Prioritizing Forest Conservation and Reforestation Sites

In an ideal world, communities would be able to permanently protect the most ecologically valuable forest lands in their watersheds, and reforest all their open lands to increase habitat areas and protect water quality. Unfortunately, limited funding resources and competing interests can make this goal unrealistic. Prioritization of specific sites for forest conservation and reforestation is an important step to guide decisions about how to target local programs, funding, and regulations. This process is especially useful for communities with extensive natural resources who wish to accommodate future growth while protecting the most sensitive or valuable lands.

This fact sheet provides an overview of the basic process for prioritizing forest conservation and reforestation sites, and includes links to various prioritization methods and tools. The process described below assumes your community has already completed a natural resources inventory that includes forest sites, and/or identified open areas that have planting potential from aerial photos or field visits.

Overview of Process

An initial desktop analysis using GIS provides a ‘first cut’ to prioritizing individual parcels for forest conservation and reforestation. We suggest doing a separate ranking for conservation versus reforestation.

The first step is to identify the criteria you wish to use for prioritizing your resources. An effective prioritization system usually begins by identifying the lands with the most environmental value (e.g., for drinking water protection, habitat conservation or flood control, depending on your goals of interest). Next, this ranking is refined by evaluating feasibility factors and potential threats and using community input, if available. Table 1 summarizes some common ranking factors.

Many tools are available to assist with prioritization of natural resources. Brief descriptions and web links are provided in the Resources section. Some tools can help you to calculate ranking criteria (e.g., patch size of remaining forest, relative influence of a parcel on downstream water quality), while others can take your input data and do the prioritization for you. Many of these tools are not specific to forest cover but take a broader approach to ‘green infrastructure’ planning (see text box on page 4).

Table 1. Common Ranking Factors to Prioritize Parcels for Conservation or Reforestation	
Ranking Factor	**Description**
Environmental Ranking Factors	
Continuity (if forest)	Prioritize sites with uninterrupted cover
Connectivity	Prioritize sites that link or have the potential to link adjacent forest, reforestation sites or protected lands
Contiguity	Prioritize sites with greater than a specified acreage (may depend on species of interest for conservation)
Ecological significance	Prioritize sites with high habitat scores, high Index of Biotic Integrity (IBI) scores, mature vegetation, RTE species, or other sensitive natural resources
Location in watershed	Prioritize sites located in riparian areas, wetlands, floodplains, steep slopes, erodible soils, recharge areas or other locations important to watershed hydrology and water quality.
Feasibility Ranking Factors	
Land ownership	Prioritize public land then private land with landowners who are willing to sell/donate land
Access to site	Project may be infeasible if access to site is not adequate for any necessary foot traffic, vehicles or heavy equipment.
Prohibitive site characteristics	Certain site characteristics may make a project infeasible, such as potentially contaminated soils or insufficient sunlight for plant growth
Cost	Prioritize sites with the lowest cost per acre, factoring in anticipated management costs
Level of effort	Prioritize sites that require minimal site preparation (soil amendments, removal of invasive species) over those requiring extensive site preparation
Community Ranking Factors	
Recreational value	Prioritize sites with recreational value
Community acceptance	Prioritize sites that received community support and have a potential base of volunteers to help with tree planting or maintenance (this may entail a public meeting to get community input on projects)
Historic or cultural value	Prioritize sites with significant cultural or historical value
Economic value	Prioritize sites that can help maintain a healthy local forest products industry
Vulnerability Ranking Factors	
Development pressure	Prioritize sites located in designated growth areas, zoned for future development, located near major roads and/or currently unprotected (or otherwise noted as having high development pressure on a buildout analysis or other similar map/dataset)
Other threats	Prioritize sites with high potential for impacts from other activities such as mining or utility construction

Field evaluations of the top ranked sites (or all sites if resources permit) can be conducted to collect information to supplement and refine the preliminary ranking. This may weed out the sites that have since been developed or may yield data to weigh ecological benefits of one site versus another. The Resources section provides information on field methods to evaluate forested sites for conservation and open lands for reforestation. Table 2 lists the forest characteristics commonly evaluated in such a field assessment, while Table 3 describes the factors to assess at potential planting sites.

