An Assessment of Cecil County's Green Infrastructure

Technical Report for the Cecil County Green Infrastructure Plan

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ABSTRACT

The most important natural lands in Cecil County, Maryland, comprise its "green infrastructure" (GI), and provide essential ecosystem services. In 2000, the Maryland Department of Natural Resources identified a statewide GI hub and corridor network, based largely on data from the early 1990's. We examined recent land use changes in Cecil County and their effect on this GI network. We found that the developed area in the county more than doubled between 1973 and 2002, at the expense of forests, wetlands, and agriculture. Furthermore, the rate of development has been increasing. 39 of 46 hubs entirely or partially within Cecil County were affected by development between 1992 and 2002. 36 corridor or hub connections were broken by development, including almost all those north of Interstate 95.

We updated the county's GI using 2002 land use and 2005 aerial photography, identifying alternate connections in some cases. The updated network, which represents 37% of the County's land, includes 75% of the County's forest land and 94% of its wetlands. We ranked hubs according to their relative ecological importance, finding those on the Elk Neck peninsula to rank the highest.

KEYWORDS: Cecil County, Maryland, Green Infrastructure, hubs, corridors

OVERVIEW OF MARYLAND'S GREEN INFRASTRUCTURE

Maryland's most important natural lands comprise its "green infrastructure" (GI), and provide a natural support system. Ecosystem services, such as cleaning the air, filtering and cooling water, storing and cycling nutrients, conserving and generating soils, pollinating crops and other plants, regulating climate, sequestering carbon, protecting areas against storm and flood damage, and maintaining aquifers and streams, are all provided by the existing expanses of forests, wetlands, and other natural lands. These ecologically valuable lands also provide marketable goods and services, like forest products, fish and wildlife, and recreation. They serve as vital habitat for resident and migratory species, maintain a vast genetic library, provide scenery, and contribute in many ways to the health and quality of life for Maryland residents (Weber 2003).

When wetlands and forest are developed into human-centered uses, there are costs incurred that are typically not accounted for in the marketplace. The losses in ecosystem services are hidden costs to society. These services, such as cleansing the air and filtering water, are fundamental needs for humans and other species, but in the past, the lands providing them have been so plentiful and resilient, that they have been largely taken for granted. In the face of a tremendous rise in both population and rate of land use conversion, many people now realize that these natural or ecosystem services must be afforded greater consideration. The breakdown in ecosystem functions causes damages that are difficult and costly to repair, as well as taking a toll on the health of plant, animal, and human populations (Weber 2003).

An Assessment of Cecil County's Green Infrastructure

Maryland's green infrastructure was mapped using satellite imagery from 1991-93, road and stream locations, biological data, and other information, with the results reviewed by scientists, local government officials, and conservation groups. Although even yard and street trees provide some benefits, like shading and air purification, the state's most important natural lands are those that are large and intact enough to provide a full range of environmental functions (Weber 2003).

The first step in the assessment of the state's green infrastructure identified the most important remaining natural lands, called "hubs." These are typically unfragmented areas hundreds or thousands of acres in size, and are vital to maintaining ecological health. They provide habitat for native plants and animals, protect water quality and soils, regulate climate, and perform other critical functions (Weber 2003).

The second step connected hubs with "corridors" - linear remnants of natural land such as stream valleys that allow animals, seeds, and pollen to move from one area to another. They also protect the health of streams and wetlands by maintaining adjacent vegetation. Preserving linkages between the remaining blocks of habitat will ensure the long-term survival and continued diversity of Maryland's plants, wildlife, and environment (Weber 2003).

For more information about Maryland's Green Infrastructure Assessment, see Weber (2003) and Weber et al. (2006), or http://www.dnr.state.md.us/greenways/gi/gi.html. For more information about green infrastructure in general, the most comprehensive work is Benedict and McMahon (2006).

CHANGES IN CECIL COUNTY'S GREEN INFRASTRUCTURE

Land Use Changes in Cecil County

Based on 2002 land use data, forests and wetlands comprised 39% of the County's land, with agriculture comprising 44%, and urban and other developed comprising 16%. Table 1 shows how land use has changed in Cecil County between 1973 and 2002. Developed area has more than doubled, at the expense of forests, wetlands, and agriculture. Furthermore, the rate of development has been increasing, with more area being converted.

Table 1. Land use changes in Cecil County, 1973-2002.

Category	Acres			% change 1973-2002	% change 1997-2002
	1973	1997	2002		
Developed	15,845	31,077	35,962	127.0%	15.7%
Agriculture	112,729	102,489	98,655	-12.5%	-3.7%
Forest and wetlands	91,259	86,002	84,853	-7.0%	-1.3%

Category	Acres			Avg. ac change per year	
	1973	1997	2002	1973-1997	1997-2002
Developed	15,845	31,077	35,962	635	977
Agriculture	112,729	102,489	98,655	-427	-767
Forest and wetlands	91,259	86,002	84,853	-219	-230

Only 17% of new developed area (between 1997 and 2002) fell within town boundaries. About half (52%) of new development fell within town or designated growth boundaries. Sewer service did not seem to be an issue; only 26% of new development had existing sewer service.

