Low-Access Forests and their Level of Protection in North America

GLOBAL FOREST WATCH

WORLD RESOURCES INSTITUTE

Karen Holmes
Editor

Hyacinth Billings
Production Manager

Maggie Powell
Layout

Cover photographs

1. © Ruth Noguerón
2. © WRI; Andrew Malk
3. © WRI; Andrew Malk
4. © Ruth Noguerón

ISBN 1-56973-514-x

LOW-ACCESS FORESTS AND THEIR LEVEL OF PROTECTION IN NORTH AMERICA

Ruth Noguerón

with contributions by
Dirk A. Bryant
James Strittholt
Jonathan Kool

Acknowledgments

Global Forest Watch wishes to thank the following individuals for their support, contributions and review comments on this report:

Hussein Alidina, Frank Ahern, Rodney Bartgis, Hortensia Chang, Dominick DellaSalla, Anthony Iacobelli, Deborah Jensen, Peter Lee, Peter Morrison, Roger Sayre and Jim Strittholt.

WRI staff also provided support, reviewed, provided input, or helped prepare the report: Dirk Bryant, Tony Janetos, Grace Bermudez, Hyacinth Billings, Jonathan Kool, Susan Minnemeyer, Ralph Ridder, Wynet Smith and Tyson Walker.

Global Forest Watch would also like to thank the Surdna Foundation and ESRI for providing funds and software to support this work.

Key Findings

- Less than half (42%) of the region's forests and woodlands are in large tracts (larger than 200 km^2) of low-access forest. Over 90% of these areas are located within Alaska and Canada.
- Only 6% of the forest cover of the lower 48 states of the United States remains within large tracts of low-access forest. Of these, 40% are in areas categorized as either strictly or moderately protected and about 30% are within national forests.
- Across North America, 9% of large, low-access forest tracts are strictly or moderately protected in national parks, wilderness areas, nature preserves, or other land-protection categories.
- In the lower 48, significant portions of relatively intact forest—in the northern Cascades and the northern Rocky Mountains as well as parts in Washington State, northern Maine and northern Minnesota—remain outside of the protected areas system.
- Close to half (42%) of large blocks of low-access forests in the lower 48 are administered by the federal government. Idaho, Montana, and Washington rank highest among the 48 states in terms of land area in large tracts of low-access, federally managed forest.

Introduction

This paper presents the results of a map-based analysis of the location and status of North American forests (excluding Mexico) that remain mostly undivided by roads and other access routes, so-called low-access forests. It provides a regional look at where large tracts (larger than 200 square kilometers (km^2) of low-access forest are located, as well as an assessment of the degree to which these tracts are currently protected. Because of data limitations (for example, the analysis does not factor in the presence of logging roads), these results create only a coarse picture, at a continental scale, of the location and status of large, low-access forest tracts. The results are useful for identifying forests that, due to their limited development, offer opportunities for expanding protected area networks and/or for restoration, as well as priority areas for future mapping to characterize intact forests at finer scales.

Why Identify Low-Access Forests?

Fragmentation and Degradation of Natural Forests

Approximately 20% of North American forests have been permanently cleared for agriculture and other uses, primarily within the last two centuries (Bryant***, et al.*** 1997). Currently, forest cover is stable (Matthews***, et al.*** 2000); however, in most of the lower 48 states and southern Canada, remaining forests have experienced significant human disturbance and do not possess the same degree of ecological integrity as the original forest. As human populations grow, forest fragmentation and degradation continues. One result has been the loss of extensive areas of old-growth forest. According to one estimate, stands of century-old forest now account for only 7% of forest cover in the United States (USDA-FS 2000).

Consequently, remaining large tracts of relatively undisturbed natural forest are increasingly important, for several reasons:

1. ***Conservation value***. Large patches of natural forest provide sufficient area for natural ecological processes which shaping the forest ecosystem that cannot be sustained across smaller areas. For instance, large forest areas are able to preserve some habitat intact in the face of periodic natural disturbances, such as fires. Large tracts of forest also provide habitat for far-ranging species, such as wolves, wood buffalo, and elk. As such, these areas serve as a reservoir for the successful colonization of smaller patches of habitat, especially those too small to maintain themselves over the long term.
2. ***Ecosystem goods and services value***. Forests provide a range of products and life support services essential to humans and other species. Among the ecosystem services provided by forests are the maintenance of water quality, storage of carbon (which might otherwise contribute to global climate change), and regulation of local climatic processes (e.g., rainfall patterns). Even intensely modified forests, such as plantations, supply such benefits, to some degree. However, because of their condition and extent, large tracts of relatively undisturbed forest possess the greatest potential value in terms of ecosystem services for a given forest type. In addition, these areas often include our greatest reservoirs of mature and old-growth timber stands and other commercially significant natural resources. In many countries, including Canada, the timber industry relies heavily on harvest of old-growth and primary forest stands, which are a dwindling resource. In order to balance timber needs with the need for non-market ecosystem services, many of which are associated with relatively undisturbed forests, it is important to know how much natural forest remains and where these areas are located.
3. ***Recreational, aesthetic, and heritage values***. As populations grow and natural forest is converted to other uses, the remaining large tracts of relatively undisturbed forest are increasingly valued for their natural heritage and for the opportunities they afford in terms of recreation and the experience of wilderness.

As forests in North America continue to be fragmented and degraded, there is growing public debate concerning the management of large tracts of relatively undisturbed natural forest, particularly on public lands. Some argue that remaining areas should be closed to further development in order to maintain their biological diversity and for their recreational and wilderness values; others urge development and use of the natural resources these forests contain. This debate is exemplified by the current controversy over the Clinton Roadless Rule in the United States, as well as by the lobbying of environmental groups in the United States and Canada against continued logging in what various call primary, old-growth, or intact forests.

Measuring Forest Condition

Currently, continental-scale forest monitoring efforts track only changes in forest cover. Little integrated information exists about forest condition, especially the location and status of large tracts of relatively undisturbed forest. In the absence of such information, two indicators provide a useful proxy for data on forest condition:

- ***Access***. The presence of roads and other access routes is an excellent indicator of human disturbance of the forest. Roads, deforestation, and forest fragmentation are intimately related. Through physical, chemical, and biological mechanisms, roads affect the terrestrial and aquatic environment of the forest in many significant ways. Road building in natural forest areas is accompanied by increased erosion, air and water pollution, spread of invasive exotic species, increased animal and plant mortality, and habitat fragmentation (Trombulak and Frissell 2000). Even more important than the direct damage to natural ecosystems, the access to forest areas provided by roads leads to subsequent human disturbances from activities such as logging, mining, grazing, agriculture, and urban development. These disturbances result in substantial declines in native species and an overall degradation of ecosystem integrity.
- ***Size of forest blocks***. As noted above, large blocks of forest are more likely to contain and support a full complement of native species, including wide-ranging mammals. Large tracts also permit natural disturbance regimes, such as fire, to shape these ecosystems (Bryant et al. 1997, Crowley 1978).

Approach

The objective of the analysis reported on here is to provide a coarse-scale picture of the location of North American forests (excluding Mexico) that have been only minimally disturbed by recent human activity, such as logging, other commercial-scale activities, or development-induced fragmentation. To this end, we first identified all forests at least 500 m from a road or other access route, excluding logging roads, and designated these areas as ***low-access forest***. Evidence indicates that, in boreal and deciduous forests, fragmentation and conversion often occur at 0.3-0.9 km from human infrastructure, including roads (UNEP 2001). Therefore, for the purposes of this assessment, we assumed that 1 km is the critical distance beyond which human pressures are less prevalent (Canadian Council of Forest Ministers 1997).

Next, we identified forested areas larger than 200 km^2 and classified these as ***large tracts of low-access forest***. The rationale for selecting a threshold of 200 km^2 is as follows.

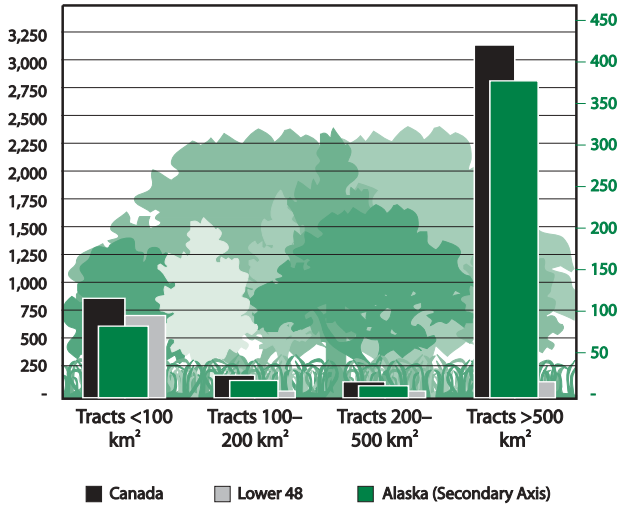
1 Because of the coarse scale of the analysis, small roads, logging roads, and other access routes are not included in the regional transport data. Thus, the actual extent of truly low-access forests is overestimated here. The use of relatively large block sizes in the analysis will tend to counterbalance this effect.

2 To maintain populations of far-ranging species and/or preserve some habitat intact in the face of periodic natural disturbance (e.g., fires in the boreal forests), forest areas must occupy a minimum patch size, which varies considerably according to ecosystem type and species native to the area. For example, World Wildlife Fund-Canada (1999) suggested that a single protected area should exceed a minimum threshold of 500 km^2 in order to accommodate landscape-scale ecological processes in the boreal forest. Similarly, Greenpeace Russia and Global Forest Watch used a threshold of 500 km^2 for mapping intact forest landscapes in northern Europe, a region characterized by boreal forests (Yaroshenko***, et al.*** 2001). The Nature Conservancy (2001) applied a block size of at least 60 km^2 for "ecological land units" in its Central Appalachians ecoregional planning process.

For this continental-scale analysis, we selected a conservative threshold of 200 km^2. This midrange value was chosen in part to account for the wide variety of ecosystem types and, as indicated above, to offset the impact of incomplete road-access data. Table 1 and Figure 1 present estimates and proportions of how results would change if a higher (500 km^2) or lower (less than 100 km^2) threshold for tract size were used.

It is important to note that this approach provides only one measure of forest condition. For other useful indicators—such as, stand age, tree species types, patch size, and patch shape—continental-scale data are difficult to acquire. Several of these indicators have been applied in other regional assessments, as described in Box 1.

