CRITERION 1—

Chapter 2. Forest Fragmentation

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What Is Forest Fragmentation, and Why Is It Important?

Forest fragmentation refers to a loss of forest and the division of the remaining forest into smaller blocks. Fragmentation is of concern primarily because of its impact on the conservation of biological diversity. Forest fragmentation can affect the amount and quality of habitat for many wildlife species (Fahrig 2003, Roundtable on Sustainable Forests 2000). Fragmented forests may consist of patches of forest too small to maintain viable populations of certain species. Fragmentation is also an issue because the resulting smaller blocks of forest may not be viable units for forest management (Roundtable on Sustainable Forests 2000).

So, How Fragmented Are the Forests?

Forest Health Monitoring (FHM) has conducted several national assessments of forest fragmentation for the conterminous States. The results have appeared in the series of national technical reports produced by FHM (e.g., Conkling and others 2005); in the report entitled "State of the Nation's Ecosystems," which was produced by the H.J. Heinz III Center for Science, Economics, and the Environment (2002); in the "National Report on Sustainable Forests—2003" by the U.S. Department of Agriculture Forest Service (2004); and in other outlets. Preparations are now underway to utilize newer landcover maps based on satellite imagery that will enable national updates and analysis of fragmentation changes over time. It is now appropriate to summarize an answer to the motivating question, "How fragmented are U.S. forests?"

The landcover maps used in the assessments reported here were derived from 1992 satellite imagery (Vogelmann and others 2001) with a spatial resolution of 0.09 ha per parcel of land, an area about the size of a baseball diamond infield. Of the 8.6 billion parcels of land evaluated, 2.8 billion were classified as forest. Some of the assessments also used detailed road maps (Geographic Data Technology 2002) that identify approximately 10 million km of roads of all sizes. The road maps were superimposed on the landcover maps when analyzing "road-caused" fragmentation (Riitters and others 2004b).

Two general approaches were used to analyze the landcover and road data. These can be described briefly as follows. One approach (Riitters and others 2004a) used classical procedures to assess forest patch size, forest edge, distance between forest patches, and other fragmentation indices within approximately 140,000 non-overlapping, 56.25 km^2 analysis units, each containing 62,500 land parcels. The other approach (Riitters and others 2002) used an innovative multiple-scale procedure to evaluate each forest parcel separately, in terms of the fragmentation experienced in the surrounding landscape, for five landscape sizes from 2.25 ha to 5314 ha. The assessments typically combined all classes of forest into one class and ignored fragmentation by water, snow, ice, talus slopes, bare rock, sand, and clay.

This section is a synthesis of information contained in eight published manuscripts (Riitters and others 2000, 2002, 2003, 2004a, 2004b, 2006; Riitters and Wickham 2003; Riitters and Coulston 2005), which will not be cited again in this section in order to maintain readability. Considering first the gross distribution of forest area, there is at least some forest land cover nearly everywhere in the lower 48 States. Forest is the dominant landcover for one-third of all land area, and three-fourths of all forest area is found in these forest-dominated landscapes. Fifteen percent of forest is located in landscapes dominated by shrubs and grasses, and the remainder occurs in landscapes dominated by agricultural and urban land uses. There is a marked distinction between regions that are mostly forested and those that are not, and these regions more or less correspond to ecological regions defined by biophysical constraints. At the same time, the fragmentation or spatial pattern of forest is not correlated with ecological regions because patterns are created by human activities that do not typically follow biophysical constraints. The gross distribution of forest area is a regional-scale phenomenon, and the spatial pattern of forest is a local-scale phenomenon.

Considering the spatial arrangement of forest land, most forest land is near other forest land, over very large regions. The perimeter of a typical forest "patch" (contiguous clump of forest parcels) is only about 100 m from the perimeter of its nearest neighbor patch except where there is not much forest, in which case that distance is

200 to 300 m. At the same time, fragmentation is so common that one-half of all forest is within about 100 m of forest edge, and < 1 percent is > 1 km from forest edge. About half of all fragmentation is associated with the physical separation of distinct forest patches, and half is associated with small (< 7-ha) perforations in otherwise continuous forest cover. A typical location has between 10 and 40 percent as much edge as it could possibly have, for the amount of forest present.