Examining data from the Maryland Department of Planning, 91% of development by area in Cecil County between 1997 and 2004 was outside of Priority Funding Areas (PFAs), one of the highest ratios in the state: only Garrett and Caroline counties were worse. The average single-family lot size throughout the county was 1.144 ac; inside PFAs, 0.243 ac; and outside PFAs, 1.834 ac. Between 2000 and 2005, 5319 housing units were authorized for construction, with 85% (4509) of these being single-family homes.

Impacts to Green Infrastructure

We then mapped recent development within the green infrastructure (Fig. 1) and tabulated its impacts. 39 of 46 hubs entirely or partially within Cecil Co. (85%) were affected by development between the early 1990's and 2002. 8 of these hubs (17%) were significantly reduced or fragmented. 36 corridor or hub connections were broken by development, including almost all those north of I-95.

UPDATE OF CECIL COUNTY'S GREEN INFRASTRUCTURE

Green Infrastructure Network Update

Because maps of green infrastructure in Cecil County were no longer accurate, we updated it using 2002 land use and 2005 aerial photography (see Appendix A for details). In many cases, we identified alternate corridors where those identified earlier had been broken. We also identified linkages to the Delaware Ecological Network (see Weber, 2007) on the eastern border, and to areas of forest in Pennsylvania.

The updated Cecil GI (Fig. 2) is much more accurate than the earlier statewide GI, both because it is based on more recent data, and because the spatial resolution is much finer. Still, conservation and restoration efforts should be preceded by site visits to verify conditions.

Hub and Corridor Analysis

Within the updated network, we identified 59 hubs within the GI network totaling approximately 58,725 acres (see Appendix B, steps 2 and 3, for methodology details). Hubs in Cecil County ranged in size from 200 acres to over 11,000 acres, with the median hub size a little over 600 acres. These hubs provide critical habitat for native plants and animals, protect water quality, provide recreational opportunities for humans, and supply an array of other ecosystem services. Corridors, totaling approximately 22,894 acres, connect the hubs and preserve linkages between these large unfragmented areas. Corridors varied in width but were generally at least 200 meters wide.

In sum, the green infrastructure network encompassed 81,619 acres, or 37% of the County's land (222,969 acres). Based on 2002 land use data, it included 75% of the County's forest and 94% of its wetlands. Only 23% of the network was protected, leaving 63,218 acres unprotected.

Fig. 1. Loss of Green Infrastructure in Cecil County, 1992-2002.

