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THE LAST FRONTIER FORESTS:

ECOSYSTEMS & ECONOMIES ON THE EDGE

WHAT IS THE STATUS OF THE WORLD'S REMAINING LARGE, NATURAL FOREST ECOSYSTEMS?

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A Contribution to the
Forest Frontiers Initiative

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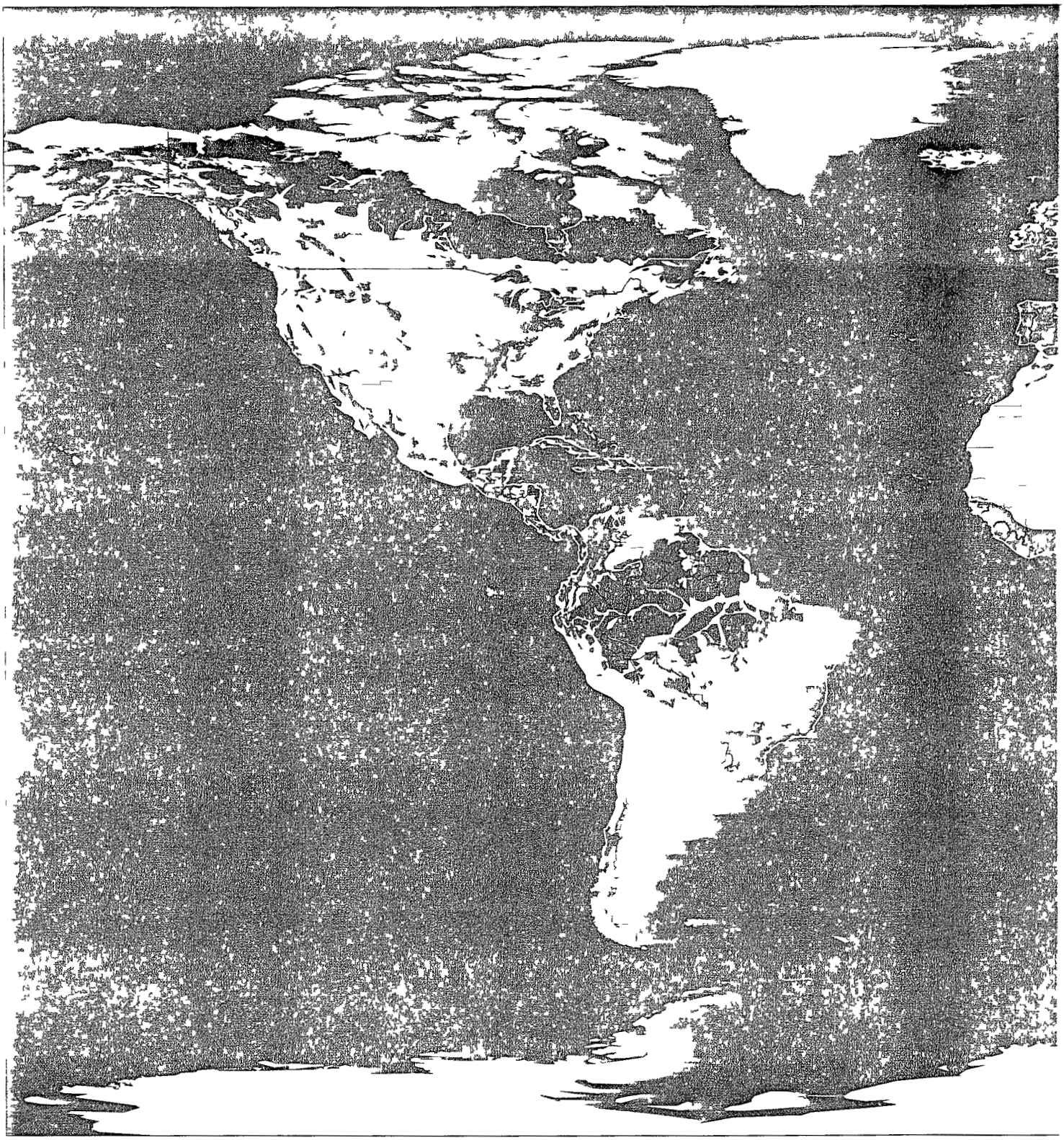
THREATENED FRONTIER