Figure 1. Low Access Forests in North America (1000 km^2)



BOX 1. Examples of National- and Regional-Scale Analyses Relevant for Assessing Forest Condition

Low-Access Forest in Canada (Smith and Lee 2000)

As part of its assessment of Canadian forests, GFW-Canada estimated low-access forests by overlaying linear features on land cover. Land cover data were provided by the 1995 Land Cover of Canada (LC95). Provincial transportation and utility lines data were compiled from various sources. Provincial data were trimmed to exclude any data on features not under its jurisdiction and then merged to produce a national access-corridor grid. A buffer of 1 km was created around the access corridors to simulate their impact on forests. The national access-corridor grid was merged then with the LC95 land cover data. Any LC95 cell (excluding water and developed classes such as cropland and urban) that corresponded to an access grid cell were reclassified as accessed. The resulting accessed/non-accessed land cover grid was merged with a national 1:1,000,000 populated places dataset to ensure that small, fly-in northern communities were accounted for in the analysis.

A second version of this analysis was completed during 2000 using a national transportation and utility dataset to provide a consistent national picture. The previous version is still useful for individual provinces, as more detailed features are reflected in the earlier analysis. (Note that the Canadian results presented here vary somewhat from those in this Global Forest Watch-Canada study; we used a different land cover base in order to create a consistent base map for both the entire North American (excluding Mexico) region.)

Remaining Frontier Forests (Bryant, et al. 1997)

This map-based assessment by the World Resources Institute (WRI) identified large, intact "frontier forest" ecosystems—defined as relatively undisturbed areas large enough to maintain viable populations of all their species in the face of periodic natural disturbance—at a global scale. This entailed a two-step process. First, global datasets depicting roads and forest cover were used to delineate candidate frontier areas. WRI then used expert opinion and ancillary datasets to identify final boundaries of frontier forests and assess their threat status. Maps in this report identify: frontier forests under low or no threat; frontier forests under medium or high threat; and non-frontier forests, including secondary forests, plantations, degraded forests, and patches of primary forest.

Forest Fragmentation in the Conterminous United States (Heilman, et al. In Press)

The Conservation Biology Institute (CBI) evaluated forest fragmentation for the conterminous United States using various GIS datasets. These include National Land Cover Database (NLDC) based on 30-m resolution from Landsat 5 TM satellite imagery, roads, administrative boundaries, urban areas with population exceeding 50,000, and ecoregions. Land units were delineated by major highways and only areas of at least 20 km^2 were assessed. Land cover was classified as forests and non-forests, and roads were overlaid to account for the fragmentation effect of roads. The spatial analysis was conducted within the context of forest ecoregions as defined by World Wildlife Fund (Ricketts***, et al.*** 1999). For each land unit, road density and indices of fragmentation were calculated using FRAGSTATS (McGarigal and Marks 1995), a spatial pattern analysis software program to quantify landscape patterns in the combined NLCD and roads dataset. Five indices (road density, core area, mean nearest neighbor, class area, and percent forest cover) were aggregated by ecoregion based on natural breaks. Land units were ranked according to the combined score of the five indices.

The Nature Conservancy's Ecoregional Planning Process (Groves, et al. 2000)

The Nature Conservancy (TNC) is designing ecoregional conservation plans that identify a network of conservation areas containing representative examples of the species, communities, and ecosystems of that region. They use many different types of datasets to identify target species and systems, set conservation goals, map examples, and select conservation areas. The first step is to identify conservation targets—i.e., endemic, rare, and/or threatened species. Next, occurrence and viability on the ground is evaluated and assessed to determine target communities based on association. Forest communities are examined in the Geographic Information Systems environment by evaluating roads, cutting history, percentage of clearcuts, agriculture and developments, and condition of streams, as well as landforms, geology, slopes, and land ecological units. This step results in communities classified as matrix, large patch, and small patch based on their ranking for specified thresholds for

BOX 1 continued

size, viability for target species, habitat diversity, and condition. TNC identifies a portfolio of matrix, large patch and small patch forest communities to direct long-term conservation action with its partners.

Second Roadless Area Review and Evaluation (USDA-FS 2000)

In 1964, the US Congress passed the Wilderness Act and established the National Wilderness Preservation System. Land area under federal management "retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions" were required to be included within the wilderness system (***Wilderness Act*** 1964). Although the Act itself did not require an inventory of areas that could qualify as wilderness, the Forest Service completed a first inventory of roadless areas (RARE I) in 1972. Legal challenges forced the Forest Service to conduct a second assessment in 1979 (RARE II). Inventoried Roadless Areas (IRAs) in the recent Roadless Area Conservation Plan (the Roadless Rule) are underdeveloped areas, usually exceeding 20 km^2, that meet the minimum criteria of the Wilderness Act. They were inventoried in RARE II and subsequent assessments of forest planning. This inventory was conducted locally in each national forest, based on forest plans and revisions.

Wildlands of the United States. (Karl, et al. 2001)

This analysis by the Pacific Biodiversity Institute examined roadless areas within US federal- and state-owned lands. It identified tracts larger than 4 km^2, at least 200 m wide, and at least 60 m away from roads. Ownership was also analyzed in terms of existing units of the National Wilderness Preservation System and state equivalents, the US Forest Service Roadless Areas Inventory 2000, similar roadless areas surveys by the Bureau of Land Management (BLM), and land use/land cover and representation of Bailey Ecoregions classification.

Input datasets for this assessment included roads, permanently disturbed areas, major water bodies, ownership, and Bailey's Ecoregion Provinces for the United States. The roads layer was created by complementing and comparing the Environmental Systems Research Institute's Streetmap with data from the National Forests and Grasslands System, BLM Regional Offices, and states agencies. In general, Forest Service data was used for Forest Service lands, Streetmap was used for non-Forest Service lands, and BLM or state data was overlapped and completed with Streetmap where available. Cover classes representing developed and disturbed areas were extracted from the US Geological Service's National Land Cover Data to create a layer of permanently disturbed and developed areas. Data for major bodies of water were provided by ESRI, and land ownership and protected status was compiled from various sources. The initial analysis for roadless areas was performed in base grids of 30-m cells. Once these cells were merged, major bodies of water and developed areas were removed. Next, the final roadless grid was combined with the ownership layer to identify public lands, both federal and state. Finally, the roadless grid was also intersected with US state boundaries and with Bailey's Ecoregions to estimate both acreage of public roadless areas and representation of ecoregions by state.

Literature Cited

Bryant, D., D. Nielsen, and L. Tangley. 1997. "The Last Frontier Forests: Ecosystems and Economies on the Edge." 42. Washington, DC: World Resources Institute (Sections of the report available online at: http://www.igc.org/wri/ffi/lff-eng/lff-toc.htm). (3/15/02).

Groves, C., L. Valutis, D. Vosick, B. Neely, K. Wheaton, J. Touval, and B. Runnels. "Designing a Geography of Hope: A Practicioner's Handbook for Ecoregional Conservation Planning." 2000. The Nature Conservancy. (Available online at: http://www.conserveonline.org/2000/11/b/GOH2-v1;internal&action=buildframes.action) (3/18/02).

Heilman, G.E., J.R. Strittholt, N.C. Slosser, and D.A. DellaSalla. In Press. "Forest Fragmentation of The Conterminous United States: Assessing Forest Intactness Through Road Density and Spatial Characteristics." BioScience.

Karl, J., P. Morrison, L. Swope, and K. Ackley. 2001. "Wildlands of the United States." Winthrop, WA: Pacific Biodiversity Institute. (Available online at: http://www.pacificbio.org/pubs/wildlands_of_the_united_states.htm).

McGarigal, K., and B.J. Marks. 1995. "FRAGSTATS: Spatial Pattern Analysis Program for Quantifying Landscape Structure. Fragstats NT Version 2.0." Portland, OR: United States Department of Agriculture-Forest Service. Pacific Northwest Research Station.

Ricketts, T.H., E. Dinerstein, D.M. Olson, C.J. Loucks, W. Eichbaum, D.A. DellaSalla, K. Kavanagh, P. Hedao, P.T. Hurley, K.M. Carney, R. Abell, and S. Walters. 1999. "Terrestrial Ecoregions of North America: A Conservation Assessment." Washington, D.C.: Island Press.

Smith, W., and P.E. Lee (Eds.). 2000. "Canada's Forests at a Crossroads: An Assessment in the Year 2000." Washington, DC: World Resources Institute, Global Forest Watch Canada. (Available online at: http://www.globalforestwatch.org/english/canada/maps.htm). (3/15/02).

[USDA-FS] United States Department of Agriculture-Forest Service. 2000. "Roadless Area Conservation. Final Environmental Impact Statement." edited by U.-F. Service. Washington DC. (Available online at: http://www.roadless.fs.fed.us/documents/feis). (3/15/02).

Methods

Using Geographic Information Systems (GIS), we analyzed at coarse level forest blocks, their relative intactness, and their protected status. The approach entailed:

- Developing a 1-km^2 transportation grid, effectively creating a 500 m buffer around access routes. Transportation layers were at a scale of 1:100,000 and included primary and secondary roads, pipelines, and utility lines, where possible;
- Overlaying the access-routes grid on a spatial land-cover dataset (1992-3) at a resolution of 1 km^2. The land cover data were modified to depict two forest types: forests and woodlands (canopy cover of 10-60%) and dense forests (canopy cover greater than 60%);
- Identifying as "low-access forests" all forests outside of the access-routes grid;
- Delineating "large tracts" (larger than 200 km^2) of low-access forest;
- Identifying the degree to which these large blocks of low-access forest are protected. For this purpose, we used existing datasets for Canada and the United States, classified by degree of protection according to internationally recognized World Conservation Union (IUCN) standards (see Box 2). IUCN Categories I-II are strictly protected, while Categories III-V are moderately protected. This standard was chosen so that these results can be compared with those from other countries in which similar Global Forest Watch mapping is underway.

BOX 2 IUCN Management Categories for Protected Areas

In 1994, the World Conservation Union (known as IUCN, and at that time officially named the International Union for the Conservation of Nature) established what has come to be a globally recognized system for classifying protected areas according to their management regimes. However, for the protected areas created since 1994, the interpretation of categories and definitions contained within the IUCN scheme has been inconsistent. For example, in Canada, where most protected areas are established and administered at the provincial level, protected areas are assigned to specific IUCN categories; in practice, however, management regimes for protected areas in a given IUCN category vary from province to province, depending on individual interpretations. At the level of the federal Canadian government, on the other hand, there is some consistency in classifying protected areas according to management regime. To date, no formal assessment has been done to establish equivalents between federal and IUCN management categories in Canada. [1]

Since 1987, the US Geological Service has been carrying out a national effort—the National Gap Analysis Program (GAP)—to identify the degree to which native animal species and natural communities are represented throughout conservation lands in the United States. Part of the GAP methodology includes a land-stewardship classification scheme that is widely used at the national level.

