildings were used to align the two images. Where no man-made features were present on the base map, the matches and subsequent transfer were approximate at best.

Lessons Learned

The selected classification system must contain information relevant to the user and be achievable using the imagery at hand. These two goals were fulfilled through close cooperation and communication between those making the maps (Virginia Tech) and those using the maps (HFNHP). This step always requires some compromise. Having appropriate aerial photographs of the region of interest is important in the creation of vegetation overlays. For the Harpers Ferry Project, we had four sets of aerial photos available to create the vegetation overlays. Unfortunately, only the 1:24,000 scale normal color photos covered the entire region of interest. The additional photos in conjunction with ground surveys were used to verify the photo interpretation. Normal color aerial photographs were not as effective as CIR photographs for vegetative classification. Conifers and deciduous trees both had similar appearance on the normal color photos. In the CIR photos, the differences between conifers and deciduous trees was more pronounced. The second field check resulted in changing a great deal of conifers and mixed areas on the photo mylar overlays to hardwoods. Using CIR leaf-off photos from the onset would have reduced changes to the photo mylar overlays. Having CIR photos of the entire region of interest would improve the quality of vegetation overlays for use in GIS.

Film type, scale, and season of acquisition greatly influenced the effectiveness of the photo interpretation. The normal color, 1:24,000 scale photos suffered most from an early Spring acquisition where hardwoods were just leafing out. These hardwoods appeared similar to conifers in the photos and were a cause of error and confusion. Paine (Paine, David P., *Introduction to Aerial Photography For Natural Resource Management*, Published by O.S.U. Book Stores, Corvallis, Oregon, 1977.) lists the advantages of CIR films as:

1. Much better penetration of haze.
2. Emphasizes water or moist areas.
3. Good differentiation between hardwoods and conifers.

4. Sick, dying or vegetation under stress is more easily detected.

By studying aerial photographs of different scales, we concluded that scales between 1:12,000 and 1:18,000 would be optimal for vegetation classification of this type. The 1:3,000 scale photos were of too large a scale, had excessive relief distortion, and suffered from the same classification problems as the 1:24,000 scale photos. The 1:24,000 scale photos used in the study did not show enough detail to distinguish some vegetation types.

The leaf-on CIR photos were of acceptable scale, but in the leaf-on photos, most vegetation appears red. It is possible to distinguish between conifers and hardwoods by the color variations, but it is difficult and unnecessary. The CIR leaf-off photos differentiate between conifers and hardwoods distinctly. Hardwoods appear as dark brown while conifers appear as dark red.

Our recommendation for future photo interpretations is to procure CIR photos for the entire region of interest at a scale between 1:12,000 and 1:18,000 in Winter prior to vegetation leaf-out. The Normal Color film used in this study suffered from being taken at a transitional time where some hardwoods were just leafing out. Normal Color film maybe more effective if taken during a period of complete leaf off. The film types are summarized in Table 2.

In the Harpers Ferry Project, some vegetation overlays were classified from three or more photos. These overlays suffered from utilization of information near the edge of the photo effective area where relief displacement is greatest. The effects of this displacement was evident when edge-matching the 37 vegetation overlays. The large change in scale and relief distortion resulted in some lines being off by as much as .25" between two vegetation overlays. Where possible, the

photo mylar overlays were consulted in an attempt to match the vegetation overlays. Forced edge-matching of the 37 vegetative overlays, while possible, would not reflect the data inaccuracies resultant from manual photo interpretation, scale changes and relief distortion. It is recommended that the maximum number of photos per vegetative overlay be two, and that one is ideal. In the Harpers Ferry Project, the overlays requiring the greatest number of photos showed the greatest relief distortion. As photo scale is reduced, the number of photos per overlay increases with subsequent increases in relief distortion. A trade-off can therefore be seen between increased detail and increased relief distortion.

Conclusions

Having aerial photographs of correct scale, film type, and date of the region of interest minimizes effort in the creation of vegetation overlays for use in GIS. In addition, ground surveys are critical to verify the photo interpretation. While the ZTS is an effective tool for the transfer of cover type information from photos to mylar overlays, where there are no identifiable man made features, the ZTS is not very helpful. CIR photos, leaf-off, were most effective for delineating among forest cover types. Ideally, CIR photos, leaf-off, of a scale between 1:12,000 and 1:18,000 should be taken for the entire region of interest. In choosing stereo pairs, care should be taken to limit the number of photos per overlay to two (2) where possible.

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Table 2. Summarization of Film Types

Film Type	Scale	Season	Appearance of Conifers	Appearance of Hardwoods	Comment
Normal Color	1:24,000	Early Spring	Dark Green	Brown or Light Green	Not enough detail. Timing poor, hardwoods just leafing out — look like conifers.
Normal Color	1:3,000	""	""	""	Difficult to classify vegetation types. Relief distortion excessive.
CIR	1:12,000	Leaf-on	Light Pink to Red	Darker Pink to Reddish color	Difficult to distinguish between conifers and hardwoods.
CIR	1:12,000	Leaf-off	Pink to Red	Brown	Best of vegetative classification, easy to distinguish between conifers and hardwoods