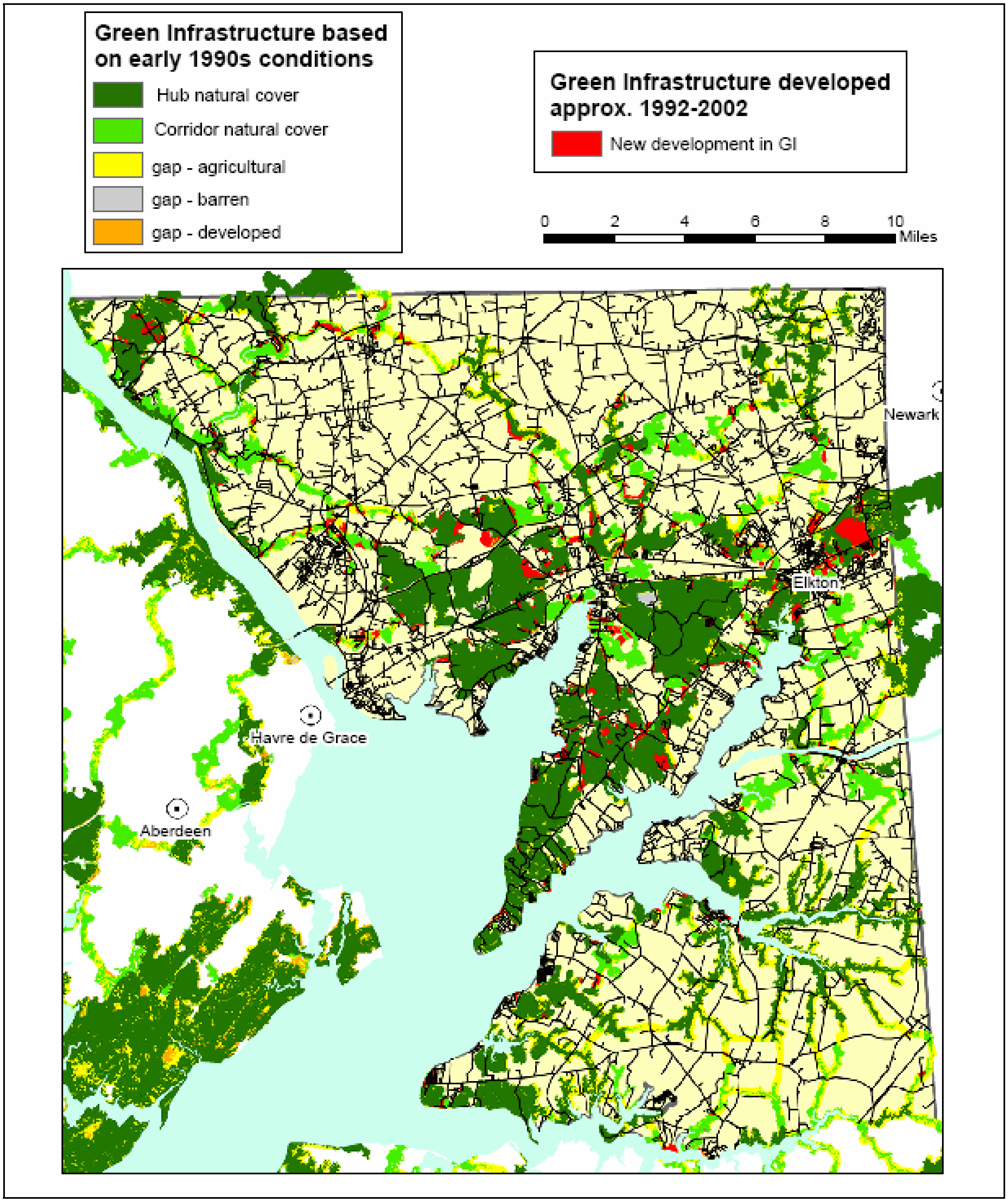
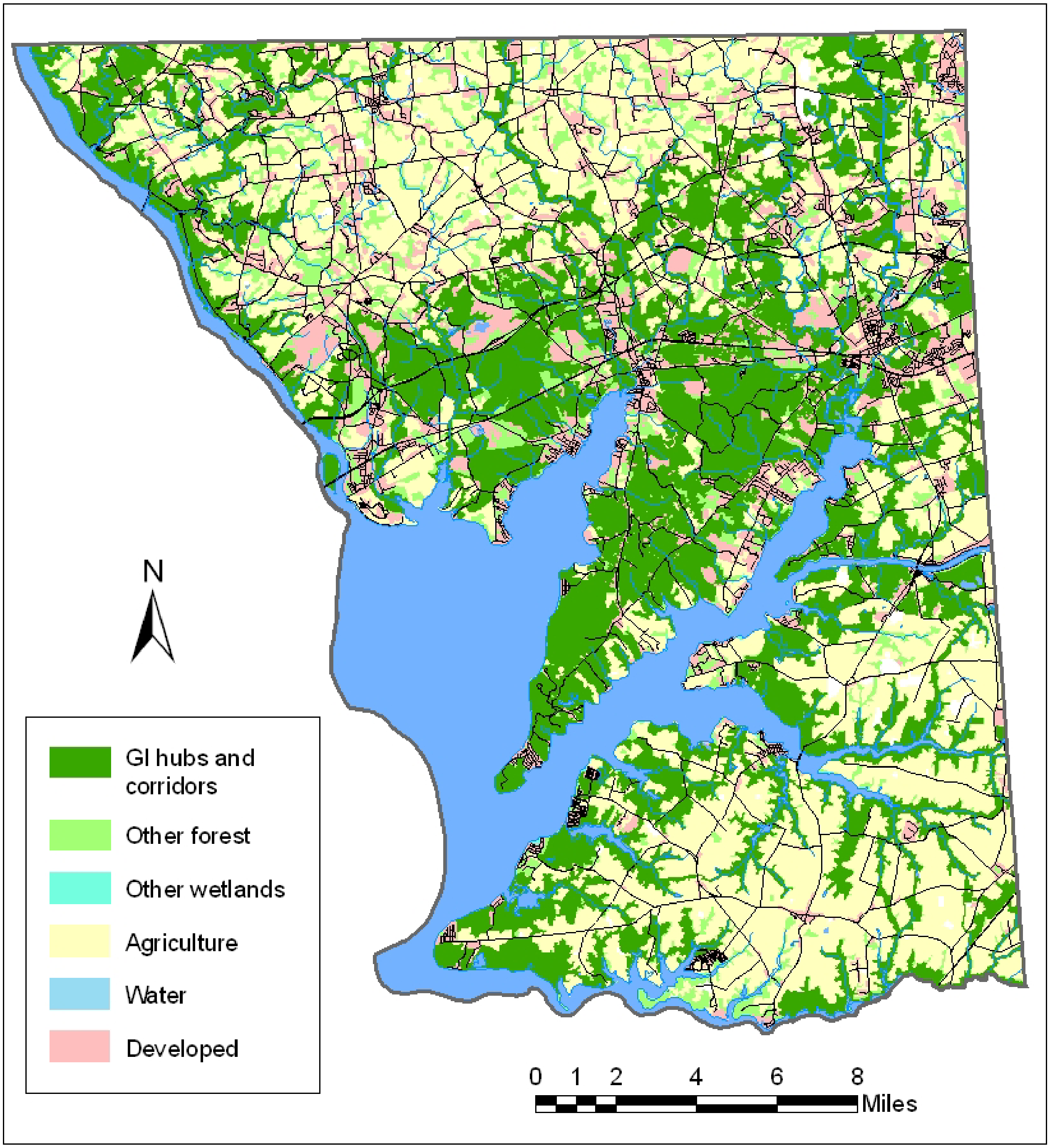


Fig. 2. Updated map of green infrastructure in Cecil County.



