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MEETING OF NATURAL RESOURCES COMMITTEE
OF THE HIGHLANDS COUNCIL

RMP Component:	**Resource Assessment / Ecosystem Assessment**
Technical Report:	**Forest Integrity**
Council Committee:	**Natural Resource Committee**
Memorandum Title:	**Technical Approach to Define Highlands Forest Integrity**
Date:	**April 25, 2006**

1. INTRODUCTION

The Highlands forests and wetlands serve as natural water filtration systems, thereby protecting the integrity of vital water supplies for the Highlands Region. The positive correlation between forest cover and surface water quality is well documented in scientific literature. The larger forest tracts that form the core of the Highlands also serve to protect the integrity of natural communities by reducing anthropogenic effects and protecting area-sensitive species of wildlife. The original and existing primary land cover of the Highlands is forest. Despite this, the USDA Forest Service ("USFS") 2002 New Jersey Highlands Study Update concluded that the process of land use change is transforming the Highlands forest directly through land conversion and indirectly through habitat fragmentation.

Forest fragmentation results in quantifiable landscape changes including increased edge, reduced forest interior, increased number and isolation of forest patches, and reduced habitat area. A forest fragmentation analysis to evaluate and understand the integrity of Highlands forests is one element of the Ecosystem Management resource assessment necessary to respond to the goals and requirements of the Highlands Water Protection and Planning Act ("Highlands Act"). Specifically, the Highlands Act includes goals for the development of the Regional Master Plan ("RMP") with respect to forest protection as follows:

> Section 10. a. The goal of the regional master plan with respect to the entire Highlands Region shall be to **protect and enhance the significant values of the resources thereo**f in a manner which is consistent with the purposes and provisions of this act.
> b. The goals of the regional master plan with respect to the preservation area shall be to:
> (1) protect, restore, and enhance the quality and quantity of surface and ground waters therein;
> (2) **preserve extensive and, to the maximum extent possible, contiguous areas of land in its natural state**, thereby ensuring the continuation of a Highlands environment which contains the unique and significant natural, scenic, and other resources representative of the Highlands Region;
> (3) **protect the natural, scenic, and other resources of the Highlands Region, including but not limited to contiguous forests**, wetlands, vegetated stream corridors, steep slopes, and critical habitat for fauna and flora;
> c. The goals of the regional master plan with respect to the planning area shall be to:
> (1) protect, restore, and enhance the quality and quantity of surface and ground waters therein;
> (2) **preserve to the maximum extent possible any environmentally sensitive lands** and other lands needed for recreation and conservation purposes;… (Emphasis added)
>
> 11. a. The regional master plan shall include, but need not necessarily be limited to:
> (1) A resource assessment which:

> (a) determines the amount and type of human development and activity which the ecosystem of the Highlands Region can sustain while still maintaining the overall ecological values thereof, with special reference to surface and ground water quality and supply; **contiguous forests and woodlands**; endangered and threatened animals, plants, and biotic communities; ecological factors relating to the protection and enhancement of agricultural or horticultural production or activity; air quality; and other appropriate considerations affecting the ecological integrity of the Highlands Region; (Emphasis added).[1]

The graphic illustration of forest distribution and measures of shape and size that will be included in the RMP will enable large-scale examination of the mosaic of the landscape in terms of forest contiguity and forest fragmentation. The use of forest metrics analysis not only defines the integrity of the forest also serves as a predictive tool to identify future changes. Therefore, understanding the geographical extent and patterns of forest fragmentation should assist the Highlands Council in making informed planning and conservation decisions.

Since no single metric measurement can capture the full complexity of spatial arrangement of forest patches, several approaches to measure Highlands forest fragmentation have been explored. This memorandum describes the technical approaches used to evaluate Highlands forest integrity.

The literature suggests that the effects of forest fragmentation can be broken down into three major categories: area effects, edge effects and isolation effects.