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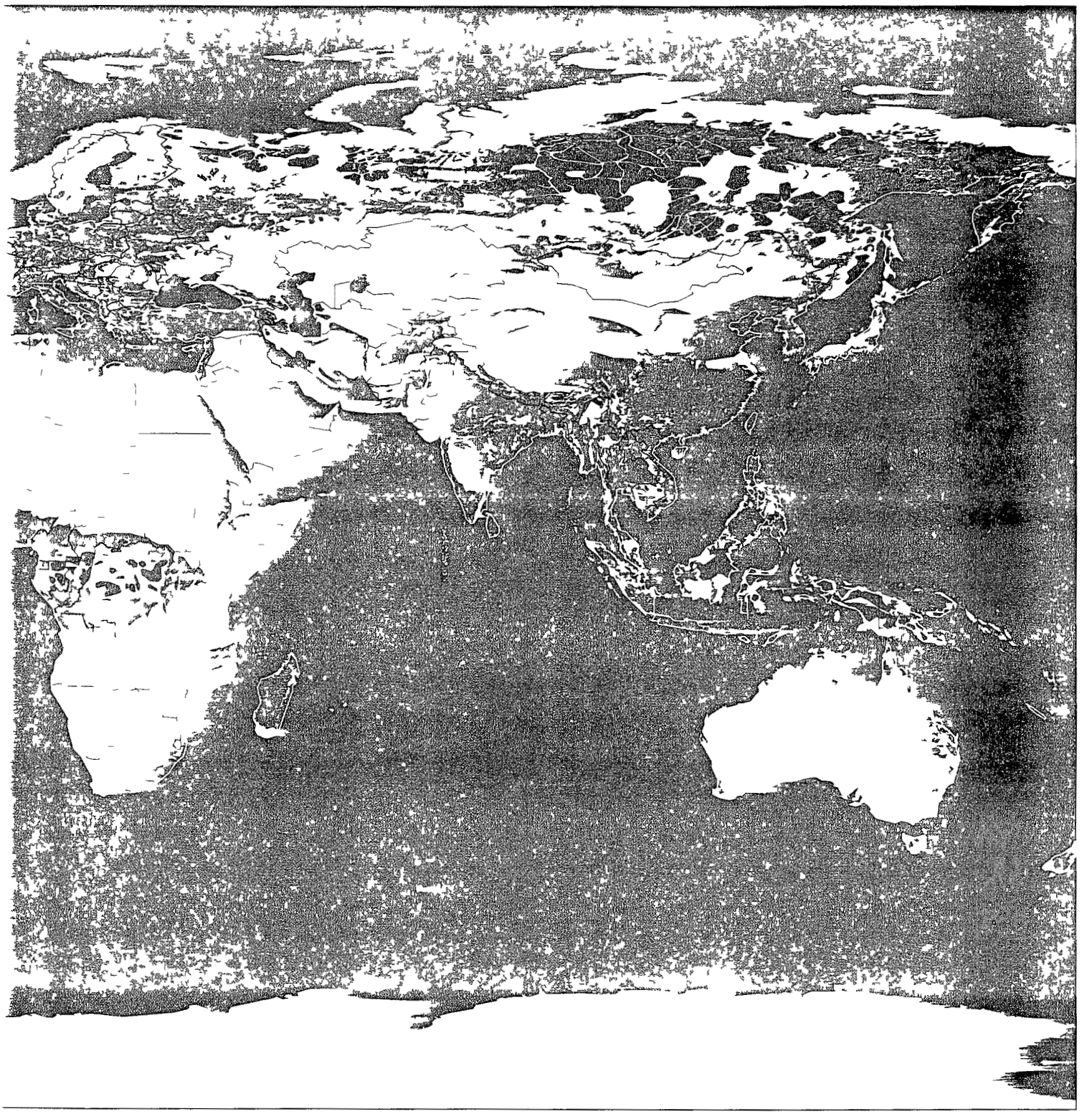
FORESTS OF THE WORLD



Frontier forests 8,000 years ago

Frontier forests today
Large intact natural forest ecosystems that are relatively undisturbed and large enough to maintain all of their biodiversity

Current non-frontier forests
secondary forest plantations degraded forest and patches of primary forest not meeting this study's criteria as frontier