Hub Ecological Ranking

Maryland's Green Infrastructure assessment not only identifies a network of hubs and corridors, but assesses ecological conditions and development risk within each hub and corridor. This information can be used to help prioritize protection efforts, by concentrating on those areas of the greatest ecological value and the most at risk.

We calculated a suite of parameters within each hub in the updated GI network (Table 2; see Appendix B for methodology details). The area of interior forest, area of unmodified wetlands, and length of streams in a hub were highly correlated with hub area (88-99%). These three parameters were also highly intercorrelated (84-95%). Other high correlations were between maximum and mean edge distance (91%), and the number of vegetation alliances and wetland area (79%). Maximum and mean vertebrate richness were only 25% correlated.

Table 2. Parameters used to assess hubs in Cecil County's green infrastructure.

Parameter name	Parameter description	Correlation with hub area
SSPRASENHA	Area of sensitive species habitat (SSPRA) or sentinel watersheds	59%
INTFOR_HA	Area of interior forest (>30m from edge)	99%
UNMODWETHA	Area of unmodified wetlands	88%
STR_RIV_M	Length of streams and rivers	98%
MEAN_SUCC	Fraction in mature and natural vegetation communities (from GAP)	5%
NUMVEGCOMM	Number of natural vegetation alliances (from GAP)	63%
MAXVERTRCH	Maximum modeled vertebrate richness (from GAP)	47%
MEAN_VERTR	Mean modeled vertebrate richness (from GAP)	-21%
MEANWATQUA	Mean water quality rank	13%
MAXEDGEDIS	Maximum distance to edge	48%
MEANEDGEDS	Mean distance to edge	30%
BUF_PCT_GI	Area of other GI within 1 km (measurement of connectivity)	-7%

These parameters were then weighted (Table 3) and used to rank each hub according to its overall ecological importance relative to other hubs in the county. We weighed each parameter equally (1.0), unless two different methods were used to measure a similar condition (e.g., maximum and mean vertebrate richness). In those cases, a weight of 0.5 was assigned to each parameter so that the total weight would add to 1.0.

Table 3. Parameter weights used to rank hubs in Cecil County's green infrastructure.

Hub parameter	Weight
Area of sensitive species habitat (SSPRA) or sentinel watersheds	1.0
Area of interior forest (>30m from edge)	1.0
Area of unmodified wetlands	1.0
Length of streams and rivers	1.0
Fraction in mature and natural vegetation communities (from GAP)	0.5
Number of natural vegetation alliances (from GAP)	0.5
Maximum modeled vertebrate richness (from GAP)	0.5
Mean modeled vertebrate richness (from GAP)	0.5
Mean water quality rank	1.0
Maximum distance to edge	0.5
Mean distance to edge	0.5
Area of other GI within 1 km (measurement of connectivity)	1.0

We performed a sensitivity analysis by comparing the weights in Table 3 (Weight1 in Table 4) to three logical alternatives (Weight2, Weight3, and Weight4), as well as a set of ten random weights.