Table 2. Forest Characteristics Evaluated in Field Assessments	
Characteristic	**Description**
Basic site information	Landowner and use, parcel size, location, protection and development status, soil type and condition
Surrounding landuses	Observe adjacent forest or open areas and evaluate potential for connection with these nearby fragments, evaluate viewshed
Dominant species	Dominant tree species or forest association
Forest age	Indicated by successional stage or size class of dominant trees
Vertical structure	Presence of different vertical layers of vegetation such as ground cover, understory, mid-story and canopy trees. Measure of habitat complexity.
Canopy density & condition	Percentage of forest covered by tree canopy, Canopy condition and health.
Herbaceous vegetation	Density and species or herbaceous vegetation, presence of duff layer
Understory vegetation	Density and species of understory vegetation
Invasive species	Density, extent and species of invasive plant species
Indicator or rare, threatened, or endangered (RTE) species	Species and specific location. Indicator species are intolerant of a decline in habitat quality and are therefore indicators of high quality habitat
Evidence of disturbance	Clearing, trash dumping, erosion, pollution, overbrowsing, trails
Presence of food, water, cover and habitat	Includes streams, wetlands, snags and cavity trees, large woody debris, conifers, mast species, vernal pools, leaf litter
Potential threats	Amount of forest edge is used to evaluate potential for competition from invasive species, dominant species in canopy is used to evaluate potential threats from forest pests (e.g., gypsy moths, emerald ash borer, hemlock woolly adelgid)

Table 3. Factors Evaluated in Field Assessment of Reforestation Sites	
Factor Type	**Description**
Feasibility	Landowner and use, site access, potential soil contamination, lack of sun or water, severe and widespread invasive species or overbrowsing, conflicts with infrastructure, potential for damage by forest pests
Ranking	Size and dimensions of planting area, location in watershed, surrounding landuse, potential for connection to nearby forest or protected land, presence of nearby streams, wetlands, RTE species or other sensitive resource
Reforestation Planning	Current vegetative cover, invasive species, trash dumping, soil pH, soil texture, soil compaction, soil drainage, soil salinity, soil depth, distance to water table, light exposure and aspect, heat exposure, wind exposure, slope, and potential for damage from vandalism, automobiles, wildlife (e.g., deer, rabbits, voles, mice, beaver), lawnmowers.

Of the factors listed in Table 2, basic site information and surrounding land uses are used to rank the site in terms of its potential to connect other forest fragments or habitat corridors. The remaining characteristics provide an overall indicator of the ecological significance or value of the forest. Most forest assessment methods will include a system for interpreting data collected in the field that results in an actual score or classification of the forest in terms of ecological value. These can be used to supplement the initial site ranking.

The feasibility and ranking factors shown in Table 3 can be used in to refine the initial site ranking, while the reforestation planning factors collected will be used to determine exactly what to plant and where to plant at the site.

The resulting map of priority conservation/reforestation sites should be included in the local watershed plan and the comprehensive land use plan. This allows the community to use this information when making decisions about where to locate future growth, and provides a sound basis for targeting lands for conservation as funds become available. For more information on incorporating forests into watershed planning, see Cappiella et al. (2006).

Green Infrastructure Assessments

Numerous methodologies exist for conducting regional assessments of green infrastructure (GI). GI planning is a form of strategic conservation planning whereby a core of interconnected networks of green and open space areas is defined. The concept underlying green infrastructure protection is to link large, contiguous blocks of ecologically significant natural areas (hubs) with natural corridors. Such connections can help to offset the functional losses caused by fragmentation from development. GI assessment methodologies range from loosely structured "back of the napkin" approaches to much more formalized and complicated GIS analyses. The basics of any GI planning approach include the following common characteristics (McDonald, et al. 2005):

- Linking components and processes of the ecosystem;
- Identifying ecologically valuable areas as well as areas in need of restoration;
- Considering the distribution and relationship of landscape features and processes over time, as well as the interaction of these features with the human built environment
- A decision-support tool for the prioritization of conservation opportunities that results in a land protection strategy that can guide implementation efforts.