E

Major Findings

- Almost half of Earth's original forest cover is gone much of it destroyed within the past three decades
- Today, just one fifth of the world's original forest cover remains in large tracts of relatively undisturbed forest – what WRI calls ***frontier forest***
- Three countries – Russia, Canada, and Brazil – house almost 70 percent of the world's remaining frontier forest
- 40 percent of forest on Earth today qualifies as frontier forest
- Seventy six countries assessed in this study have lost ***all*** of their frontier forest
- 39 percent of Earth's remaining frontier forest is threatened by logging, agricultural clearing and other human activity
- Only 3 percent of the world's frontier forest falls entirely within the temperate zone (regions characterized by moderate climate, including much of the U S and Europe) Today, temperate forests are the most endangered frontier forests of all
- Half of today's frontier forest lies in boreal regions within Canada, Russia and Alaska – inhospitable northern zones between temperate forest and tundra
- Outside of boreal regions about 75 percent of the world's frontier forest is threatened
- Eleven countries – including Finland Sweden, Vietnam, Guatemala and Thailand – are on the verge of losing their frontier forest These countries maintain less than 5 percent of their original forest as frontier and all of it is threatened

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FOREWORD

The word frontier conjures up notions of new challenges of new lands, or new intellectual endeavors ripe for human exploitation and development If a frontier is out there, people will not be far behind

The frontier vision often saw trees as a commodity at best or simply an obstacle in the way of progress Over many centuries about half of the world's forests – almost 3 billion hectares – were burned cleared or cut down Just one fifth of the world's original forest cover remains in large undisturbed tracts today and the cutting has accelerated about 16 million hectares are cut or burned each year In the course of this devastation we are losing species and a valuable cornucopia of resources, altering the atmosphere's composition and brutally degrading ecosystems

Road building and other infrastructure development often accompanying logging mining or other large investments are also proceeding quickly Once the way is paved population pressure and landlessness in some parts of the world especially developing countries can prompt migration into frontier regions and rapid deforestation by small land holders and large land speculators

There are better ways to use manage and preserve forests The reach of human ingenuity extends to the stewardship of trees but at the frontiers the destruction continues

This report describes for the first time the location and status of the world's frontier forests – the large ecologically intact and relatively undisturbed natural forests that still remain Working with several partners including the World Conservation Monitoring Centre the World Wildlife Fund and 90 forest experts, WRI developed a first map of frontier forest areas assembling in one place unprecedented location specific information on current and future threats to forest integrity

Using a geographic information system WRI has developed a single global database and a preliminary series of regional maps depicting the world's frontier forests – both first of their kinds In the coming years WRI will update and improve these maps and get their obvious message to the world's decision makers

This report is the opening salvo of WRI's Forest Frontiers Initiative a five year multidisciplinary effort to promote stewardship in and around the world's last major frontier forests by influencing investment policy, and public opinion

For each forest frontier region – in Amazonia, Central Africa, Asia North America and Russia – WRI is building a network of policy makers activists investors and researchers to promote alternatives to forest destruction that take advantage of the full economic potential of forests not just immediate revenue from logging and forest clearing As part of this effort, WRI will help build the capacity of local organizations to carry on this work independently

The business community is an important partner in this effort We are working with others to develop case studies with innovative firms to demonstrate the business impacts and opportunities that sustainability presents

We must act quickly Transnational logging companies are already operating in Siberia and Canada and rapidly expanding operations into South America the Caribbean Rim, and Central Africa Within the next five years many pending and proposed contracts will be signed and the leverage of governments and non governmental organizations will be greatly diminished

At the same time, mainstream industry and investors are increasingly open to change There is a significant opportunity to increase market demand for green timber WRI is already a backer of the Forest Stewardship Council the first international organization created to evaluate accredit and monitor organizations that certify sustainably produced forest products Meanwhile many developing countries are searching for practical policy alternatives to destructive timber harvest agreements

We are deeply grateful to the AVINA Group and the Netherlands Ministry of Foreign Affairs for their general support for the Forest Frontiers Initiative and to the Wallace Global Fund for supporting this project

Jonathan Lash
President
World Resources Institute

INTRODUCTION

By now most people who read a newspaper or watch television know that deforestation is a serious problem particularly in the tropics This World Resources Institute (WRI) analysis shows that we have lost almost half – almost 3 billion hectares – of the forests that once blanketed the earth Every year at least 16 million additional hectares fall to the ax torch, bulldozer or chain saw [12]

Hidden behind such familiar statistics, however is another equally sobering reality Of the forests that do remain standing, the vast majority are no more than small or highly disturbed pieces of the fully functioning ecosystems they once were These modified forests should not be forgotten of course They are the last refuge for some of the world's most endangered species and they provide important economic products and environmental services Yet, they may have lost their ability to sustain themselves in the long term To support their full complement of plant and animal inhabitants fragmented forests will probably need regular interventions by resource managers

Hidden behind familiar statistics is an equally sobering reality Of the forests that do remain standing, the vast majority are no more than small or highly disturbed pieces of the fully functioning ecosystems they once were