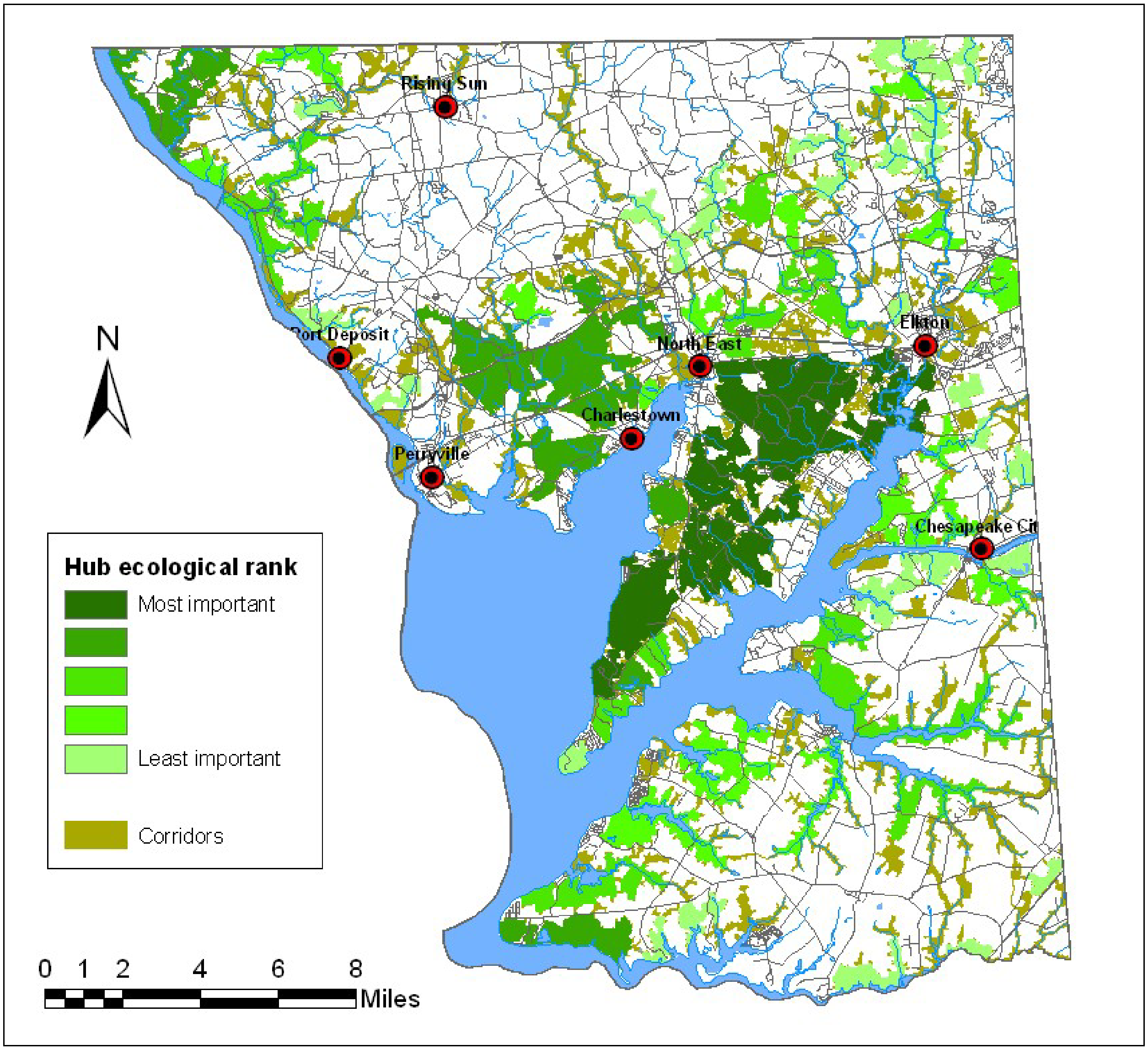
Table 4. Four parameter weights compared rank hubs in Cecil County's green infrastructure.

Hub parameter	**Weight1**	**Weight2**	**Weight3**	**Weight4**
Area of sensitive species habitat (SSPRA) or sentinel watersheds	1.0	1.0	1.0	1.0
Area of interior forest (>30m from edge)	1.0	1.0	1.0	1.0
Area of unmodified wetlands	1.0	1.0	1.0	1.0
Length of streams and rivers	1.0	1.0	1.0	1.0
Fraction in mature and natural vegetation communities	0.5	1.0	1.0	1.0
Number of natural vegetation alliances (from GAP)	0.5	1.0	1.0	1.0
Maximum modeled vertebrate richness (from GAP)	0.5	1.0	0.5	0.5
Mean modeled vertebrate richness (from GAP)	0.5	1.0	0.5	0.5
Mean water quality rank	1.0	1.0	1.0	2.0
Maximum distance to edge	0.5	1.0	0.5	0.5
Mean distance to edge	0.5	1.0	0.5	0.5
Area of other GI within 1 km (measurement of connectivity)	1.0	1.0	1.0	1.0

The four weighting schemes in Table 4 produced very similar hub rankings (96-99% correlated). The highest ranking hubs were always identified as such; results for lower ranking hubs were similar. Therefore, in the absence of strong reason otherwise, we retained the original parameter weights in Table 3. The random weights were only 40-66% correlated (mean = 54%) with the weights in Table 3, implying importance to systematic weights.

Fig. 3 shows the updated GI network with hub ecological rankings. Generally, hubs on the Elk Neck ranked the highest; followed by hubs in the Charlestown/Principio Creek vicinity, along Conowingo Creek, and on Grove Neck.

Fig. 3. Green infrastructure hub ranks in Cecil County.



FUTURE CHANGES TO CECIL COUNTY'S GREEN INFRASTRUCTURE

According to data from the Maryland Department of Planning, Cecil County's population is projected to rise 64% between 2005 and 2030, from 97,250 to 159,950. The number of households is projected to rise 74% in the same period, from 35,250 to 61,175. If present development trends continue (85% of housing units being single-family homes, with an average lot size of 1.144 ac), this would consume an additional 25,200 ac of land. Much of this development will occur in the Green Infrastructure. We found through field investigations that some green infrastructure hubs and corridors had been fragmented since the aerial photography we used was taken in 2005 (e.g., Fig. 4).

Fig. 4. Part of a massive clearing for development in the middle of a large, high-ranking GI hub. The photo below was taken Sep. 19, 2007; this area was forested as of 2005.