The spatial network of conservation areas within the study area should incorporate agreed upon criteria. A suitability analysis is used to calculate a range of resource values with a focus on a range of goals for the planning area. Each independent green infrastructure goal may be analyzed separately and/or later compiled to define the entire network. The evaluation can be "coarse-scale," that is based upon larger landscape values, or "fine-scale," which aims to look within the ranked resource areas for a smaller-scale evaluation within the broader context. According to McDonald et al. (2005), "the network design should utilize a hub/corridor framework and incorporate a diversity of land uses" thereby protecting the optimal environment for an area's ecological systems. Any GI assessment should take into consideration certain key factors such as land use/land cover, protection status, and other features such as stream and road networks, along with any goal specific layers such as threatened species distribution information. A GI plan should provide a list of the mechanisms and tools for land protection as well as federal, state, local and private funding sources for reaching plan goals.

Resources

Tools for Natural Resources Inventories and Prioritization

- The **Watershed Forest Management Information System** is a spatial decision support system developed to evaluate and plan (1) forest conservation and nonpoint source pollution mitigation (2) forest road maintenance, and (3) silvicultural operations. It assists land managers with objectively evaluating the influence of these plans and activities (both positive and negative) on the landscape in order to maintain or enhance water supply and quality. It uses commonly available GIS data and basic field measurements. One module, the Watershed Management Priority Indices, differentiates land use and site characteristics to quantify their relative influence on overall water quality. Land uses are categorized into three priority indices: the Conservation Priority Index, the Restoration

Priority Index and the Stormwater Management Priority Index. Results of the analysis are paired with field-based knowledge to make landscape-scale plans and decisions. The resulting indices can be correlated with parcel data to determine critical areas based on priority indices. Other submodules are available for watershed delineation, identifying potential sediment source areas from roads, deriving the hydraulic capacity of stream crossings and analyzing the spatial distribution of recent and proposed harvest units to avoid changes in streamflow and water quality impacts: http://www.forest-to-faucet.org/software_downloads2.html

- The **Maryland Department of Natural Resources' Green Infrastructure Assessment** is working to identify and prioritize the State's green infrastructure: those undeveloped lands most critical to long-term ecological health. This analysis included an evaluation of 27 ecological indicators or parameters and ranked these within each physiographic region. The ranking was completed at two different scales – for individual hubs or corridors and by individual cell. A nonparametric ranking of hubs themselves allowed a prioritization of initial conservation efforts. Individual cells (~0.314 acres) were prioritized because they contribute energy and matter to the larger system and are controlled by the larger system. Likewise, cell based ranking can be used to evaluate and manage individual parcels. Reports that describe the methodology and resulting maps are available here: http://www.dnr.state.md.us/greenways/gi/gi.html

- The **Southeastern Ecological Framework Project** is a GIS-based analysis to identify ecologically significant areas and connectivity in Florida, Georgia, Alabama, Mississippi, South Carolina, North Carolina, Tennessee and Kentucky. The modeling process identifies core areas, landscape linkages or connectivity zones, and buffer zones that are integrated into networks that maximize protection for the most sensitive species; provide enough space for viable populations of wide-ranging species; maintain functional ecological processes and services; and provide opportunities for biota to functionally respond to future environmental changes. The process begins with an inventory phase where all relevant available GIS data are collected, including regional, sub-regional, and state data layers. These are assessed to determine areas of ecological conservation significance and land use and landscape features that could impact ecological integrity. The largest intact areas of ecological significance are delineated. A specific GIS model was utilized to identify the best opportunities to maintain ecological connectedness between selected hubs. The project report and data are available at: http://www.geoplan.ufl.edu/epa/