To ensure consistency, the Conservation Biology Institute-World Wildlife Fund's Protected Areas Database for the United States and Canada (PAD) assigned both IUCN and GAP land status codes to protected areas in each country (DellaSalla***, et al.*** 2001). In general, designations were made categorically, in accordance with the equivalents below.

Literature Cited

Crist, P.J., ed. 2000."Mapping and Categorizing Land Stewardship", ***GAP Handbook***. Moscow, Idaho: Idaho Cooperative Fish and Wildlife Research Unit.

DellaSalla, D.A., N.L. Staus, J.R. Strittholt, A. Hackman, and A. Iacobelli. 2001. "An Updated Protected Areas Database for The United States and Canada." ***Natural Areas Journal*** 21. 124-35.

International Union for Conservation of Nature. 1994. "Guidelines for Protected Areas Management Categories. Part II: The Management Categories." Gland, Switzerland: IUCN. (Available online at: http://www.biodiv.org/cross-cutting/protected/prot-areas-annex.asp.).

Endnotes

1. Alidina, H. WWF-Canada. Private communication.

For details and caveats regarding the analysis of this assessment, please refer to the Technical Notes.

BOX 2 continued

IUCN Categories and Definition (International Union for Conservation of Nature 1994)	Equivalent Protected Areas in the PAD	GAP Analysis Status Classification Scheme (Crist 2000)
I. Subdivided into Categories Ia and Ib. Strict Nature Reserve/Wilderness Area: Protected areas managed mainly for science or wilderness protection	National Park, National Monument, Wilderness Area, Nature Reserve/Preserve, Research Natural Area	1. Areas with permanent protection from conversion. Management plans should maintain the natural state; natural disturbance events are either allowed to proceed without interference or mimicked through management.
II. National Park: Protected areas managed mainly for ecosystem protection and recreation	National Park, National Monument, Wilderness Area, Nature Reserve/Preserve, Research Natural Area	
III. Natural Monument: Protected areas mainly for conservation through management intervention	National Park, National Monument, Wilderness Area, Nature Reserve/Preserve, Research Natural Area	
IV. Habitat/Species Management Area: Protected areas managed mainly for conservation through management intervention	State Parks, State Recreation Areas, National Wildlife Refuge, National Recreation Area, Area of Critical Environmental Concern, Wilderness Study Area, Conservation Easement, Private Conservation Land, National Seashore	2. Areas with permanent protection from conversion. However, management plans may include activities that degrade the quality of existing natural communities, including the suppression of natural disturbance regimes.
V. Protected Landscape/ Seascape: Protected areas managed mainly for landscape /seascape conservation and recreation	State Parks, State Recreation Areas, National Wildlife Refuge, National Recreation Area, Area of Critical Environmental Concern, Wilderness Study Area, Conservation Easement, Private Conservation Land, National Seashore	
VI. Managed Resource Protected Area: Protected areas managed mainly for sustainable use of natural ecosystems	BLM Holdings, Military Reservations, National Forests, State Forests, Wildlife Management Areas, Game and Fish Preserves, Fish Hatcheries, State Commemorative Area, Access Area, National Grassland, Army Corps of Engineers Holding	3. The majority of the area has permanent protection from conversion. However, the area is subject to extractive activities of either a broad, low-intensity type or a localized, intense type. Protection is granted to federally-listed endangered and threatened species throughout the area.

Results

Almost half of today's forests and woodlands in North America (excluding Mexico) still qualify as large tracts of low-access forest; however, all but a fraction (5%) of this area is located in the northern-most regions of the continent, namely boreal Canada and Alaska. Most forests of southern Canada and the lower 48 states have been extensively disturbed by human activity. In the lower 48, only 6% of forest cover remains in large, low-access tracts, mostly located in the Rocky Mountains and the Pacific Northwest, in portions of the Cascade Range and in the Klamath-Siskiyou of southwest Oregon and northern California. Relatively undisturbed large tracts of dense forest, generally the most productive, account for15% of all remaining forests in the United States and Canada.

Major Findings for the United States

- About three-quarters of low-access woodlands and forests in the lower 48 are in tracts smaller than 100 km^2.
- Two-thirds of all large tracts (larger than 200 km^2) of low-access forests in the United States are found in Alaska. About one-quarter (26%) has protected status, either moderate or strict. Close to 11%—including wilderness areas—are found within the Tongass and Chugach national forests (74% of the Pacific Coast forests in Alaska is managed by the US Forest Service).
- Just six states account for more than 60% of large, low-access forest tracts in the lower 48. Ranked in order of relevant land area, they are Idaho, Montana, Washington, California, Wyoming, and Minnesota.
- In the Pacific Northwest, most low-access forest blocks are located in portions of the Cascade Range as well as in the Klamath-Siskiyou in southwest Oregon and northern California. East of the Rocky Mountains, low-access forest blocks are located primarily in northern Minnesota, Maine, and the Adirondack region of New York.
- Approximately 30% of large, low-access forest blocks in the lower 48 states are found within national forests in the states of Idaho, Montana, Wyoming (northern Rocky Mountains), and Washington. Idaho, Montana and Wyoming house 43% of all Inventoried Roadless Areas (IRAs) in the lower 48 states. For some of the large-low access forests blocks, their protected status is under review, under the roadless-area logging ban. (By definition, many of the large, low-access forest tracts identified by this analysis are included within the US Forest Service's IRAs) Approximately 40% is strictly or moderately protected in parks and reserves.

Major Findings for Canada

- Two-thirds of Canada's forests remain in large, low-access tracts.[1] Much of this area is in the central and northern portions of the country, characterized by slow-growing forests and open woodland. Dense forests account for just under a third of this area.
- About half the country's low-access forests are located in Quebec, the Northwest Territories, and Manitoba. Alberta, British Columbia, and Ontario house over half of Canada's large, low-access tracts of dense forests, i.e., those with greatest potential timber value.
- Only 4% of large, low-access forest tracts are strictly or moderately protected.

For details by region, country, and state or province, please refer to Tables 1 and 2.

Protected Status at the Regional Level

Most (91%) large, low-access forest tracts in North America are located outside strictly or moderately protected areas, i.e., parks and reserves classified in IUCN categories I-V. About 36% of large tracts dominated by dense forests are strictly or moderately protected. However, as indicated above, the degree to which these tracts are protected varies significantly between the United States and Canada. Although vast areas of these forests remain in the far northern regions, most of these tracts are threatened not only by logging but also by mining and oil and gas development. In the United States as a whole, about 34% of large tracts of low-access forests are strictly or moderately protected.

One recent analysis concluded that the current system of protected areas in the United States fails to preserve a representative sample of the country's biological richness. Most of the protected areas are located at higher elevations and on low-productivity soils (Scott***, et al.*** 2001). That study indicated that most types of forest communities in the United States are underrepresented in the protected area system. Not surprisingly, this analysis shows that large blocks of protected, low-access forest are located mostly in mountainous areas or at high latitudes.

Another study determined that, if granted permanent protected status, IRAs could play a significant role in creating a representative network of conservation reserves in the United States (DeVelice and Martin 2001). As mentioned above, by definition, many of the large, low-access forest tracts are included within IRAs. National forests contain almost a third of all remaining large, low-accesss forest tracts in the lower 48. Although some such tracts are already strictly or moderately protected, granting permanent status to IRAs would significantly extend protection of large, low-access forests in the United States.

In the Kalamath-Siskiyou in southwest Oregon and northern California, roadless areas provide a wide range of important ecological attributes that maintain ecosystem integrity. For example, they contain significant numbers of threatened and rare species, special habitats— such as old-growth forests and serpentine geology. They also sustain key watersheds for aquatic biodiversity, and provide connectivity between existing wilderness areas (Strittholt and DellaSalla 1999).

Because of their size and distance from transport routes and associated human pressures, large tracts of low-access forest often offer important conservation opportunities. For example, significant areas of low-access forest—in the Cascade and the Rocky Mountains of Washington as well as in parts of northern Maine and northern Minnesota—remain outside of the protected areas system. Here, wilderness, recreational, and biodiversity values might be further enhanced through establishment of new parks and reserves or through management regimes that emphasize conservation values as well as extractive activities (e.g., certified logging operations).

Next Steps

The analysis presented here provides only a coarse picture, using proxy measures, of the location and status of large, relatively undisturbed forests in North America. Careful management and stewardship of those forest areas in North America and elsewhere that are not yet significantly degraded or fragmented requires data of greater accuracy at a much finer resolution.

To address this information gap, Global Forest Watch is in the process of mapping forest conditions in several global regions. The first step in a two-phased approach entails identifying large, low-access forest blocks (as was done here), using existing datasets on land cover and roads and other transport routes. Similar analyses have been completed for forests in Central Africa and Indonesia. These coarse-scale assessments provide a rough picture, comparable across major regions, of the location of remaining large tracts of relatively undisturbed forest. This assessment for North America builds on earlier work by Global Forest Watch-Canada (Smith and Lee 2000) and extends it to provide a region-wide picture, including neighboring forests of the United States.

Coarse-scale assessments provide a starting point for the second phase of GFW mapping efforts, which features finer-scale analysis. This second-phase work usually incorporates high-resolution satellite imagery, which is used to identify logging and other transport routes not shown in existing roads datasets and then further eliminate forest tracts accessed by these logging roads, including those that have undergone recent logging and other extractive activities (e.g., oil and gas development). Final maps depict at detailed scales what we refer to as "intact natural forests"—i.e., forests with few or no signs of recent, commercial-scale human activities and of sufficient size to maintain viable populations of resident species in the face of periodic natural disturbance. Such mapping has been completed for Chile and Russia and is now underway for Alaska and Canada. Similar work is planned for portions of the lower 48 states of the United States. (Note that, in this phase of work, threshold tract sizes for "large" blocks of intact forests are defined according to forest type.)