Overall, at least half of the fragmentation is associated with human land uses. Almost all fragmentation in the East is clearly anthropogenic. Partitioning natural vs. anthropogenic causal factors is problematic in the West because landcover is not an accurate guide to actual land use, but generally speaking most of the western fragmentation is associated with semi-natural landcover types such as grassland and shrubland. In both the East and West, the largest reserves of intact forest are contained in public forests on land that is not suited for agriculture or urban development (fig. 2.1). In a global context, the Eastern United States contains the last major reserve of relatively intact deciduous broadleaf forest, and this region is expected to experience significant urbanization with consequent fragmentation over the next 50 years.

Landcover maps derived from satellite imagery do not adequately portray the extensive road network that many believe is critical information when assessing forest fragmentation (fig. 2.2). Taking into account some 10 million km of major and minor roads, 20 percent of all forest land is within 125 m of a road, and the proportion increases rapidly with distance, such that 80 percent of forest land is within 1000 m of a road, and only 3 percent is > 5 km from a road. Ecological impacts from roads may be the rule rather than the exception in most of the conterminous United States. Roads are so pervasive that fragmentation associated with roads is clearly a significant contributor to overall fragmentation, even if roads are not directly the proximate cause of fragmentation, for example, where nonforest landcover types are between the road and the forest. In heavily forested landscapes containing large shares of public forest land where small roads traverse undeveloped landscapes,