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APPENDIX A. CECIL GI UPDATE PROCEDURE.

1. Maryland GI is mostly based on land cover data from 1991-3.
2. Identified developed land from 2002 land use (residential, commercial, industrial, institutional, and other developed). Converted to grid.
3. Compared this to 2005 NAIP 1-m imagery. Spot checks were consistent: all areas identified as developed in 2002 contained buildings and other human structures in the aerial photos. However, some developed polygons were partially forested.
4. Compared 1973, 1997, and 2002 land use for county-wide picture:

Category	Acres			% change 1973-2002	% change 1997-2002
	1973	1997	2002		
Developed	15,845	31,077	35,962	127.0%	15.7%
Agriculture	112,729	102,489	98,655	-12.5%	-3.7%
Forest and wetlands	91,259	86,002	84,853	-7.0%	-1.3%

Category	Acres			Avg. ac change per year	
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Agriculture	112,729	102,489	98,655	-427	-767
Forest and wetlands	91,259	86,002	84,853	-219	-230

5. Mapped recent development within GI (Cecil_GI_loss_map.pdf) and tabulated its impacts:
   a. 39 of 46 hubs entirely or partially within Cecil Co. (85%) were affected by development between c.1992 and 2002. 8 of these hubs (17%) were significantly reduced or fragmented.
   b. 36 corridor or hub connections were broken by development, including almost all those north of I-95.
6. Updated GI in Cecil Co. using 2002 land use:
   a. Subtract developed land use from MD GI.
   b. Identify areas of natural land (forest, wetland, and open water ≤50m from shore) containing interior conditions (>100m from nearest edge).
   c. Add the above areas to MD GI with developed land use subtracted.
   d. Subtract major roads (note: roads from SHA, dated 2000)
   e. Identify groupings >40 ha (100 ac).
   f. This is the preliminary GI model, with original hubs and corridors, minus development, plus additional natural areas at least 40 ha (100 ac) in size and containing interior conditions (>100m from nearest edge).
7. Convert to shapefile for editing.
8. Compare GI shapefile to 2005 NAIP 1-m imagery. Change hub and corridor borders as appropriate, editing at ~1:8K scale, and add new corridors where possible connections are visible. NAIP data was unavailable for western Grove Neck, but was available for the rest of the county. Also link to Delaware Ecological Network on eastern border where possible.
9. Dissolve to create continuous coverage of updated Cecil Co. GI

APPENDIX B. CECIL GI HUB RANKING PROCEDURE.

1. Set map extent to shapefile of updated Cecil GI (cecil_gi_update.shp). Set cell size to 10m.
2. Identify major road crossings (not including bridges)
    a. Convert updated Cecil GI to grid (gi_update).
    b. Mask out GI not within county (just ranking areas within county) (grid name = grd_cecil_gi).
    c. Select bridges from SHA roads in Cecil County (Cecil_roads.shp; "LAYER" = 'RD_BRG'). Export as Cecil_bridges.shp.
    d. Buffer Cecil_bridges 35m to select major roads on bridges. Convert shapefile (Cecil_bridges_35m_buffer.shp) to grid (grd_bridgebuf).
    e. Major roads were converted to a grid earlier (grd_major_rds, cell size = 10m).
    f. Reclassify grd_bridgebuf 1→NoData, NoData→1 (not_bridgebuf)
    g. Remove bridge buffers from major roads (→ majrds_notbrg)
    h. Reclassify majrds_notbrg 1→NoData, NoData→1 (not_majrds)
    i. Remove major roads from Cecil GI (→ gi_no_majrds)
3. Identify separate hubs and corridors
    a. Measure depth to interior of gi_no_majrds (model Interior Distance)
    b. Reclassify output (grd_depth) to >100m → 1, elsewhere → NoData. Save as grd_gi_int100
    c. Regiongroup grd_gi_int100 (→grp_gi_int100)
    d. Select groups >40 ha (100 ac; 4000 cells). Save as gi_int_ge40ha.
    e. Add edge back in (model Add edge to interior).
    f. Regiongroup output (gi_hubs) → gi_hub_id
    g. There were 59 hubs, ranging from 80 to 4600 ha (mean = 403 ha).
    h. Non-hub elements included corridors, buffers, and natural areas below hub size (at least 40 ha >100m from edge).
    i. Convert hubs to shapefile also, hubs_separate.shp. Set field [Hub_ID] = grid value.
4. Tabulate key resources within hubs
    a. Area of sensitive species habitat (SSPRA) or sentinel watersheds
    b. Area of interior forest (>30m from edge)
    c. Area of unmodified wetlands
    d. Length of streams and rivers
    e. Fraction in mature and natural vegetation communities (from GAP)
    f. Number of natural vegetation alliances (from GAP)
    g. Modeled vertebrate richness (from GAP)
    h. Mean water quality rank
    i. Mean distance to edge
    j. Area of other GI within 1 km (measurement of connectivity)
5. Area of sensitive species habitat or sentinel watersheds
    a. There was one MBSS sentinel watershed in Cecil County, an unnamed tributary to Principio Creek. Sentinel sites represent the best remaining streams in the state.
    b. Sensitive Species Project Review Areas (SSPRA) are buffered areas that primarily contain habitat for rare, threatened, and endangered species and rare natural community types. It generally includes, but does not specifically delineate, such regulated areas as Natural Heritage Areas, Wetlands of Special State Concern, Colonial Waterbird Colonies, and Habitat Protection Areas.
    c. A more accurate product, Ecologically Significant Areas, would be preferable, but was not available.
    d. The sentinel watershed and SSPRAs were merged and converted to a grid, sspra_mbss.
    e. Tabulate area by hub (grid gi_hub_id).
6. Area of interior forest (>30 m from edge)
    a. Forest cover was obtained from NLCD 2001 land cover. Imagery was acquired 1999-2001. There have been changes since then, but development, mining, etc. as of 2005 was removed from the GI.
    b. Reclassified forest and woody wetlands (values 41, 42, 43, and 90) to 1, elsewhere = No Data. Saved as grid nlcd_forest.
    c. From Cecil road data, select all roads except bridges. Save as Cecil_roads_no_bridges.shp.