In contrast, frontier forests – large, ecologically intact, and relatively undisturbed natural forests – are likely to survive indefinitely without human assistance *(See Box 1 and the Technical Annex)* Within these forests natural ecological and evolutionary processes will continue to generate and maintain the biodiversity upon which we all rely Frontier forests also contribute a large portion of the ecological services – such as watershed protection and climate stabilization – that make the planet habitable And they are home to many of the world's remaining indigenous peoples

Keeping Earth's last frontier forests will require a fundamental shift in how we view them From the American Wild West of the 1800s to Russia's Far East and the South American Amazon today, frontiers have been seen as limitless providers of land timber, gold wildlife and other sources of wealth Careless and wasteful a typical frontier economy mines the forest for a quick profit and moves on

We believe it is time to replace this outdated thinking with a concept of frontier that is based on stewardship – taking responsibility for the forest and ensuring that its riches will be available for future generations Good stewardship may mean complete protection of some frontier forests combined with careful management of portions of others for both timber and non timber products

The change must happen soon over the coming years, citizens policy makers, industry leaders, and others have a chance to decide the fate of the world's last frontier forests The key decisions before us are windows of opportunity that may never open again

WHY DO FRONTIER FORESTS MATTER?

As large intact ecosys tems, frontier forests dif fer fundamentally from the fragmented or otherwise modified forests that dominate the landscape today For one thing, frontier forests are large enough to provide a safe haven for all of their indigenous species To ensure long term survival, far ranging animals such as grizzly bears, harpy eagles, and wolves need blocks of natural habitat thousands, if not tens of thousands, of square kilometers in size [3,4,5]

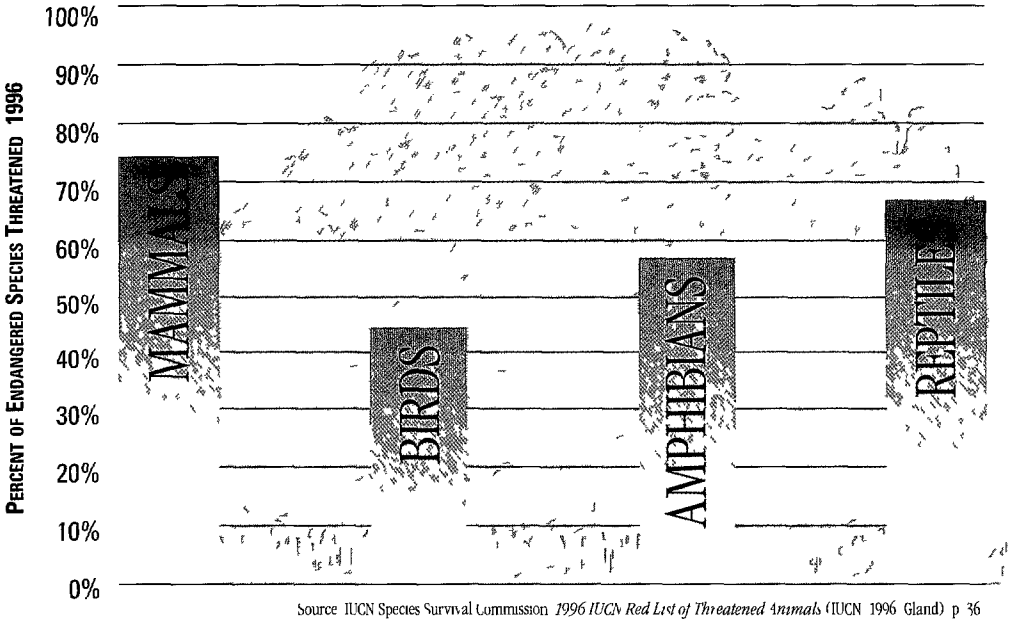
Fragmented forests on the other hand are probably too small to support their full com plement of species in the coming centuries [6] Smaller tracts are also vulnerable to processes beyond their borders In the United States for example, the nests of songbirds in small forest patches are under heavy attack by cowbirds bluejays raccoons, and other animals that thrive along forest edges [7] Many non frontier forests also lack the natural fea tures that native species rely on In the U S Pacific Northwest the spotted owl and marbled murrelet – birds that depend on large standing dead trees typically found in old growth forests – are threatened by logging of these ecosystems [8]