Table 1. Low-Access Forests by Tract Size Class (areas expressed in km^2)

			Tracts < 100 km²				Tracts between 100 and 200 km²			
	Forest Cover	Low-Access Forests	Total	% of Forest Cover	Woodlands *	Dense Forests ¥	Total	% of Forest Cover	Woodlands *	Dense Forests ¥
North America	9,395,148	5,984,993	1,739,641	19	988,303	751,338	284,762	3	103,416	181,346
Canada	5,207,772	4,463,877	902,666	17	499,244	403,422	205,064	4	62,062	143,002
United States	4,187,376	1,521,116	836,975	20	489,059	347,916	79,698	2	41,354	38,344
Alaska	510,312	502,575	85,800	17	62,219	23,581	20,212	4	13,989	6,223
Lower 48	3,677,064	1,018,541	751,175	20	426,840	324,335	59,486	2	27,365	32,121
Canada										
Alberta	480,830	388,921	82,966	17	53,621	29,345	19,809	4	4,093	15,716
British Columbia	769,333	626,634	189,624	25	112,727	76,897	45,135	6	9,233	35,902
Manitoba	471,323	426,972	65,197	14	36,290	28,907	15,478	3	6,577	8,901
New Brunswick	67,246	19,321	18,728	28	8,856	9,872	-	-	-	-
Newfoundland	223,223	211,054	39,245	18	24,439	14,806	7,966	4	6,146	1,820
Northwest Territories	607,804	596,726	58,638	10	33,643	24,995	11,129	2	5,922	5,207
Nova Scotia	48,375	16,250	11,490	24	3,519	7,971	1,582	3	336	1,246
Nunavut	10,239	10,152	4,616	45	4,527	89	-	-	-	-
Ontario	881,025	742,965	141,343	16	68,482	72,861	37,306	4	6,869	30,437
Prince Edward Island	2,895	550	550	19	471	79	-	-	-	-
Quebec	988,423	821,268	157,566	16	77,158	80,408	33,493	3	6,723	26,770
Saskatchewan	349,242	310,162	78,436	22	45,843	32,593	18,227	5	7,646	10,581
Yukon Territories	307,814	292,902	54,267	18	29,668	24,599	14,939	5	8,517	6,422
United States										
Alabama	119,790	23,898	23,280	19	10,869	12,411	-	-	-	-
Alaska	510,312	502,575	85,800	17	62,219	23,581	20,212	4	13,989	6,223
Arizona	68,499	39,433	19,514	28	17,986	1,528	5,061	7	5,061	-
Arkansas	91,470	20,104	19,746	22	8,636	11,110	-	-	-	-
California	185,804	73,690	48,469	26	36,476	11,993	5,005	3	3,832	1,173
Colorado	87,998	49,332	35,976	41	23,873	12,103	4,467	5	1,361	3,106
Connecticut	11,544	671	671	6	34	637	-	-	-	-
Delaware	2,754	230	230	8	175	55	-	-	-	-
District of Columbia	47	-	-	-			-	-	-	-
Florida	105,794	29,989	25,019	24	19,329	5,690	908	1	908	-
Georgia	127,368	22,480	21,409	17	14,782	6,627	407	0	-	407
Idaho	107,011	65,992	31,598	30	18,540	13,058	8,404	8	4,531	3,873
Illinois	49,792	5,746	5,746	12	4,487	1,259	-	-	-	-
Indiana	49,316	3,967	3,967	8	2,433	1,534	-	-	-	-

* Between 10% and 60% woody vegetation cover

¥ Above 60% woody vegetation cover

Table 1 continued (areas expressed in km²)

	Tracts between 200 and 500 km²				Tracts larger than 500 km²			
	Total	% of Forest Cover	Woodlands *	Dense Forests ¥	Total	% of Forest Cover	Woodlands *	Dense Forests ¥
North America	222,098	2	90,698	131,400	3,738,492	40	2,470,054	1,268,438
Canada	144,678	3	52,557	92,121	3,211,469	62	2,058,334	1,153,135
United States	77,420	2	38,141	39,279	527,023	13	411,720	115,303
Alaska	15,018	3	9,132	5,886	381,545	75	360,618	20,927
Lower 48	62,402	2	29,009	33,393	145,478	4	51,102	94,376
Canada								
Alberta	15,777	3	4,625	11,152	270,369	56	28,629	241,740
British Columbia	34,577	4	11,824	22,753	357,298	46	36,185	321,113
Manitoba	12,142	3	6,262	5,880	334,155	71	321,608	12,547
New Brunswick	579	1	-	579	14	0	-	14
Newfoundland	4,299	2	3,531	768	159,544	71	150,345	9,199
Northwest Territories	8,933	1	3,981	4,952	518,026	85	476,021	42,005
Nova Scotia	774	2	-	774	2,404	5	-	2,404
Nunavut	165	2	165	-	5,371	52	5,371	-
Ontario	21,944	2	5,023	16,921	542,372	62	258,903	283,469
Prince Edward Island	-	-	-	-	-	-	-	-
Quebec	25,463	3	7,328	18,135	604,746	61	466,244	138,502
Saskatchewan	11,287	3	4,307	6,980	202,212	58	125,500	76,712
Yukon Territories	8,738	3	5,511	3,227	214,958	70	189,528	25,430
United States	-				-			
Alabama	618	1	-	618	-	-	-	-
Alaska	15,018	3	9,132	5,886	381,545	75	360,618	20,927
Arizona	4,680	7	4,271	409	10,178	15	10,178	-
Arkansas	358	0	-	358	-	-	-	-
California	6,546	4	5,453	1,093	13,670	7	11,358	2,312
Colorado	6,856	8	3,712	3,144	2,033	2	-	2,033
Connecticut	-	-	-	-	-	-	-	-
Delaware	-	-	-	-	-	-	-	-
District of Columbia	-	-	-	-	-	-	-	-
Florida	1,335	1	1,189	146	2,727	3	2,727	-
Georgia	171	0	-	171	493	0	493	-
Idaho	4,946	5	3,020	1,926	21,044	20	3,641	17,403
Illinois	-	-	-	-	-	-	-	-
Indiana	-	-	-	-	-	-	-	-

Table 1 continued (areas expressed in km²)

	Forest Cover	Low-Access Forests	Tracts < 100 km²				Tracts between 100 and 200 km²			
			Total	% of Forest Cover	Woodlands *	Dense Forests ¥	Total	% of Forest Cover	Woodlands *	Dense Forests ¥
Iowa	47,114	6,791	6,791	14	5,485	1,306	-	-	-	-
Kansas	27,834	5,205	5,205	19	5,189	16	-	-	-	-
Kentucky	85,426	12,525	12,503	15	3,397	9,106	-	-	-	-
Louisiana	85,682	24,066	17,148	20	9,391	7,757	1,734	2	1,498	236
Maine	77,252	37,763	21,895	28	7,961	13,934	1,855	2	-	1,855
Maryland	18,126	1,469	1,469	8	650	819	-	-	-	-
Massachusetts	18,083	1,366	1,366	8	158	1,208	-	-	-	-
Michigan	115,699	22,647	20,664	18	5,625	15,039	160	0	-	160
Minnesota	142,830	50,720	30,907	22	14,456	16,451	4,400	3	420	3,980
Mississippi	99,868	19,068	19,053	19	10,070	8,983	-	-	-	-
Missouri	106,286	17,590	17,590	17	9,976	7,614	-	-	-	-
Montana	118,241	69,377	37,043	31	23,596	13,447	7,613	6	2,278	5,335
Nebraska	12,804	3,339	3,339	26	3,327	12	-	-	-	-
Nevada	23,304	16,161	11,607	50	11,477	130	1,955	8	1,955	-
New Hampshire	23,088	7,345	4,600	20	299	4,301	1,468	6	-	1,468
New Jersey	15,772	780	780	5	319	461	-	-	-	-
New Mexico	53,545	27,629	19,726	37	16,211	3,515	2,348	4	787	1,561
New York	118,582	27,247	16,299	14	3,125	13,174	2,579	2	-	2,579
North Carolina	108,449	17,338	15,934	15	6,013	9,921	192	0	-	192
North Dakota	19,444	3,616	3,616	19	3,534	82	-	-	-	-
Ohio	63,690	4,076	4,076	6	2,277	1,799	-	-	-	-
Oklahoma	75,730	14,741	14,076	19	9,574	4,502	-	-	-	-
Oregon	136,071	43,763	33,682	25	19,475	14,207	3,327	2	1,030	2,297
Pennsylvania	108,627	13,172	13,172	12	1,257	11,915	-	-	-	-
Rhode Island	2,048	130	130	6	26	104	-	-	-	-
South Carolina	67,903	8,249	8,249	12	4,566	3,683	-	-	-	-
South Dakota	31,451	9,015	9,015	29	8,285	730	-	-	-	-
Tennessee	92,020	16,674	15,249	17	3,598	11,651	130	0	-	130
Texas	270,272	40,661	40,259	15	37,121	3,138	-	-	-	-
Utah	38,780	22,414	17,423	45	14,450	2,973	1,794	5	1,794	-
Vermont	24,228	7,052	5,328	22	616	4,712	475	2	-	475
Virginia	95,068	15,295	15,212	16	2,504	12,708	-	-	-	-
Washington	107,506	43,880	20,720	19	8,719	12,001	2,353	2	211	2,142
West Virginia	61,906	12,663	12,095	20	798	11,297	207	0	-	207
Wisconsin	127,921	24,192	23,635	18	5,543	18,092	51	0	-	51
Wyoming	49,227	34,990	15,694	32	10,152	5,542	2,593	5	1,699	894

* Between 10% and 60% woody vegetation cover

¥ Above 60% woody vegetation cover

Table 1 continued (areas expressed in km²)

	Tracts between 200 and 500 km²				Tracts larger than 500 km²			
	Total	% of Forest Cover	Woodlands *	Dense Forests ¥	Total	% of Forest Cover	Woodlands *	Dense Forests ¥
Iowa	-	-	-	-	-	-	-	-
Kansas	-	-	-	-	-	-	-	-
Kentucky	22	0	-	22	-	-	-	-
Louisiana	864	1	594	270	4,320	5	3,323	997
Maine	3,959	5	106	3,853	10,054	13	-	10,054
Maryland	-	-	-	-	-	-	-	-
Massachusetts	-	-	-	-	-	-	-	-
Michigan	1,448	1	-	1,448	375	0	-	375
Minnesota	3,961	3	654	3,307	11,452	8	539	10,913
Mississippi	15	0	-	15	-	-	-	-
Missouri	-	-	-	-	-	-	-	-
Montana	6,215	5	1,677	4,538	18,506	16	2,195	16,311
Nebraska	-	-	-	-	-	-	-	-
Nevada	2,599	11	2,599	-	-	-	-	-
New Hampshire	241	1	-	241	1,036	4	-	1,036
New Jersey	-	-	-	-	-	-	-	-
New Mexico	1,277	2	1,142	135	4,278	8	3,107	1,171
New York	1,438	1	-	1,438	6,931	6	-	6,931
North Carolina	273	0	-	273	939	1	-	939
North Dakota	-	-	-	-	-	-	-	-
Ohio	-	-	-	-	-	-	-	-
Oklahoma	665	1	-	665	-	-	-	-
Oregon	3,127	2	762	2,365	3,627	3	1,856	1,771
Pennsylvania	-	-	-	-	-	-	-	-
Rhode Island	-	-	-	-	-	-	-	-
South Carolina	-	-	-	-	-	-	-	-
South Dakota	-	-	-	-	-	-	-	-
Tennessee	788	1	-	788	507	1	-	507
Texas	402	0	402	-	-	-	-	-
Utah	1,735	4	1,413	322	1,462	4	1,462	-
Vermont	1,249	5	-	1,249	-	-	-	-
Virginia	83	0	-	83	-	-	-	-
Washington	2,204	2	218	1,986	18,603	17	60	18,543
West Virginia	361	1	-	361	-	-	-	-
Wisconsin	506	0	-	506	-	-	-	-
Wyoming	3,460	7	1,797	1,663	13,243	27	10,163	3,080