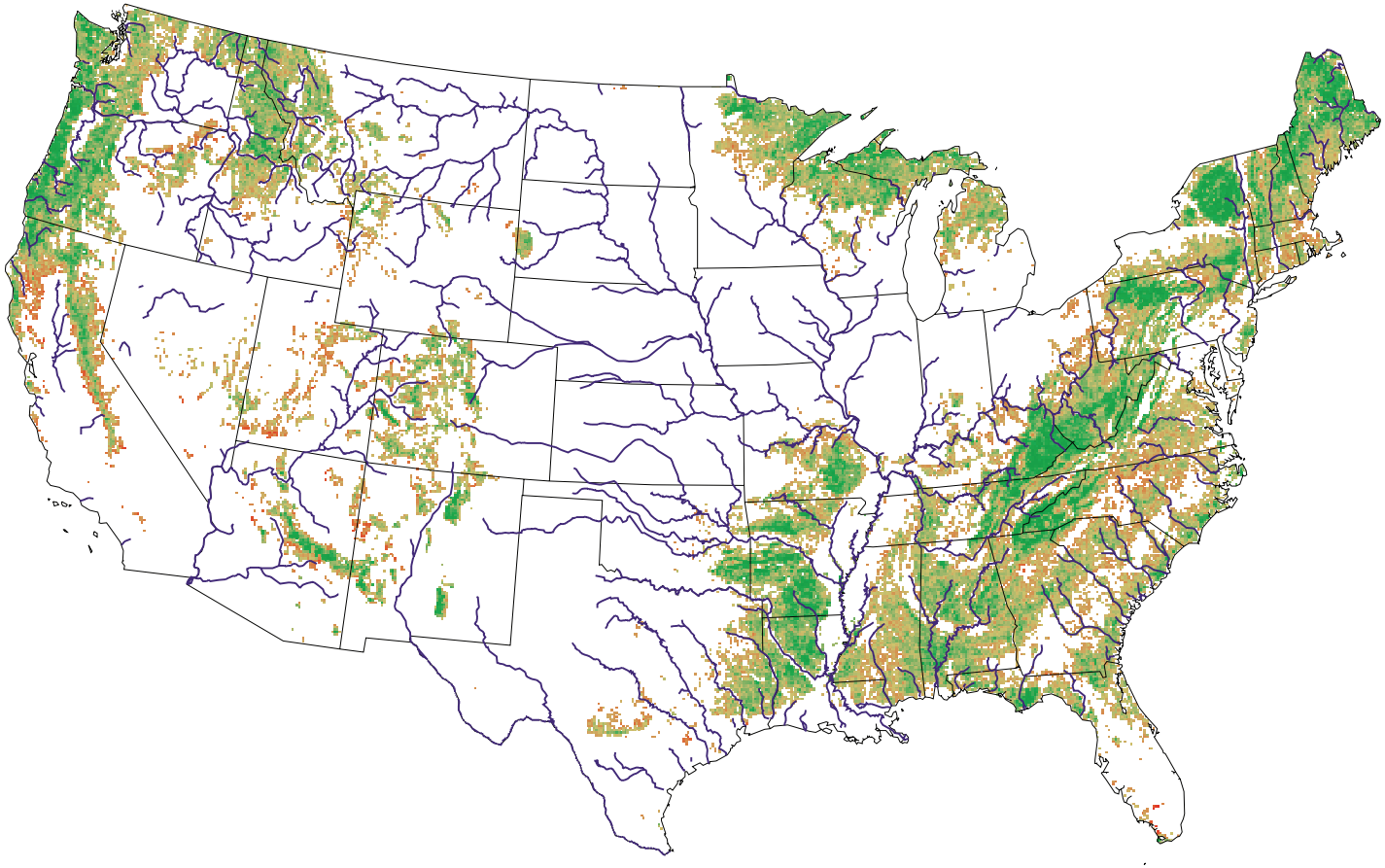

Figure 2.1—Forest land fragmentation from national landcover maps. This map shows the relative amount of "interior" forest at a 7-ha scale shaded from low (red) to high (green) for areas containing > 60 percent forest overall. The large green areas contain the major reserves of less fragmented forest land. (Data source: U.S. Department of Agriculture Forest Service 2004)

Figure 2.2—Panoramic view of Quinnimont and Grandview Sandbar (New River Gorge National River, West Virginia). The forest fragmentation associated with the main road is detectable on landcover maps because the adjacent nonforest parcels are large enough to be detected on satellite images. The "subpixel" canopy gaps created by the unpaved road along the far shore of the river are too small to be detected. The national road map identifies even more roads than are visible in this photograph. (Photograph by Frank Sellers, courtesy of the National Park Service)

fragmentation from roads accounts for over half of the total fragmentation. While roads increase total fragmentation, they do not change the relative geographic distribution of intact forest. With or without roads, the largest reserves of intact forest are on the Oregon-Washington coast; in northern Minnesota, New York, and Maine; and in the Northern Rocky, Ouachita, Ozark, and Appalachian Mountains.

National fragmentation assessments satisfy national reporting requirements, but they do not identify specific places where ecological impacts are likely or the particular forest types that are at risk. The location of perforated forest is of special concern because it represents emergent "holes" in otherwise intact forest cover that are expected to grow and coalesce with additional loss of forest. In the East, hotspots of perforated forest are widely distributed and cover 20 percent of the total area of

10 forest-dominated ecological provinces, but anthropogenic hotspots are concentrated in the Piedmont and upper Great Lakes regions. More than 90 percent of the forest edge in hotspots was attributed to anthropogenic landcover in the central latitudes, but in northern and southern latitudes it was more often associated with semi-natural landcover such as herbaceous wetlands. Nationwide, hotspots of different types of fragmentation tend to dominate in different ecological provinces. In the East, hotspots of "edge" and "patch" fragmentation dominate the less forested regions, such as the outer Coastal Plain and the Ohio River Valley. In the West, hotspots of edge fragmentation were more common in the northern ecological provinces, whereas hotspots of perforated and patch forest were concentrated in the southern ecological provinces. These geographic patterns of fragmentation imply that management and interpretation of forest fragmentation must be tailored to local conditions.

In summary, over the past 5 years the FHM program has provided unprecedented assessments of the fragmentation status of forest land in a consistent national framework. In comparison to pristine conditions, the forests of the conterminous States are heavily fragmented by human activities. But in comparison to the high development in Europe, for example, the forests are still in relatively good condition. More attention must be given to interpreting the findings of these assessments, which have created a unique opportunity to study the impacts of fragmentation on ecological endpoints such as biodiversity and water quality over extremely large regions. Such work is necessary because ecology at that scale is important, perhaps more important than local concern over individual species or water supplies, yet ecological understanding of dynamics at that scale is at best meager. Our ability to quantify and assess fragmentation in physical terms has outpaced our ability to interpret the findings in ecological terms. In the future, FHM will continue to assess and report the status of and trends in forest fragmentation, and will continue to assist ecologists and forest managers in understanding and making use of the data.

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