Secure habitats for indige nous species, frontier forests are invaluable refuges for global biodi versity Between 50 and 90 percent of all terrestrial species inhabit the world's forests,[9] and many of them are threatened by extinc tion primarily because of habitat loss *(See Figure 1)* By main taining these last strongholds we protect the biodiversity within them and provide a source for recolonizing non frontier and restored forests with native species Beyond its obvious intrin sic value, biodiversity supplies humans with food medicines, and many other staples needed to survive and make a living

More than safe houses for genes and species under siege frontier forests maintain complex and inimitable ecological com munities and processes Vast and undisturbed, they give free play to nature and to such natural events as wildfires and seed dispersal by large herbivores both of which determine the composition and distribution of species Such natural processes create unique habi tats, including ancient stands of old growth forest

FIGURE 1

Percent of the world s endangered animal species threatened by the loss of forest and other natural habitat



Source IUCN Species Survival Commission *1996 IUCN Red List of Threatened Animals* (IUCN 1996 Gland) p 36

It is time to replace outdated thinking with a concept of frontier that is based on stewardship

As large intact ecosystems governed by nature, frontier forests provide baseline information on how such systems should work Just as doctors use standard body temperature and blood pressure to determine health ecologists study natural forests to evaluate the impact of different human interventions – asking, for instance how forest clearing might affect local rainfall patterns The results help land managers find ways to lighten the human footprint in heavily used landscapes

All forests help maintain the environmental conditions that make life possible from regional hydrologic cycles to global climate But huge frontiers are particularly important Frontier forest ecosystems store tremendous amounts of carbon for example – approximately 435 billion tonnes or more than all carbon that will be released from fossil fuel burning and cement manufacture over the next 69 years at current global emission rates [10] Without these forests, this carbon would go straight into the atmosphere as carbon dioxide, a powerful greenhouse gas

Protecting and responsibly managing our last frontiers today will help countries avoid paying the high costs associated with massive forest loss and degradation History abounds with examples of civilizations that foundered after deforestation led to soil erosion river siltation wood shortages and other banes of agricultural and industrial productivity These doomed civilizations include ancient societies in Mesopotamia, the Mediterranean, and Central America [11]

More recently erosion since 1950 due to deforestation is responsible for the loss of 580 million hectares of fertile land worldwide an area bigger than all of Western Europe [12] Loss of large forested watersheds is blamed for heavier flooding in India's Ganges Valley and government losses of $1 billion a year in property damage [13] By carefully managing what's left of the world's frontier forests we can dramatically reduce such environmental side effects and costs

Dwindling frontier forests are also home to many of the world's last indigenous cultures About 50 million indigenous people live in tropical forests alone [14] Amazonian forests house at least 400 indigenous groups – 1 million people in all [15] Wiping out indigenous cultures by transforming forests is a moral crime And when these cultures vanish so does a gold mine of useful information about the natural world

Frontier forests are invaluable refuges for global biodiversity

A legacy inherited from our ancestors, Earth's last frontier forests may indeed be the most valuable gift we can leave for our children Guardians of biodiversity indigenous cultures, and ecological processes, frontiers also provide recreational and ecotourism opportunities Because so many irreplaceable forests have already disappeared the worth to future generations of those that remain is greater than ever

Above and beyond practical considerations is the very real aesthetic and spiritual need just to know that remote and wild places remain on our crowded planet One concrete reflection of this need is the considerable sum of money many people pay to visit such places But even to many people who will never see them, wild plants and animals along with the forests that house them, have an inalienable right to exist Certainly as Earth's most powerful species, we have a responsibility to ensure their survival

What Do We Know About the World's Forests?

Surprisingly, we know very little about the status of the world's forests as a whole Most monitoring efforts are confined to individual countries and the results often do not compute across borders

Sponsored by the United Nations (U N) the most comprehensive study of the world's forests to date estimates recent deforestation but gives no information on the overall condition of remaining forest [16] This U N study cost $4 million – less than one eighth the amount U S citizens spend each day on newspapers [17 18]

People need to know that remote and wild places remain on our crowded planet

To help fill the gap, WRI asked the World Conservation Monitoring Centre (WCMC) to develop a map of Earth's forest cover as it appeared 8 000 years ago The result represents the first detailed attempt to show what the world's original forest cover looked like before humans began transforming it

The WRI map also shows current forest cover, drawing from an earlier WCMC map that provides the most comprehensive image of total forest cover today Though based on the best available data, the WCMC current forest cover map is far from complete Many areas depicted as forested can hardly be considered forest Some are heavily degraded by logging and other activities while others are single species plantations A rough picture of where forests are is invaluable, but until WRI's assessment virtually nothing was known about their condition on a global scale