Table 2. Large Tracts of Low-Access Forests (area is expressed in km²)

	Forest Cover (above 10% tree coverage per km²)	Low-Access Forests			… in Tracts over 200 km²					
		Total	Woodlands*	Dense Forests ¥	Total	% of Forest Cover	Woodlands*	% Low-Access Woodlands	Dense Forests ¥	% Low-Access Dense Forests
North America	9,395,148	5,984,993	3,652,471	2,332,522	3,960,590	42	2,560,752	43	1,399,838	23
Canada	5,207,772	4,463,877	2,672,197	1,791,680	3,356,147	64	2,110,891	47	1,245,256	28
United States	4,187,376	1,521,116	980,274	540,842	604,443	14	449,861	30	154,582	10
Alaska	510,312	502,575	445,958	56,617	396,563	78	369,750	74	26,813	5
Lower 48	3,677,064	1,018,541	534,316	484,225	207,880	6	80,111	8	127,769	13
Canada										
Alberta	480,830	388,921	90,968	297,953	286,146	60	33,254	9	252,892	65
British Columbia	769,333	626,634	169,969	456,665	391,875	51	48,009	8	343,866	55
Manitoba	471,323	426,972	370,737	56,235	346,297	73	327,870	77	18,427	4
New Brunswick	67,246	19,321	8,856	10,465	593	1	-	-	593	3
Newfoundland	223,223	211,054	184,461	26,593	163,843	73	153,876	73	9,967	5
Northwest Territories	607,804	596,726	519,567	77,159	526,959	87	480,002	80	46,957	8
Nova Scotia	48,375	16,250	3,855	12,395	3,178	7	-	-	3,178	20
Nunavut	10,239	10,152	10,063	89	5,536	54	5,536	55	-	-
Ontario	881,025	742,965	339,277	403,688	564,316	64	263,926	36	300,390	40
Prince Edward Island	2,895	550	471	79	-	-	-	-	-	-
Quebec	988,423	821,268	557,453	263,815	630,209	64	473,572	58	156,637	19
Saskatchewan	349,242	310,162	183,296	126,866	213,499	61	129,807	42	83,692	27
Yukon Territory	307,814	292,902	233,224	59,678	223,696	73	195,039	67	28,657	10
United States										
Alabama	119,790	23,898	10,869	13,029	618	1	-	-	618	3
Alaska	510,312	502,575	445,958	56,617	396,563	78	369,750	74	26,813	5
Arizona	68,499	39,433	37,496	1,937	14,858	22	14,449	37	409	1
Arkansas	91,470	20,104	8,636	11,468	358	0	-	-	358	2
California	185,804	73,690	57,119	16,571	20,216	11	16,811	23	3,405	5
Colorado	87,998	49,332	28,946	20,386	8,889	10	3,712	8	5,177	10
Connecticut	11,544	671	34	637	-	-	-	-	-	-
Delaware*	2,754	230	175	55	-	-	-	-	-	-
District of Columbia	47	-	-	-	-	-	-	-	-	-
Florida	105,794	29,989	24,153	5,836	4,062	4	3,916	13	146	0
Georgia	127,368	22,480	15,275	7,205	664	1	493	2	171	1
Idaho	107,011	65,992	29,732	36,260	25,990	24	6,661	10	19,329	29
Illinois	49,792	5,746	4,487	1,259	-	-	-	-	-	-
Indiana	49,316	3,967	2,433	1,534	-	-	-	-	-	-

* Between 10% and 60% woody vegetation cover

¥ Above 60% woody vegetation cover

§ Large tracts extending from neighbor states

¶ May include areas assigned IUCN Categories I-V

» Does not have National Forest System lands

» Does not have National Forest System lands

Table 2. continued (area is expressed in km^2)

	… That Are Strictly and Moderately Protected (based on IUCN Categories I-V)							National Forests (United States only)¶						
	Total	% of Large Blocks of Low-Access Forest	% of Low-Access Forest	Woodlands*	%	Dense Forests ¥	%	Large Blocks in NFS	% of Large Low-Access Blocks in NFS	% of Forest Cover in NFS	Woodlands*	% Woodlands in Large Blocks within NFS	Dense Forests ¥	% Dense Forests in Large Blocks within NFS
North America	341,000	9	6	218,721	64	122,279	36							
Canada	136,297	4	3	68,069	50	68,228	50							
United States	156,749	34	10	132,122	74	54,051	26	68,120	11	4	29,325	5	38,795	6
Alaska	120,585	30	24	115,960	96	4,625	4	11,167	3	2	5,845	1	5,322	1
Lower 48	84,118	40	8	34,692	41	49,426	59	56,953	27	6	23,480	11	33,473	16
Canada														
Alberta	15	0	0	5	33	10	67							
British Columbia	37,925	10	6	7,745	-	30,180	-							
Manitoba	31,583	9	7	30,571	97	1,012	3							
New Brunswick	-	-	-	-	-	-	-							
Newfoundland	609	0	0	609	100	-	-					`		
Northwest Territories	9,034	2	2	5,964	66	3,070	34							
Nova Scotia	1,553	49	10	-	-	1,553	-							
Nunavut	1,476			1,476		-								
Ontario	41,302	7	6	17,397	42	23,905	58							
Prince Edward Island	-	-	-	-	-	-	-							
Quebec	1,217	0	0	107	9	1,110	91							
Saskatchewan	8,330	4	3	942	11	7,388	89							
Yukon Territory	3,253	1	1	3,253	100	-	-							
	-													
United States	-													
Alabama	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alaska	120,585	30	24	115,960	96	4,625	4	11,167	3	2	5,845	1	5,322	1
Arizona	4,120	28	10	3,995	97	125	3	5,642	38	14	5,567	37	75	1
Arkansas	-	-	-	-	-	-	-	-	-	-	-	-	-	-
California	11,138	55	15	9,188	82	1,950	18	5,476	27	7	4,306	21	1,170	6
Colorado	3,205	36	6	1,384	43	1,821	57	3,986	45	8	1,054	12	2,932	33
Connecticut	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Delaware*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
District of Columbia	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Florida	2,041	50	7	2,036	100	5	0	147	4	-	5	0	142	3
Georgia	526	79	2	473	90	53	10	92	14	0	-	-	92	14
Idaho	12,395	48	19	3,024	24	9,371	76	12,268	47	19	3,026	12	9,242	36
Illinois	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indiana	-	-	-	-	-	-	-	-	-	-	-	-	-	

Table 2. continued (area is expressed in km^2)

	Forest Cover (above 10% tree coverage per km²)	Low-Access Forests			… in Tracts over 200 km²					
		Total	Woodlands*	Dense Forests ¥	Total	% of Forest Cover	Woodlands*	% Low-Access Woodlands	Dense Forests ¥	% Low-Access Dense Forests
Iowa »	47,114	6,791	5,485	1,306	-	-	-	-	-	-
Kansas	27,834	5,205	5,189	16	-	-	-	-	-	-
Kentucky §	85,426	12,525	3,397	9,128	22	0	-	-	22	0
Louisiana	85,682	24,066	14,806	9,260	5,184	6	3,917	16	1,267	5
Maine	77,252	37,763	8,067	29,696	14,013	18	106	0	13,907	37
Maryland »	18,126	1,469	650	819	-	-	-	-	-	-
Massachusetts »	18,083	1,366	158	1,208	-	-	-	-	-	-
Michigan	115,699	22,647	5,625	17,022	1,823	2	-	-	1,823	8
Minnesota	142,830	50,720	16,069	34,651	15,413	11	1,193	2	14,220	28
Mississippi §	99,868	19,068	10,070	8,998	15	0	-	-	15	0
Missouri	106,286	17,590	9,976	7,614	-	-	-	-	-	-
Montana	118,241	69,377	29,746	39,631	24,721	21	3,872	6	20,849	30
Nebraska	12,804	3,339	3,327	12	-	-	-	-	-	-
Nevada	23,304	16,161	16,031	130	2,599	11	2,599	16	-	-
New Hampshire	23,088	7,345	299	7,046	1,277	6	-	-	1,277	17
New Jersey »	15,772	780	319	461	-	-	-	-	-	-
New Mexico	53,545	27,629	21,247	6,382	5,555	10	4,249	15	1,306	5
New York	118,582	27,247	3,125	24,122	8,369	7	-	-	8,369	31
North Carolina	108,449	17,338	6,013	11,325	1,212	1	-	-	1,212	7
North Dakota	19,444	3,616	3,534	82	-	-	-	-	-	-
Ohio	63,690	4,076	2,277	1,799	-	-	-	-	-	-
Oklahoma	75,730	14,741	9,574	5,167	665	1	-	-	665	5
Oregon	136,071	43,763	23,123	20,640	6,754	5	2,618	6	4,136	9
Pennsylvania	108,627	13,172	1,257	11,915	-	-	-	-	-	-
Rhode Island »	2,048	130	26	104	-	-	-	-	-	-
South Carolina	67,903	8,249	4,566	3,683	-	-	-	-	-	-
South Dakota	31,451	9,015	8,285	730	-	-	-	-	-	-
Tennessee	92,020	16,674	3,598	13,076	1,295	1	-	-	1,295	8
Texas	270,272	40,661	37,523	3,138	402	0	402	1	-	-
Utah	38,780	22,414	19,119	3,295	3,197	8	2,875	13	322	1
Vermont	24,228	7,052	616	6,436	1,249	5	-	-	1,249	18
Virginia §	95,068	15,295	2,504	12,791	83	0	-	-	83	1
Washington	107,506	43,880	9,208	34,672	20,807	19	278	1	20,529	47
West Virginia	61,906	12,663	798	11,865	361	1	-	-	361	3
Wisconsin §	127,921	24,192	5,543	18,649	506	0	-	-	506	2
Wyoming	49,227	34,990	23,811	11,179	16,703	34	11,960	34	4,743	14

* Between 10% and 60% woody vegetation cover

¥ Above 60% woody vegetation cover

§ Large tracts extending from neighbor states

¶ May include areas assigned IUCN Categories I-V

» Does not have National Forest System lands

» Does not have National Forest System lands

Table 2. continued (area is expressed in km^2)