   d. Convert to grid roads_no_brg (value = 1).
   e. Reclassify to roads = No Data, elsewhere = 1 (grid not_roads).
   f. Multiply grids not_roads * nlcd_forest (i.e., remove roads). Save as forest_no_rds.
   g. Reclassify to forest = No Data, elsewhere = 1.
   h. Find distance to edge.
   i. Reclassify to interior forest (>30m from edge) = 1, elsewhere = No Data. Save as int_forest.
   j. Tabulate area by hub (grid gi_hub_id).

7. Area of unmodified wetlands
   a. From DNR wetlands, remove subtidal and limnetic systems (E1, L1). Also remove riverine open water (R1UB, R2UB, R3UB).
   b. Remove human-modified wetlands (special modifier = d,f,h,r,s,x) and farm ponds (PUBF/H). Save as cecil_unmodified_wetlands.shp.
   c. Convert to grid ce_unmod_wetl (value = 1).
   d. Tabulate area by hub (grid gi_hub_id).
8. Length of streams
   a. Selected streams and shorelines from county hydrology file (hydro_ln). Saved as Cecil_streams_shorelines.shp.
   b. Note: divide length of shorelines by 2. There will be some inaccuracy in doing this, but less than if it were not done.
   c. What hub does each stream fall in: Identity operation on Cecil_streams_shorelines.shp by shapefile hubs_separate. Save as streams_with_hub_ID.shp.
   d. Select "Hub_ID" = 0. Delete these records (i.e., streams not in hubs).
   e. Select "Layer" = 'X-STREAM'. Summarize Hub_ID Sum of Shape_Length for selected records. Save as hub_stream_length.dbf. Create field [stream_m] with integer value of Sum_Shape_Length.
   f. Select "Layer" = 'X-SHORELINE'. Summarize Hub_ID Sum of Shape_Length for selected records. Save as hub_shore_length.dbf. Create field [shore_m] with integer value of Sum_Shape_Length.
   g. Join hub_shore_length.dbf to hub_stream_length.dbf by field [Hub_ID]. Export as hub_stream_shore_length.dbf.
   h. Create field [str_riv_m]. Calculate [str_riv_m] = [stream_m] + ([shore_m] / 2)
9. Fraction in mature and natural vegetation communities (from GAP)
   a. See http://dnrweb.dnr.state.md.us/download/bays/gia_chp5.pdf
   b. Reprojected to C:\CecilCoMD\Source_Data\GAP\ce_gap_succ.
   c. Zonal Statistics as Table by hub (grid gi_hub_id). Save mean value.
10. Number of natural vegetation alliances
   a. Reclassify GAP vegetation to omit classes 400, 401, 402, 411, 414, 427, 429, 430, 435, 452, 453, 455, and 65535. Save as ce_gap_natveg.
   b. Zonal Statistics as Table by hub (grid gi_hub_id). Save variety value.
11. Modeled vertebrate richness
   a. Reprojected grid vert_rich (Delmarva peninsula). Riparian areas had the highest modeled vertebrate richness.
   b. Zonal Statistics as Table by hub (grid gi_hub_id). Save max and mean values; use both.
   c. Ideally, would identify how many species might be found in each hub, but with hundreds of species, this would require writing a program to loop through them all.
12. Mean water quality conservation rank
   a. See water quality documentation
   b. Calculate mean value of grid wq_conserve within each hub (Zonal Statistics as Table). Save mean value.
13. Mean distance to edge
   a. Identify forest, wetland, and nearshore water (grid for_wet_nswat)
   b. Multiply grids not_roads * for_wet_nswat (i.e., remove roads). Save as forwetwatnord.
   c. Reclassify to habitat = No Data, elsewhere = 1.
   d. Find distance to edge.
   e. Convert to integer value. Save as dist_edge.
   f. Zonal Statistics as Table by hub (grid gi_hub_id). Save max and mean values; use both.