TABLE 1

Total Area in Original Current and Frontier Forest

Region	Original Forest (000 Km²)	Total Remaining Forest (Frontier and Non Frontier Forest) (000 Km²)	Total Remaining as a % of Original Forest	Total Frontier Forest (000 Km²)	Frontier Forest as a % of Total Original Forest	Frontier Forest as a % of Total Remaining Forest
Africa	6,799	2 302	34%	527	8%	23%
Asia	15 132	4 275	28%	844	6%	20%
North & Central America	12 656	9 453	75%	3 909	31%	41%
Central America	1 779	970	55%	172	10%	18%
North America	10 877	8 483	78%	3 737	34%	44%
South America	9 736	6 800	70%	4 439	46%	65%
Russia & Europe	16 449	9 604	58%	3 463	21%	36%
Europe	4 690	1 521	32%	14	0 3%	1%
Russia	11 759	8 083	69%	3 448	29%	43%
Oceania (1)	1,431	929	65%	319	22%	34%
World	62 203	33 363	54%	13 501	22%	40%

Notes (1) Oceania consists of Papua New Guinea Australia and New Zealand

WRI's Frontier Forests Assessment

Most information on forests is scattered far and wide and buried within the walls of isolated institutions Much lives only in the minds of biologists and foresters who are experts on a single forest region

Most of the tremendous amount of information on individual forests that exists is scattered far and wide and buried within the walls of isolated institutions Much of it lives only in the minds of biologists and foresters who are experts on a single forest region

Working with several partners – including WCMC and the World Wildlife Fund – WRI wove together some of this diverse data knowledge and expertise First we developed a preliminary map of "candidate frontier forests – large forested areas with few roads or modern settlements – and sent it to 90 forest experts around the world Using criteria WRI developed, ten to fifteen experts for each region commented on proposed frontier areas – confirming sites as frontier forests rejecting sites, or redrawing their shape and boundaries *(See Box 1)* [19]

Experts also supplied information on the status of frontiers they identified – if and how these forests are endangered by development They also answered our queries about future threats specifying whether frontiers were in timber concessions or housed such high value resources as timber oil or gold

Using a geographic information system [20] WRI combined all of these site specific data into a single global database and a series of regional maps *(See Maps 2 7)* Far from perfect these maps nonetheless provide the first realistic picture of the location and status of the world's frontier forests In the coming months and years WRI will work with partners around the globe to update and improve the maps as more information becomes available and to get them to decision makers in whose hands the fate of frontier forests rests

WRI's maps provide the first realistic picture of the location and status of the world's frontier forests

1 DEFINITIONS USED IN THIS STUDY

FRONTIER FORESTS are the world's remaining large intact natural forest ecosystems These forests are – on the whole – relatively undisturbed and big enough to maintain all of their biodiversity including viable populations of the wide ranging species associated with each forest type As defined in this assessment a frontier forest must meet seven criteria

1 It is primarily forested
2 It is big enough to support viable populations of all indigenous species associated with that forest type – measured by the forest's ability to support wide ranging animal species (such as elephants, harpy eagles, or brown bears)
3 It is large enough to keep these species populations viable even in the face of the natural disasters – such as hurricanes fires and pest or disease out breaks – that might occur there in a century
4 Its structure and composition are determined mainly by natural events though limited human disturbance by traditional activities of the sort that have shaped forests for thousands of years – such as low density shifting cultivation – is acceptable As such it remains relatively unmanaged by humans and natural disturbances (such as fire) are permitted to shape much of the forest
5 In forests where patches of trees of different ages would naturally occur, the landscape exhibits this type of heterogeneity
6 It is dominated by indigenous tree species
7 It is home to most, if not all of the other plant and animal species that typically live in this type of forest

THREATENED FRONTIER FORESTS are forests where ongoing or planned human activities (such as logging agricultural clearing and mining) will eventually degrade the ecosystem (through, for example, declines in or local extinctions of plants and animals or large-scale changes in the forest's age and structure)

LOW-THREAT POTENTIALLY VULNERABLE FRONTIER FORESTS are those not now considered under enough pressure to degrade ecosystems But because they are unprotected and contain valuable natural resources or because human encroachment is likely most of these forests are vulnerable to future degradation and destruction

NON-FRONTIER FORESTS are dominated by secondary forests plantations, degraded forest and patches of primary forest that do not meet this study's frontier criteria (even though some might be restored as frontier forest) This category includes some of the world's most unique valuable, and endangered forest types, including the biologically rich, highly fragmented forests of Madagascar and Central Europe's last stands of old growth forest Such forests are high priorities for conservation Non-frontier forests are also important because they provide us with a wide range of economic goods and services

