Application of DEM-derived Floodplain Models to Vegetation Mapping in Kentucky

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Introduction

Efforts by the Kentucky Gap Analysis Project (KY-GAP) to produce a statewide vegetation map using satellite image classification are ongoing. Because the spectral resolution of Landsat TM is not adequate for detailed vegetation mapping in this region, development of ancillary data layers for use in a vegetation modeling approach is essential. This poster presents a method for generating a simulated floodplain layer working within the constraints of limited data sources, time, and money. The simulated floodplain model was generated in ArcInfo GRID using USGS Digital Elevation Models (DEMs) and Digital Line Graphs (DLGs). A similar approach has been successfully applied to predicting animal distributions (Rowe 1999).

Study Area
The Upper East Gulf Coastal Plain of Kentucky (Fig. 1) was selected for this study. This region contains a wide variety of river and stream morphologies ranging from large river systems (Mississippi and Ohio Rivers) to small streams.

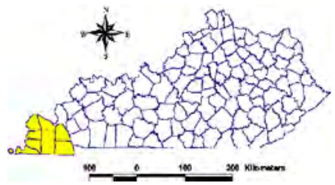

Figure 1. Eight county study area within the Upper East Gulf Coastal Plain of Kentucky.

Methods

Data sources for this study include:
1) USGS 1:24000 quadrangle Digital Elevation Models (**DEMs**). DEMs were converted to 30 meter ArcInfo GRID format and merged for the entire study area. Focal mean filtering (7x7), fast fourier transform, and an iterative adaptive box filter (Eliason and McEwen 1990) were applied to correct systematic and random errors.
2) USGS Digital Line Graphs (**DLGs**).
3) A pre-existing **digitized floodplain map** (Fig. 2). Floodplains were outlined on USGS 1:24000 topographic quads, and subsequently hand digitized. The digitized floodplain coverage was converted to grid format using POLYGRID and LINEGRID commands.

The **simulated floodplain model** was produced from the filtered DEM grid and gridded DLGs. First order streams were omitted from the DLG coverage. A cost surface was created such that all stream pixels (source pixels) were assigned a cost of zero, and all non-stream pixels were assigned a cost, where cost = (DEM value — Focal Minimum) using a Focal Minimum filter (3x3) (Fig. 3). The GRID function COSTDISTANCE was then used to determine the path of least cost accumulation. Well-developed floodplains that are wide and flat accumulate cost at a lower rate moving outward from stream (source) pixels; whereas, more incised streams with steep valley walls accumulate cost at a higher rate. A cost accumulation cutoff value must then be determined to define the floodplain.
Four quads representing the range of stream morphology within the study area were selected as samples to estimate the cost accumulation cutoff value (Fig. 4). Cost accumulation values corresponding to pixels in the pre-existing, digitized floodplain coverage were extracted from the cost accumulation grid. The average cost accumulation value from the sample was used as the cutoff. Because large river floodplain morphology (e.g. Mississippi River) differed markedly from floodplains of smaller streams in the study area, cost accumulation cutoff values were estimated for 7th-8th order streams separately from 2nd-6th order streams; the two grids were subsequently merged.
The simulated floodplain grid was then compared to the existing digitized floodplain coverage for the entire study area. Ground truth points collected by KY-GAP for vegetation mapping purposes were categorized as lowland and upland, and compared to the simulated and digitized floodplain grids.

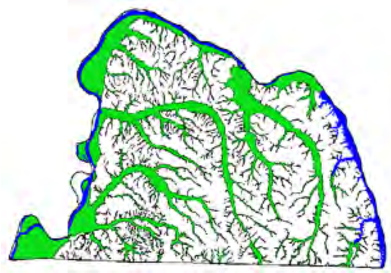

Figure 2. Digitized floodplain coverage for study area and water mask (blue).