	… That Are Strictly and Moderately Protected (based on IUCN Categories I-V)							National Forests (United States only) ¶						
	Total	% of Large Blocks of Low-Access Forest	% of Low-Access Forest	Woodlands*	%	Dense Forests ¥	%	Large Blocks in NFS	% of Large Low-Access Blocks in NFS	% of Forest Cover in NFS	Woodlands*	% Woodlands in Large Blocks within NFS	Dense Forests ¥	% Dense Forests in Large Blocks within NFS
Iowa »	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kansas	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kentucky §	-	-	-	-	-	-	-	9	-	0	-	-	9	-
Louisiana	5	0	0	4	80	1	20	-	-	-	-	-	-	-
Maine	946	7	3	-	-	946	100	70	0	0	-	-	70	0
Maryland »	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Massachusetts »	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Michigan	-	-	-	-	-	-	-	179	10	-	-	-	179	10
Minnesota	-	-	-	-	-	-	-	1,626	11	3	-	-	1,626	11
Mississippi §	1	-	-	-	-	1	-	-	-	-	-	-	-	-
Missouri	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Montana	11,903	48	17	2,006	17	9,897	83	9,076	37	13	1,180	5	7,896	32
Nebraska	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nevada	1,320	51	8	1,320	100	-	-	582	22	4	582	22	-	-
New Hampshire	97	8	1	-	-	97	100	493	39	7	-	-	493	39
New Jersey »	-	-	-	-	-	-	-	-	-	-	-	-	-	-
New Mexico	2,103	38	8	1,344	64	759	36	3,157	57	11	2,652	48	505	9
New York	5,588	67	21	-	-	5,588	100	-	-	-	-	-	-	-
North Carolina	1,051	87	6	-	-	1,051	100	98	8	1	-	-	98	8
North Dakota	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ohio	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oklahoma	35	-	0	-	-	35	100	288	-	2	-	-	288	-
Oregon	3,819	57	9	1,432	37	2,387	63	2,030	30	5	924	14	1,106	16
Pennsylvania	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhode Island »	-	-	-	-	-	-	-	-	-	-	-	-	-	-
South Carolina	-	-	-	-	-	-	-	-	-	-	-	-	-	-
South Dakota	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tennessee	-	-	-	-	-	-	-	73	6	0	-	-	73	6
Texas	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Utah	852	27	4	724	85	128	15	1,275	40	6	1,078	34	197	6
Vermont	-	-	-	-	-	-	-	237	19	3	-	-	237	19
Virginia §	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Washington	12,047	58	27	197	2	11,850	98	5,628	27	13	12	0	5,616	27
West Virginia	-	-	-	-	-	-	-	83	23	-	-	-	83	23
Wisconsin §	-	-	-	-	-	-	-	87	17	-	-	-	87	17
Wyoming	10,926	65	31	7,565	69	3,361	31	4,351	26	12	3,094	19	1,257	8

Technical Notes

We used ESRI's ArcGIS v.8.1 and ArcView v.3.2 to conduct the analysis. Datasets were managed as grids with cell size set at 1 km. All grids were reprojected to the Lambert Azimuthal projection, generally used for large, mid-latitude countries (Dent 1999). Our input layers were land cover, transportation lines, administrative units (national, state, and province boundaries), and protected areas. A description of these datasets as well as the GIS analysis follows.

Land Cover

Global Tree Cover, developed by the University of Maryland (DeFries***, et al.*** 2000), was used as the land cover base, as it provides comparable data for the United States and Canada. The dataset is a prototype derived from Advanced Very High-Resolution Radiometer (AVHRR) datasets (1992-3) at 1-km resolution. It estimates the percentage of woody vegetation and depicts proportional tree coverage without making distinctions between different leaf types (deciduous versus evergreen) or forest age (primary versus secondary growth). Each grid cell describes information about the heterogeneity of vegetation at finer scales but does not provide information on the spatial arrangements of vegetation at a finer scale. Each pixel (1 km) represents percentage of tree cover, with a value ranging between 10 to 80%. (A value of 80% corresponds to tree coverage equal to or greater than 80% and a value of 10% indicates coverage equal to or less than 10%.)

The layer was reclassified as follows to create a land cover base:

0:0	Water
10-60:10	Class I- Areas with tree canopy between 10% and 60% (referred as woodlands)
60-100:60	Class II- Areas with more than 60% tree canopy (referred as dense forests)
254-255:99	Class III- Areas with less than 10% tree canopy

(Map 1 - Land Cover)

Transportation

For Canada, we used DMTI's transportation layer, which includes streets, roads, highways, expressways, local roads, and railways as well as water and utility (e.g., pipeline) features. The transportation grid for the United States was collected from the US Geological Service's Digital Line Graph Data, and the Digital Chart of the World for Alaska. This layer includes roads, railroads, pipelines, and transmission lines at a scale of 1:100,000.

Line coverage for Canada and the United States was rasterized at a resolution of 1 km^2. Due to the size of the file, the coverage was split into multiple pieces to enable the conversion and then merged into one transportation layer.

Administrative Units

Administrative units were taken from ESRI's Administrative Units for 1997. A manually drawn select box was used to select administrative districts for Canada and the United States and create a grid.

Protected Areas

We used the Conservation Biology Institute-World Wildlife Fund's Protected Areas Database (PAD) from 1999 for Canada and the updated version (2001) for the United States (DellaSalla***, et al.*** 2001). The dataset builds on available compiled datasets such as the Managed Areas Database (McGhie***, et al.*** 1996), the Designated Areas Database for Canada (WWF-Canada 1999), the US Geological Service's GAP Analysis Project (Scott***, et al.*** 1993) as well as digital land-management datasets from each state, province, and territory. The PAD includes boundaries of all federally- or state- owned (or managed) protected areas in the United States and Canada. Most of the data are at 1:100,000 scale. The datasets include many different types of protected areas, but they have been standardized in terms of protection status, management agency, and site name. To assess the level of

protection, both GAP and IUCN codes were used. GAP and IUCN codes from existing datasets were used when available; for the remainder of the polygons, GAP and IUCN codes were assigned following the equivalents described in Box 2. The United States portion of the dataset was updated in 2001 and some of the problems identified in the first version were corrected. The updated version incorporates information from all states of the United States and data on various additional protected areas not included in the original version.

Since the goal of our analysis was to assess levels of protection in terms of strict or moderate protection, the PAD was gridded based on IUCN codes. Protected areas were reclassified and grouped to indicate areas receiving protection equivalent to IUCN Categories I-V, which we refer to as "strictly or moderately protected." In view of the current debate about the Roadless Rule on United States national forest lands, we wanted to look at the number of large blocks of low-access forests falling within the national forest system. To do this, we created a new grid including only polygons designated as national forests administered by the US Forest Service. National forests polygons in the PAD include areas designated under other categories, such as wildlife management areas, private lands, US Forest Service protective withdraws, private inholdings, wilderness areas, state parks, historic sites, research natural areas, Native American reservations, etc. Thus, some of the areas within the national forest class had their own IUCN category and were included in the grid for strictly or moderately protected areas.

We also performed an additional analysis using the PAD to examine large, low-access areas administered by the United States federal government. All polygons for which the owner was listed as "federal," regardless of their designated management categories, were selected and converted into a separate grid.

Processing

The base land-cover layer, along with administrative units, was queried to calculate three forest-coverage classes for each state and province: woodlands (10-60% tree cover); dense forests (>60% tree cover); and non-forests. The analysis properties were left to the base layer; therefore, calculations were based on 1-km^2 pixels.

Merging Roads with Forest Cover and Calculating Forest Blocks over 200 km^2

The layer resulting from the previous step was merged with the transportation layer and all roaded areas were designated non-forest areas. To prevent bodies of water from being coded as roads, water features were merged with the transportation layer. The remaining forest blocks were grouped by region, and the extent of the United States and Canada was clipped using the administrative boundaries as a mask. The next step was to classify the remaining low-access forests in four class sizes: <100, 100-200, 200-500, and >500 km^2. A grid for each class size was created and statistics tabulated. Since we wanted to focus on large tracts of low-access forests, we created an additional grid depicting tracts larger than 200 km^2 to assess their level of protection.

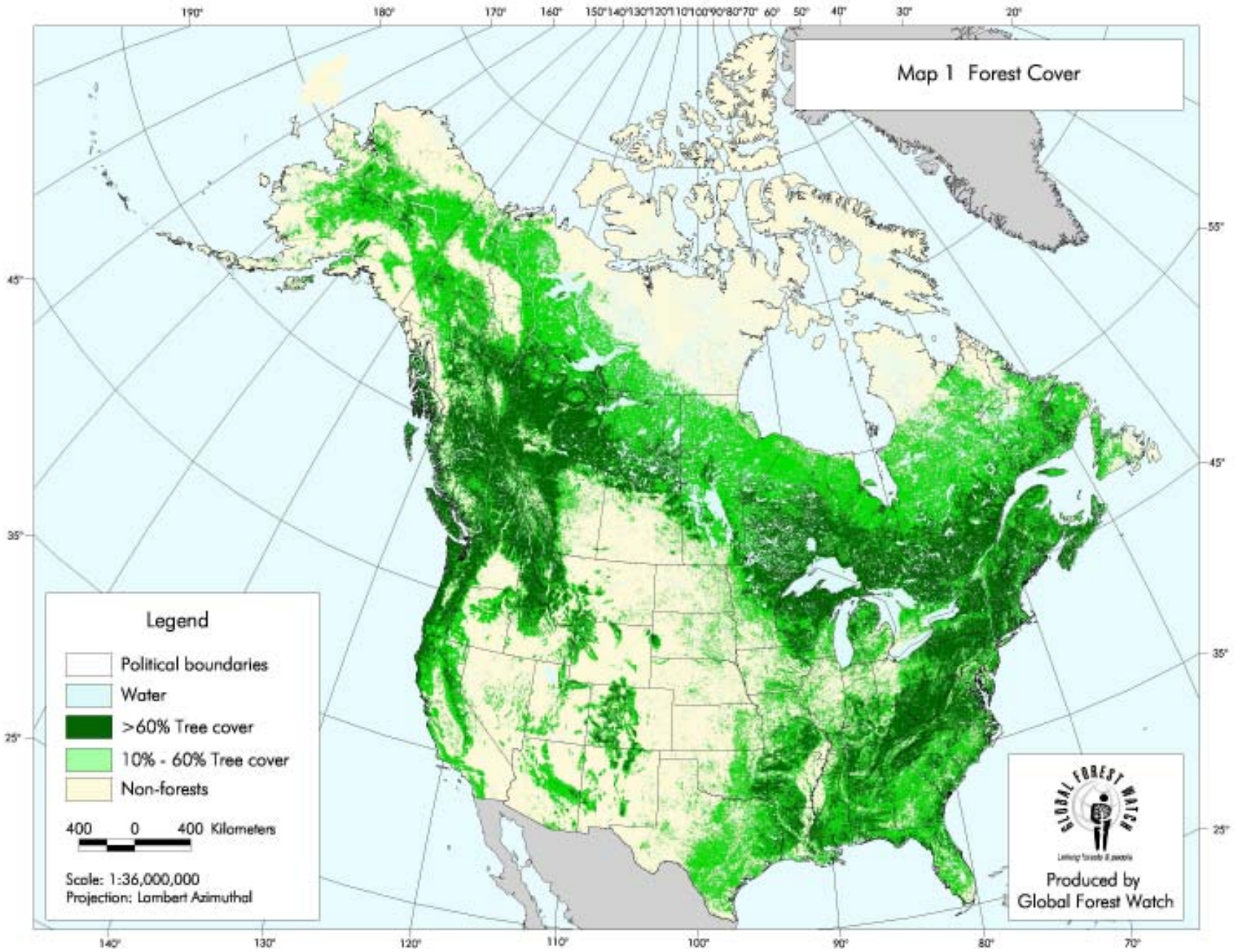
(Map 2 - Access Grid over Land Cover)