- *Area Effect.* Fragmentation is likely to be the single largest threat to Highlands forests. Forest fragmentation is the process by which larger, contiguous forests are broken into smaller, more isolated fragments. Ecological implications resulting from fragmentation include, but are not limited to decrease in native biodiversity, the irreversible loss or degradation of habitat, changes in stream conditions, decreased food to the system, changes in microclimate, increased nuisance wildlife, reduced water quality and increased flooding.

- *Edge Effect.* Large contiguous forests contain less "edge" than several patches of smaller fragmented forests. Fragmented forests exhibit a high percentage of edge habitat that is subject to greater sunlight and wind than core forest which changes the habitat structure of the forest, allowing for the introduction of invasive species and introduction of predators. These intrusions include increased air, water, noise and light pollution; changes in microclimatic conditions due to higher sunlight and wind levels; increased

[1] Section 12 also requires the Council to address NJDEP standards in the Preservation Area. The Highlands Act includes the following for forest areas in Section 34.k: "a prohibition on development that disturbs upland forested areas, in order to prevent soil erosion and sedimentation, protect water quality, prevent stormwater runoff, and protect threatened and endangered animal and plant species sites and designated habitats; and standards to protect upland forested areas that require all appropriate measures be taken to avoid impacts or disturbance to upland forested areas, and where avoidance is not possible that all appropriate measures have been taken to minimize and mitigate impacts to upland forested areas and to prevent soil erosion and sedimentation, protect water quality, prevent stormwater runoff, and protect threatened and endangered animal and plant species sites and designated habitats."

populations of invasive species; and increased frequency of disturbance due to direct contact with humans, human pets and associated rural/suburban pest species (Zipperer, 1993). The border area affected by these disturbances is classified as forest edge, as compared to the undisturbed core or interior forest habitat. Edge can promote overall biological diversity at the local scale by providing habitat for species dependent upon two or more land cover types. Conversely, the creation of edge conditions often occurs at the expense of interior conditions thereby reducing biodiversity on a larger scale.

- *Isolation Effect.* From a landscape perspective, the spatial pattern of forest patches plays an important role in maintaining connectivity across a watershed and facilitating important ecological processes such as species dispersal (Gardner et al., 1987; With and Crist, 1995). Nearest neighbor indices quantify landscape configuration. This indicator of forest fragmentation is related to the ability of species to move from forest patch to forest patch, particularly important in the event of a local extinction of some species that can only be overcome by recolonization from a nearby patch. The further a forest patch is from another forest patch, the more likely such an extinction will occur and the more difficult recolonization will be. Significant distances between forest patches can interfere with pollination, seed dispersal, wildlife migration and breeding. Ultimately these changes may result in the loss of species.

2. METHODOLOGY

Defining and Mapping Forest Cover

The total area of forest cover was determined prior to applying forest metrics. Forest area was extracted from the NJDEP 2002 Land Use/Land Cover ("LU/LC") GIS data. Forest equated to all upland and wetland forest and scrub/shrub categories, excluding old fields according to the Anderson classification system. The GIS data was rasterized (converting the digital image into a format suitable for display) to 10 x 10 foot grid cells, using ArcGIS software to facilitate later spatial analysis.

The 2002 NJDOT Roads GIS data were intersected with the forest coverage to exclude roads and identify further subdivision of forest tracts. All categories of road were included. Roads were considered to encompass one grid cell (10 feet wide), as specific information on roadway widths was not available. The resulting forest, minus the road grid coverage, formed the basis for the forest metric analysis.

The forest coverage was partially extended into New York State to include adjacent areas. Here, best available data from the U.S. Forest Service 2002 Highlands Regional Assessment was used.

Determining Core vs. Edge Forest and Contiguous Forest Patches

To differentiate edge forest from core forest, the geographic boundary or edge between forest and altered land was established. Altered land (or altered edge) equated to urban, utility rights-of-way, agriculture and barren lands according to the Anderson land use classification. Bare rock outcrop, herbaceous wetlands and water were not defined as an altered edge. These landscape features were considered an integral component of the larger forest landscape and not

a fragmenting influence.

Two types of edge forest were established.