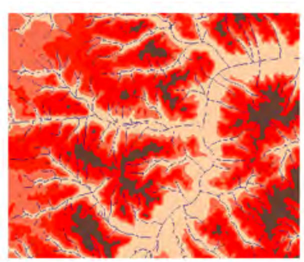

Figure 3. Example of cost accumulation surface derived from DEMs and DLGs (shown in blue).

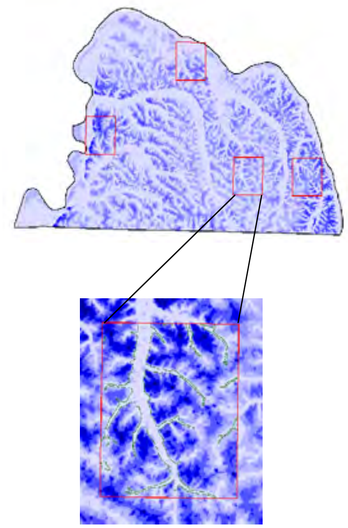

Figure 4. One of four quads used to sample cost accumulation values corresponding to gridded digitized floodplain boundary (shown in green).

Figure 5. Comparison of simulation model to digitized floodplain. Areas of disagreement are colored red (digitized as floodplain, but modeled as upland) and green (digitized as upland, but modeled as floodplain). Dark blue indicates areas within water mask.

Results and Discussion

Average cost accumulation values for gridded stream pixels were 35.5 for 7th-8th order streams and 9.2 for 2nd-6th order streams. These values were used as cutoff values to define the floodplain. Because numerous areas within the floodplain were coded as upland due to noise in the DEMs, the GRID function REGIONGROUP was used to recode inclusions of less than 1000 contiguous pixels to floodplain.
When compared pixel-by-pixel, the digitized and simulated floodplain grids were determined to have 86.5 % correspondence (Table 1, Fig. 5). When compared to actual ground truth points, overall accuracy was 95.9% and 93.1% for the digitized and simulated floodplain grids, respectively.
Some areas associated with the large river systems proved to be problematic (seen in red in Fig. 5). Many of these areas are sloughs and abandoned oxbows that are separated from the river by extensive levee systems, but that are often drained by first order streams directly into the river. Thus these are areas of low cost accumulation. In addition, floodplains along low order streams tend to be over-estimated by the model (seen in green in Fig. 5). This source of error is associated with coding problems in the original DLG coverage; second order streams were not consistently coded making it difficult to determine the correct cost accumulation cutoff value.
Exceptional correspondence between the simulated and digitized floodplain grids, and favorable comparisons to existing ground truth (Table 2) indicate that this model can be effectively used as an ancillary data set in vegetation modeling. This approach has been used successfully by KY-GAP as a pre-stratification tool to delineate lowland from upland vegetation types.

Table 1. Comparison of digitized and simulated grids.

Simulated grid	Digitized grid: Floodplain	Upland	Total
Floodplain	1,754,909	777,056	2,531,965
Upland	151,234	4,173,122	4,324,356
Total	1,906,143	4,950,178	6,856,321

Overall accuracy = 86.5 K_{hat} = 84.9

Table 2. Comparison of vegetation ground truth to grids.

Digitized grid	Reference data: Flood-plain	Upland	Total
Flood-plain	1247	42	1289
Upland	37	583	620
Total	1284	625	1909

Overall Accuracy = 95.9% K_{hat} = 95.8%

Simulated grid	Reference data: Flood-plain	Upland	Total
Flood-plain	1235	82	1317
Upland	49	543	592
Total	1284	625	1909

Overall Accuracy = 93.1% K_{hat} = 93.1%

Literature Cited

Rowe, J. 1999. Landscape-based wetland and riparian habitat modeling for amphibians and reptiles. Gap Analysis Project Annual Conference. Duluth, MN. August 1999.

Eliason, E.M. and A.S. McEwen. 1990. Adaptive box filters for removal of random noise from digital images. *Photogrammetric Engineering and Remote Sensing*. 56: 453-458.

Acknowledgements

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