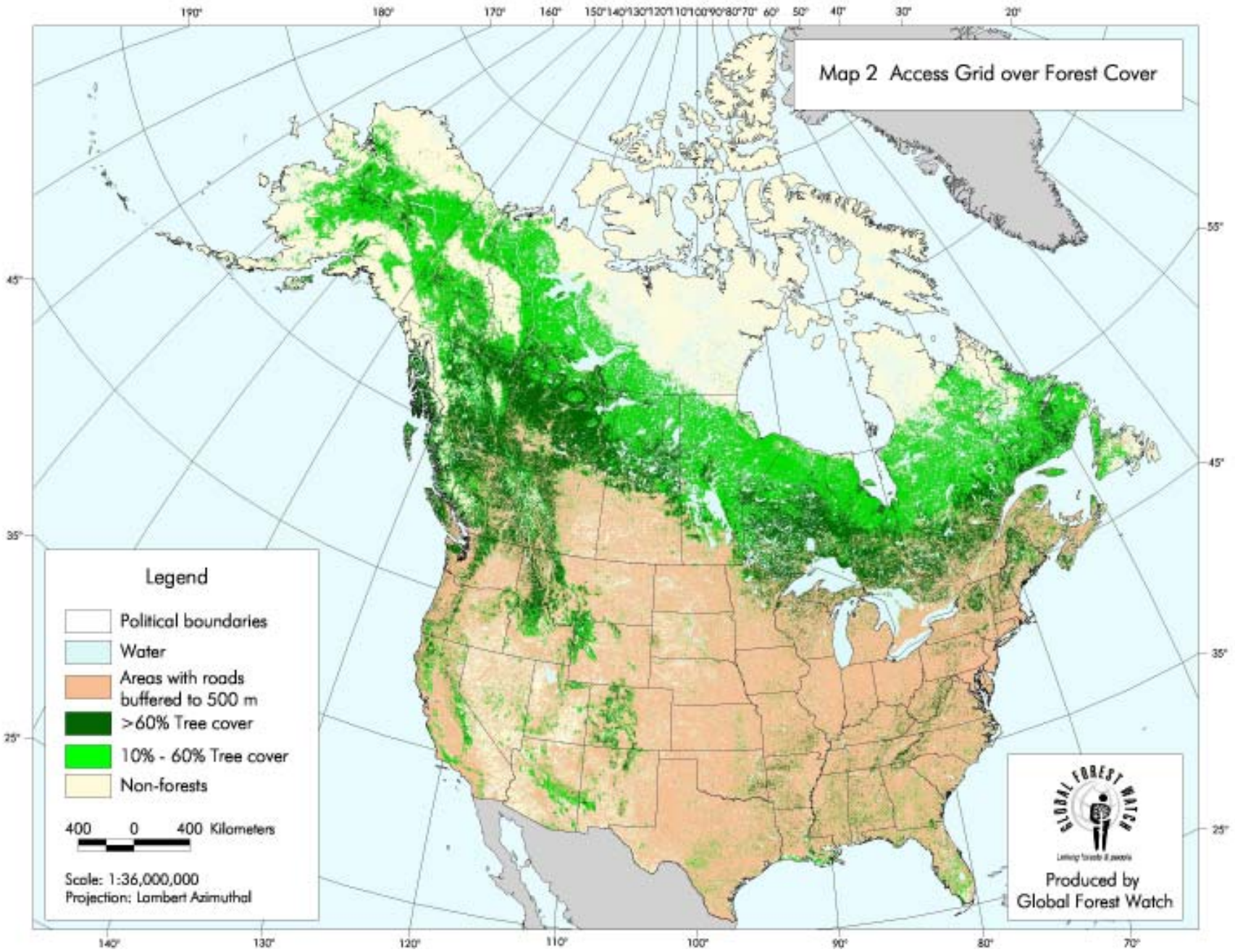
(Map 3 - Low-Access Forests in Different Class Sizes)

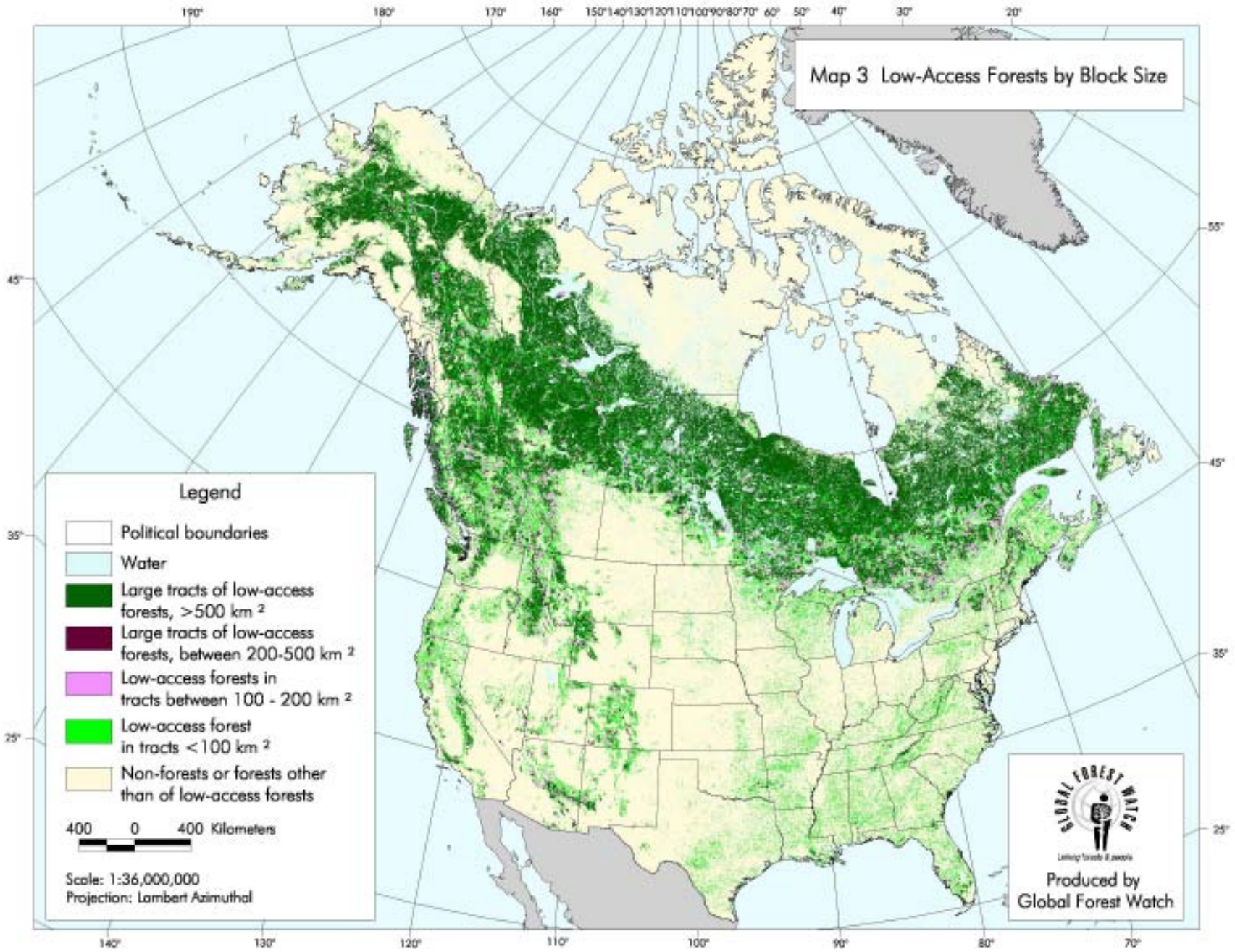
Determining Level of Protection, Proportion within National Forests, and Proportion under Federal Management