ORIGINAL FOREST is that estimated to have covered the planet about 8 000 years ago before large scale disturbance by modern society began

A note about the data This study's results represent estimates of the extent and location of frontier forests as well as threats to their survival Incomplete information from some parts of the world and difficulties estimating the magnitude of threats make the data suitable only for regional comparisons and for distinguishing major differences among countries' forests This study did not assess woodland areas of the world, or forests within many island countries (See Technical Annex)

FALLING FRONTIERS

Nearly half – 46 percent – of the world's forest has been converted to farms pastures and other uses over the past 80 centuries While just over half remains most of it has been heavily altered by people and bears little resemblance to pristine forest According to this assessment just 22 percent of Earth's original forest remains in large relatively natural ecosystems *(See Figure 2)*

Of the remaining frontier forest that is left, nearly half is boreal forest *(See Figure 3)* A broad belt of primarily coniferous trees, boreal forests lie between arctic tundra to the north and warmer, temperate forests to the south They blanket much of Alaska, Canada, Russia, and Scandinavia

For two reasons, boreal forests have been less disturbed than have other forest types First, long winters, poor soils and other factors make farming difficult, so little forest has been converted to agriculture Second, boreal trees, particularly in northern areas tend to be slow growing scrawny and widely dispersed So until modern technology increasing wood demand and other factors changed the picture commercial loggers traditionally had little incentive to exploit boreal forests

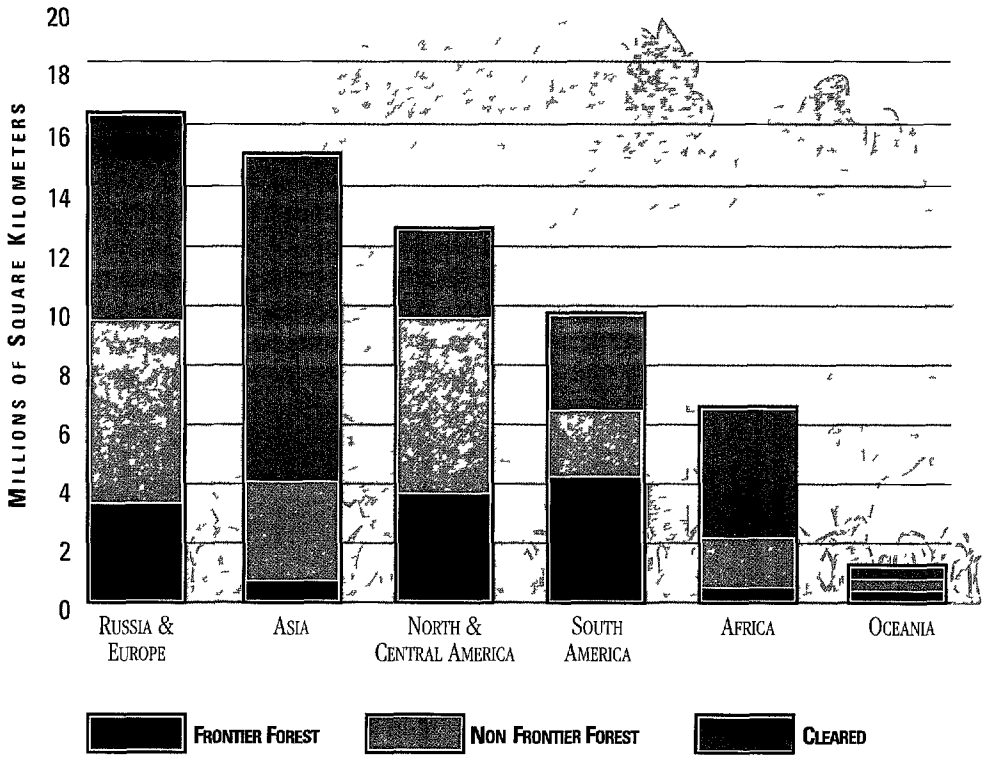
Temperate forests on the other hand, are the most heavily fragmented and disturbed of all forest types This study concludes that just 3 percent of today's frontier forests are temperate stands (another 5 percent contains both temperate and either boreal or tropical frontier forest) Thriving in a moderate climate pristine temperate forests once extended throughout most of Europe much of China and the continental United States as well as parts of Canada Australia New Zealand Chile, and Argentina

Thanks to their favorable climate and fertile soils temperate forests were the first to be cleared wholesale by humans By 1000 B C most of eastern China's forests had been converted to farmland [21] More than 2 000 years ago the Greeks and Romans destroyed much of the forest that rimmed the Mediterranean [22 23] Today the frontier forests of the Middle East and Mediterranean Basin are completely gone Western Europe's frontier forests were leveled during the Middle Ages as new cities and towns spread throughout the region [24]

According to this assessment just 22 percent of Earth's original forest remains in large, relatively natural ecosystems

FIGURE 2

What Happened to the Forests That Once Covered the Earth?