- **Habitat Priority Planner** is a geographic information system (GIS)-based tool that uses land use and natural resource information to prioritize habitat conservation and restoration areas. It is a free map-based planning tool that utilizes ArcGIS software with Spatial Analyst extension that intends to bring greater confidence in decisions by increasing the level of transparency, objectivity, and repeatability in the decision-making process. Three major steps are involved in utilizing the HPP. The first step is classifying habitat data based on project goals. During this step, land use scenarios or "what ifs" can be examined. The next step utilizes pre-packaged standard ecological metrics to perform habitat analysis. Habitat quality, habitat connectivity or custom metrics can be used during this step. Finally, habitat data can be explored via a number of functions. Limitations of the data include the following: the metrics used are only proxies for real world data as in all modeling; the tool is intended for screening level analysis only; analysis time may be limiting depending on the geographic extent of data being analyzed; and the output of the tool is limited by the data that is input: http://www.csc.noaa.gov/digitalcoast/tools/hpp/index.html

- **The Landscape Fragmentation Tool** maps the types of fragmentation present in a specified land cover type, which can assist with prioritizing habitat areas for conservation (e.g., larger forest patches are more likely to support greater numbers of interior forest species). This land cover type is classified into 4 main categories - *patch, edge, perforated, and core* - based on a specified edge width. The edge width indicates the distance over which other land covers (i.e. urban) can degrade the land cover type of interest (i.e. forest). The core pixels are outside the "edge effect" and thus are not degraded from proximity to other land cover types. Patch pixels make up small fragments that are completely degraded by the edge effect. While the LFT tool was designed to analyze fragmentation in forest, it can be used to map fragmentation in any land cover of interest: http://clear.uconn.edu/tools/lft/lft2/index.htm

- The **Resource Lands Assessment** is a GIS-based analytical approach for assessing the value of forests, farms and wetlands in the Chesapeake Bay watershed. It includes six models: Ecological Network, Water Quality Protection, Forest Economics, Prime Farmland, Cultural Assessment and Vulnerability. The model defines hubs and links within the landscape and gives priority to large patches of natural land cover. The original data sets can be reclassified and applied at different geographic scales depending on management needs, and are available here: http://www.chesapeakebay.net/resourcelandsassessment.aspx?menuitem=19096

- The **Forest Areas of Local Importance** study evaluated changes in tree canopy in Northeastern Georgia, identified and prioritized remaining critical forest area, and projected future impacts based on County land use. Specific study goals were to: 1) link urban and rural areas of the study area to demonstrate environmental relationships that exist between developed and rural areas; 2) develop a valuation methodology that indexes forest area; 3) assess the forest area resource for a regional perspective, but support site level, local and regional; 4) identify the critical forest area gains and losses that occurred during the project period; 5) quantify the current state of the forest resource and place in the context of total change and rate of change during a 17-year period; and 6) analyze expected gains and losses based on future land use as identified in the comprehensive plan. The project provided the community with a needed decision-making tool that allowed them to better manage critical forest areas and development as well as to weigh the urban/rural benefits indices based on desired local benefits while tracking critical forest areas for protection: http://www.negrdc.org/departments/planning/forestareas.asp

- The **Forests, Water and People Analysis** uses maps produced in a geographic information system (GIS) to highlight the connection between forests and the protection of surface drinking water quality. The analysis developed maps for 540 watersheds in the

Northeast and Midwest which can be used as one input in a natural resources prioritization. A report and GIS data available here: http://www.na.fs.fed.us/watershed/fwp_preview.shtm

- The **Urban Forests Effects Model** was developed to help managers and researchers quantify urban forest structure and its functions for use in the development of management plans. The program incorporates vegetation data and local hourly meteorological and pollution-concentration measurements to quantify city-specific vegetation structure and function. Four models have been developed that analyze 1) urban forest structure (e.g. species composition, leaf area, biomass, etc); 2) hourly urban forest volatile organic compound emissions, which contribute to ozone formation; 3) total carbon stored and net carbon sequestered annually by urban trees; and 4) hourly pollution removal by the urban forest and associated percent improvement in air quality: www.ufore.org