14. Area of other GI within 1 km
    a. This is a measurement of connectivity with other source areas
    b. Buffer hubs (hubs_separate.shp) 1 km, dissolving by Hub_ID. Save as Hub_1km_buffers.shp.
    c. Calculate area of buffered hubs and area of hubs. Join to buffer shapefile.
    d. Used grid gi_update, which includes some PA and DE border areas.
    e. From Hawth's Tools, use Thematic Raster Summary. Since the polygons are processed consecutively, overlapping polygons are allowed (unlike Spatial Analyst Tools).
    f. Join to table of hub_1km_buffers.shp.
    g. Calculate [buff_gi_ha] = [GI_within_1km_of_hubs.TRS_1] / 100
    h. Subtract area of hub and calculate percentage of GI in buffer alone: [buf_pct_gi] = (([buff_gi_ha] - [hub_ha]) * 100) / ([hub_buf_ha] - [hub_ha])
15. Combination of variables
    a. Join tables to hub attribute table, then export as GI_hub_data.dbf.
    b. Delete unneeded columns, and convert to Excel.
16. Rank hubs
    a. For each parameter, divide the value for each hub by the maximum value for all hubs. The hub with the highest parameter value (e.g., the most interior forest) will have a relative value of 1.0, and all other hubs will have a value between 0 and 1 (e.g., a hub with half the amount of interior forest as the maximum will have a relative value of 0.5).
    b. Multiply parameter relative values for each hub by the parameter weight:

Name	**Description**	**Weight**	**Reason for weight**
SSPRASENHA	Area of sensitive species habitat (SSPRA) or sentinel watersheds	1.0	
INTFOR_HA	Area of interior forest (>30m from edge)	1.0	
UNMODWETHA	Area of unmodified wetlands	1.0	
STR_RIV_M	Length of streams and rivers	1.0	
MEAN_SUCC	Fraction in mature and natural vegetation communities (from GAP)	0.5	Two different ways of measuring vegetation comm.
NUMVEGCOMM	Number of natural vegetation alliances (from GAP)	0.5	see above
MAXVERTRCH	Maximum modeled vertebrate richness (from GAP)	0.5	Two different ways of measuring vert. richness
MEAN_VERTR	Mean modeled vertebrate richness (from GAP)	0.5	see above
MEANWATQUA	Mean water quality rank	1.0	
MAXEDGEDIS	Maximum distance to edge	0.5	Two different ways of measuring dist. to edge
MEANEDGEDS	Mean distance to edge	0.5	see above
BUF_PCT_GI	Area of other GI within 1 km (measurement of connectivity)	1.0	

    c. Sum the weighted relative values for each hub.
    d. Rank the hubs from best (highest sum) to worst (lowest sum).

APPENDIX C. GIS DATA USED IN CECIL COUNTY GREEN INFRASTRUCTURE ANALYSES

Data Layer	Original Source	Ground Condition Date	Spatial Resolution	Comments
2002 land use	Maryland Dept. of Planning	2002	106 ft	10 acre minimum mapping unit
1997 land use	Maryland Dept. of Planning	1997	106 ft	10 acre minimum mapping unit
1973 land use	Maryland Dept. of Planning	1973	106 ft	10 acre minimum mapping unit
Land cover	US Geological Survey (USGS) National Land Cover Dataset (NLCD)	1999-2001	30 m	
Aerial photos	USDA-FSA Aerial Photography Field Office (National Agriculture Imagery Program)	2005	1 m	
Maryland's Green Infrastructure	Maryland Dept. of Natural Resources (DNR)	1991-3	30 m	See Overview section for explanation
Roads	Maryland State Highway Administration	2000	167 ft	
Hydrography	Cecil County Planning and Zoning Department	unknown	Unknown, but appeared accurate	This data set was much more accurate than other available hydrography data, and aligned well with aerial photos.
Wetlands	Maryland Dept. of Natural Resources (DNR)	1988-1995	20 ft	0.5 acre minimum mapping unit
Sensitive Species Project Review Areas	Maryland Dept. of Natural Resources (DNR)	1980-2003	Boundaries are generalized	Polygons generally encompass, but do not delineate, RTE sites and other regulated areas. Polygons are unattributed, and not spatially precise.
Sentinel watersheds	Maryland Biological Stream Survey (MBSS)	2004	Unknown	Sentinel sites represent the best remaining streams in the state.
Conservation value of land to maintain water quality	Developed by The Conservation Fund for this project	2002	10 m	See *Land Conservation, Restoration, and Management For Water Quality Benefits in Cecil County, Maryland*
GAP Vegetation Alliances	Mid-Atlantic GAP Analysis Program	1991-3	30 m	2 ha minimum mapping unit
Native Vertebrate Species Models or Richness	Mid-Atlantic GAP Analysis Program	1991-3	30 m	2 ha minimum mapping unit
Protected Lands	Cecil County Planning and Zoning Department	unknown	unknown	