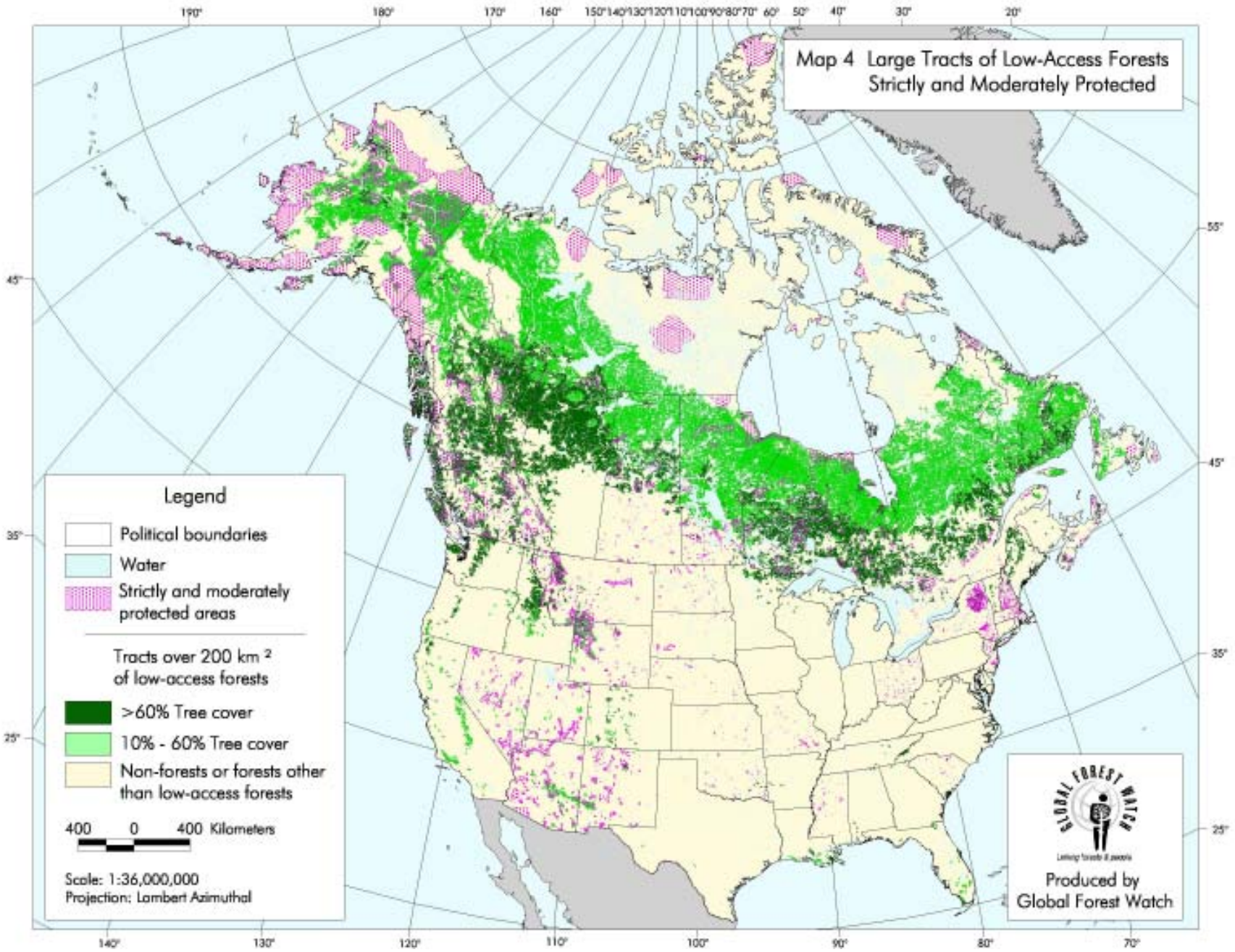
The protected areas grid was combined with information on administrative units to generate a layer displaying a unique combination of protected area status and state/province location. The number of large tracts of low-access forests was then tabulated. We repeated the procedure using the national forests grid and the tenure grid, to tabulate large tracts of low-access forests within national forests and owned by the federal government.

(Map 4 - Large Tracts of Low Access Forests Strictly and Moderately Protected)


Map 1 Forest Cover
Legend
Political boundaries
Water
>60% Tree cover
10% - 60% Tree cover
Non-forests
400 0 400 Kilometers
Scale: 1:36,000,000
Projection: Lambert Azimuthal
Produced by
Global Forest Watch


Map 2 Access Grid over Forest Cover
Legend
Political boundaries
Water
Areas with roads buffered to 500 m
>60% Tree cover
10% - 60% Tree cover
Non-forests
400 0 400 Kilometers
Scale: 1:36,000,000
Projection: Lambert Azimuthal
Produced by Global Forest Watch


Map 3 Low-Access Forests by Block Size
Legend
Political boundaries
Water
Large tracts of low-access forests, >500 km ²
Large tracts of low-access forests, between 200-500 km ²
Low-access forests in tracts between 100 - 200 km ²
Low-access forest in tracts <100 km ²
Non-forests or forests other than of low-access forests
400 0 400 Kilometers
Scale: 1:36,000,000
Projection: Lambert Azimuthal
Produced by Global Forest Watch


Map 4 Large Tracts of Low-Access Forests Strictly and Moderately Protected
Legend
Political boundaries
Water
Strictly and moderately protected areas
Tracts over 200 km ²
of low-access forests
>60% Tree cover
10% - 60% Tree cover
Non-forests or forests other than low-access forests
400 0 400 Kilometers
Scale: 1:36,000,000
Projection: Lambert Azimuthal
Produced by
Global Forest Watch

Caveats

As a coarse-scale analysis, this study attempts to provide only a rough picture of forest areas that are potentially intact and to assess their protection status. The accuracy of our results is affected by the limitations of those input datasets available for use in a continental-scale assessment. For example:

Our analysis fails to pick up disturbance from non-linear features, such as clearcuts and mines. There are no existing comprehensive datasets, at a national or regional level, that depict the location of forests that have been impacted by such disturbances.

- Because of the input datasets and scale, our analysis does not evaluate disturbances from small roads, logging roads, and seismic lines, which significantly degrade and fragment forests. This is particularly true for forests in rural areas of the United States, where existing transportation data, in many cases, underestimate the presence of roads (Karl***, et al.*** 2001). Preliminary Global Forest Watch analysis for the forests of New England provides an indication of the degree to which coarse-scale mapping underestimates the extent of forest access. Here, we found a 40% increase in access routes when switching from medium-scale (1:100,000) to a finer-scale (1:24,000) mapping, due in large part to logging roads not appearing in medium-resolution coverages.[2]
- Because the land cover used for this assessment depicts percentage of woody vegetation per grid cell, pixels do not depict patterns at a finer scale (resolution below 1 km). Consequently, when examined at a finer scale, some areas showing a high percentage of tree cover might prove to be highly fragmented; to the extent that this is true, the area of low-access forests is overestimated. Moreover, since the dataset was created (1992-3), the distribution of forest cover has changed, due to recent agricultural, urban, and other development.
- Maps are views of the surface of the earth, and representations on paper of a three-dimensional object will always be somewhat distorted in shape, size, or direction, depending on the map projection used.

Other caveats are noted in the main body of the text.

Literature Cited

Bryant, D., D. Nielsen, and L. Tangley. 1997. "The Last Frontier Forests: Ecosystems and Economies on the Edge." 42. Washington, DC: World Resources Institute. (Sections of the report available online at http://www.igc.org/wri/ffi/lff-eng/lff-toc.htm). (3/15/02).

Canadian Council of Forest Ministers. 1997. "Criteria and Indicators of Sustainable Forest Management in Canada." 137. Ottawa, ON: Canadian Council of Forest Ministers. (Available online at: http://www.nrcan.gc.ca/cfs/proj/ppiab/ci/pdf/ci_e.pdf). (3/15/02).

DeFries, R.S., J.R.G. Hansen, A.C. Janetos, and T.R. Loveland. 2000. "A New Global 1-km Data Set of Percentage Tree Cover Derived from Remote Sensing." ***Global Change Biology*** 6. 247-54.

DellaSalla, D.A., N.L. Staus, J.R. Strittholt, A. Hackman, and A. Iacobelli. 2001. "An Updated Protected Areas Database for The United States and Canada." ***Natural Areas Journal*** 21. 124-35.

Dent, B.D. "Cartography Thematic Map Design, Fifth Edition". 1999. WCB/McGraw-Hill.

Karl, J., P. Morrison, L. Swope, and K. Ackley. 2001. "Wildlands of the United States." Winthrop, WA: Pacific Biodiversity Institute. (Available online at: http://www.pacificbio.org/pubs/wildlands_of_the_united_states.htm).

Matthews, E., R. Payne, M. Rohweder, and S. Murray. 2000. "Pilot Analysis of Global Ecosystems, Forest Ecosystems." 90. Washington, DC: World Resources Institute. (Available online at: http://www.wri.org/wri/wr2000/forests_page.html). (3/18/02).

McGhie, R.G., J. Scepan, and J.E. Estes. 1996. "A Comprehensive Managed Areas Spatial Database for the Coterminous United States." ***Photogrammetric Engineering and Remote Sensing*** 62. 1303-06.

Scott, M.J., F.W. Davis, B. Csuti, R. Noss, B. Butterfield, C. Groves, H. Anderson, S. Caicco, F. D'Erchia, T.C.J. Edwards, J. Ulliman, and R.G. Wright. 1993. "GAP Analysis: A Geographic Approach to Protection of Biological Diversity." ***Wildlife Monographs No. 123***: The Wildlife Society.

Scott, M.J., F.W. Davis, G. McGhie, R. G. Wright, C. Groves, and J. Estes. 2001. "Nature Reserves: Do They Capture the Full Range of America's Biological Diversity?" ***Ecological Applications*** 11(4), no. 4. 999-1007.

Smith, W., and P.E. Lee. (Eds.). 2000. "Canada's Forests at a Crossroads: An Assessment in the Year 2000." Washington, DC: World Resources Institute, Global Forest Watch Canada. (Available online at: http://www.globalforestwatch.org/english/canada/maps.htm). (3/15/02).

Strittholt, J., and D.A. DellaSalla. 1999. "Importance of Roadless Areas in Biodiversity Conservation in Forested Ecosystems: Case Study of the Klamath-Siskiyou Ecoregion of the United States." Conservation Biology 15, no. 6. 1742-1754.

Trombulak, S.C., and C.A. Frissell. 2000. "Review of Ecological Effects of Roads on Terrestrial and Aquatic Communities." ***Conservation Biology*** 14, no. 1. 18-30.

[UNEP] United Nations Environment Programme. 2001. "GLOBIO 02. Methodology." Arendal, Norway: United Nations Environment Programme. (Available online at: http://www.globio.info/methodology/globiomethodology.pdf). (3/14/02).

[USDA-FS] United States Department of Agriculture-Forest Service. 2000. "Resources Planning Act (RPA) Assessment, Final Statistics." Washington, DC: United States Department of Agriculture-Forest Service, Forest Inventory and Analysis. (Available online at: http://www.srsfia.usfs.msstate.edu/wo/FINAL_RPA_TABLES.PDF). (3/13/02).

[WWF-Canada] World Wildlife Fund Canada. 1999. "Endangered Spaces Progress Report on Protecting Canada's Wildlands. 1998-99." Toronto, ON: WWF-Canada.

Yaroshenko, A.Y., P.V. Potapov, and S.A. Turubanova. 2001. "The Last Intact Forest Landscapes of Northern European Russia." 75. Moscow, Russia: Greenpeace Russia and Global Forest Watch. (Available online at: http://www.globalforestwatch.org/english/russia/maps.htm)

Endnotes

1. Our results are different from that W. Smith and P. Lee (Eds.), "Canada's Forests at a Crossroads: An Assessment in the Year 2000," (Washington, DC: World Resources Institute, Global Forest Watch Canada, 2000). because of land cover base used. In the first GFW assessment, the base land cover used was the 1995 Land Cover of Canada developed by the Canadian Center for Remote Sensing.
2. Jim Strittholt, private communication

World
Resources
Institute

www.globalforestwatch.org

10 G Street NE
Washington, DC 20002
USA

www.wri.org

ISBN 1-56973-514-x