Table 4. Technical Specifications and Data Needs for Prioritization Tools

Tool	Specifications
Watershed Forest Management Information System	• Technical Specifications: WFMIS is an extension of ArcGIS that can be added as a toolbar to an ArcGIS interface. ESRI Spatial Analyst is also required. • Data Requirements: Various data inputs are needed for each of the modules. Digital Elevation Models (DEMs) are recommended for most modules. Other data inputs include land use, streams, wetlands, soils, and roads.
Habitat Priority Planner	• Technical Specifications: Microsoft .NET and Microsoft .NET Support for ArcGIS ESRI ArcMap 9.2 or 9.3 (Service Pack 4 or greater); ESRI Spatial Analyst; User skillset: Intermediate GIS • Data Requirements: Raster- or vector-based land cover data (Coastal Change Analysis Program Regional Land Cover; National Wetland Inventory); Point, line or polygon data sets pertinent to project • HPP software is free; web-site contains a user manual and video overview viewable with Windows Media Player
The Landscape Fragmentation Tool	• Technical Specifications: ArcGIS ESRI ArcMap 9.3 (Service Pack 4 or greater); Two versions of the tool are available, one that requires ESRI Spatial Analyst and one that does not. • Data Requirements: two-class land cover grid as the input
Resource Lands Assessment	• Technical Specifications: ESRI ArcGIS • Data Requirements: all data layers are available on the website
UFORE	• Technical Specifications: SAS based software • Data requirements: Field data is collected from 0.04-ha plots throughout the study area, stratified by land use type; data are collected on land use, ground and tree cover, shrub characteristic, building features, and, for individual trees, species, stem diameter at breast height, tree height, height to base of crown, crown width, percent crown dieback and distance and direction from buildings. Meteorological data from the National Climatic Data Center (NCDC). Hourly pollution concentration data from the US EPA
Forest Areas of Local Importance	• Technical Specifications: ESRI ArcGIS, Visual Foxpro • Data Requirements: Landsat 5 and 7 TM imagery, TM/IRS merged data, digital elevation models (DEMs), IKONOS, CIR digital orthophoto quads, B&W digital orthophoto quads, and NHAPP CIR aerial photographs. Ancillary data and information from field training sites was to calibrate the computer to recognize vegetation and canopy closure classification schemes.

Field Assessment Methods

Table 5. Summary of Forest Assessment Methods			
Forest Assessment Method	**Applicability**	Description	**Source**
Unified Subwatershed and Site Reconnaissance (USSR)	Urban upland forests	The Pervious Area Assessment form of the USSR is used to collect basic information about existing forest remnants	Wright, et al. 2004
Woodland Buffer Habitat Assessment	Riparian forest	Evaluates the value of riparian forest for wildlife habitat	Hanssen (2003)
Upland Contiguous Forest Assessment	Upland forests	Designed to evaluate large parcels of contiguous forest to determine which are priorities for conservation	CWP (unpublished)
Maryland's Green Infrastructure Assessment	Regional application	Evaluates hubs and corridors in terms of ecological significance for the purpose of land acquisition	Weber (2003)
Maryland Forest Conservation Act Stand Assessment	Parcel scale	Evaluates forest stands on an individual development site to identify conservation areas	Greenfeld, *et al.* (1991)

Table 6. Summary of Reforestation Site Assessment Methods			
Reforestation Site Assessment Method	**Applicability**	**Description**	**Source**
Unified Subwatershed and Site Reconnaissance (USSR)	Urban upland pervious areas	The Pervious Area Assessment form of the USSR is used to collect basic information about potential planting sites	Wright *et al.* (2004)
Unified Stream Assessment	Urban riparian areas with inadequate stream buffer	The Inadequate Buffer form is used to collect basic information about potential planting sites with < 25 foot forested stream buffer	Kitchell and Schueler (2005)
Site Assessment for Urban Tree Planting	Urban planting sites	Detailed site assessment for urban tree planting to use in selecting species and developing a planting plan	Bassuk *et al.* (2003)
Urban Reforestation Site Assessment	Urban planting sites	Detailed site assessment for urban tree planting to use in selecting species and developing a planting plan	Cappiella et al. (2006)

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