- *Near edge forest* was defined as forest with less than 100 feet to an altered edge following the general rule-of-thumb that the edge distance equivalent to the dominant tree height represents a "microclimatic" edge of increased solar insulation and wind exposure.

- *Far edge forest* was defined as forest 100 to 300 feet to an altered edge. The far edge was established at 300 feet to take into account habitat disturbances that occur up to 300 feet from an altered edge.

- *Core forest* was defined as forest greater than 300 feet to an altered edge.

Maps of near edge, far edge and core forest were produced. Using ERDAS IMAGINE software, adjacent forest grid cells were clumped into unique patches. A patch represents a contiguous tract of forest bordered by either altered land or a road.

A four neighbor rule (horizontal or vertical neighbors, not diagonal neighbors) was used to create the patches. Excluding diagonal neighbors prevents the patches from "jumping" narrow features such as roads. Core forest patches (areas greater than 300 feet from altered land or road edge) were also identified.

Metrics of Forest Fragmentation

A number of forest fragmentation metrics were calculated to assess the integrity of the Highlands forest landscape. Edge and core forest area and patch area statistics, including the number and size frequency distribution for total and core forest patches, were determined across the Highlands study area and at the HUC14 level. Distance to altered land or road edge was calculated for all forest grid cells. The maximum, mean, and median distances were also summarized at the Highlands-wide and HUC14 level

The metrics listed below relied on a 10 x 10 foot grid cell forest patch map and identify the structural characteristics of a group of patches within a particular geographic area or landscape. The HUC14 basin was used as the landscape reporting unit (i.e., the smallest land area for which data is being analyzed) as the logical geographic unit that recognizes the importance of forest cover to watershed characteristics and downstream water quality and quantity.

- Area and percent of edge and core forest within the HUC14

- Number of forest patches within each HUC14

- Largest patch index (LPI) is the ratio of size of largest forest patch to HUC14 area. The LPI is a measure of the percent of the HUC composed by the largest patch. Wickham et al. (1999) in a study of forest fragmentation in the mid-Atlantic region examined the relationship between the LPI and anthropogenic land cover. They found that there was a transition in forest fragmentation as the amount of anthropogenic land cover increased

above 15 to 20% with the LPI departing from the maximum possible case.

- Landscape shape index (LSI) is the ratio of altered edge length to the square root of the HUC area, providing a unit less measure of shape complexity or fragmentation. The LSI provides a measure of shape or edge complexity. Shape has bearing on the integrity of a forest. A linear forest does not contain a core or interior characteristic of large circular/square forests. Many forest interior species are dependent upon a large, unbroken forest that exhibits a core or interior area.

- Mean distance to closest patch (MDCP) calculates the shortest edge-to-edge distance between distinct patches within a 1000 foot search radius. The MDCP provides a measure of how isolated forest patches are within the landscape area of interest.

- Road density (linear feet/acre) provides a measure of fragmentation resulting from roads.

- Mean, median, maximum distance feet to an altered edge or road edge.

A larger scale view of the Highlands forest landscape will be used to simulate more closely the habitat requirements of some of the region's wide-ranging wildlife species. Using a 3 x 3 km roving window, forest cover proportion will be calculated for each grid cell. The 3km moving window analysis will produce a coarse scale picture of forest cover across the Highlands Region. Geospacial studies performed by the Missouri Resource Assessment Partnership (MoRAP) have applied a 3 km radius target area. A 3 km radius target area was determined to be an appropriate and representative assessment area (personal communication Eric Stiles, New Jersey Audubon Society).

The following metrics are to be calculated using the 3 x 3 km roving window Forest GIS coverage with the entire Highlands Region as the landscape reporting unit:

- Proportion of Total Forest and Core Forest within the 3 km diameter window centered on each grid cell were calculated and provided as a grid cell map

- Number of forest patches within the 3 km diameter window centered on each grid cell were calculated in a manner similar to the above

- Landscape Shape Index (LSI) the ratio of Altered edge length to the square root of the 3 x 3 km window area, providing a unit less measure of shape complexity or fragmentation