Temperate forests of the Americas Australia and New Zealand were opened relatively recently – over the past few centuries – by European explorers and settlers Although indigenous peoples had long lived in and shaped these forests newcomers wrought far more dramatic changes *(See Box 2)* Even so, almost all of the world's remaining temperate frontier forests are in these three regions

The lion's share of today's frontier forests – more than 75 percent-is located in just three large tracts covering parts of seven countries

Until this century tropical forests – located in warm regions within 30 degrees of the equator – remained largely intact In the past few decades however, they have fallen with alarming speed Between 1960 and 1990, some 450 million hectares were cleared – a fifth of the world's entire tropical forest cover *(See Figure 4)*

Millions more hectares have been degraded by logging, agricultural clearing and the removal of vegetation for fuelwood building materials, and livestock feed In Asia and Africa for example this study found that though roughly a third of the original forest cover remains less than 10 percent of this original cover still qualifies as frontier forest *(See Table 1)*

Worldwide most frontier forests are now restricted to scattered, widely dispersed pockets many located in inaccessible mountains or swamps Europe – which has already lost two thirds of its historical forest cover – maintains only a few small patches of frontier forest totalling less than 1 percent of the original all in Sweden and Finland

The lion's share of today's frontier forest – more than 75 per cent – is located in just three large tracts covering parts of seven countries two blocks of boreal forest – one stretching across much of Canada and Alaska and the other in Russia – and one large relatively undisturbed chunk of tropical forest spanning the Northwestern Amazon Basin and Guyana Shield

FIGURE 3

Temperate Frontier Forests Are the Most Endangered

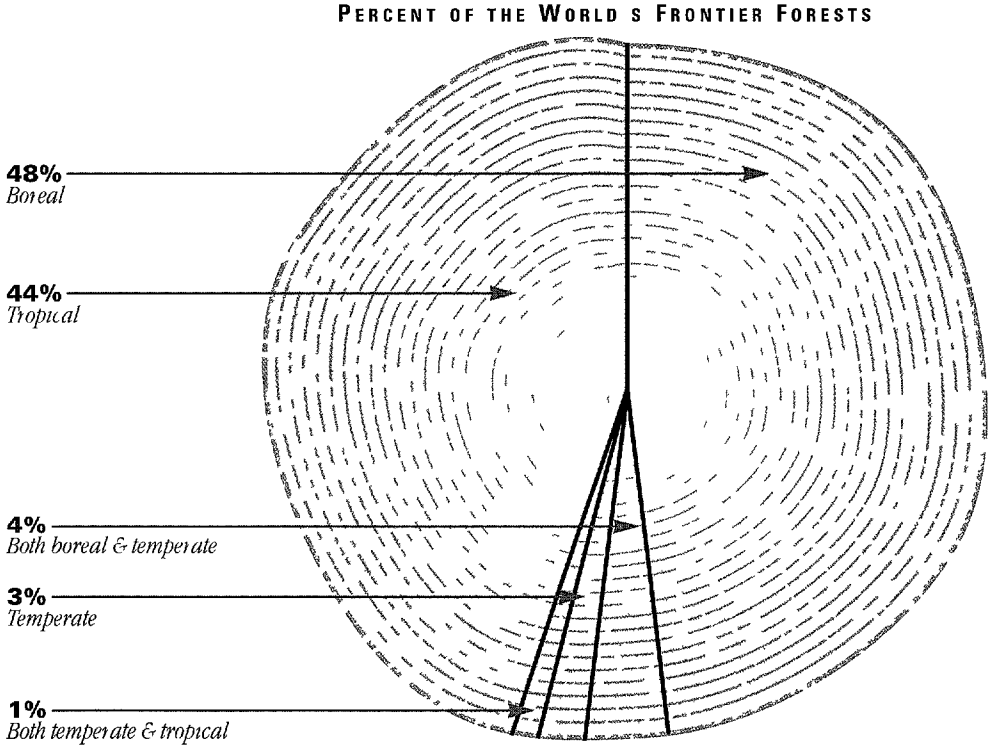
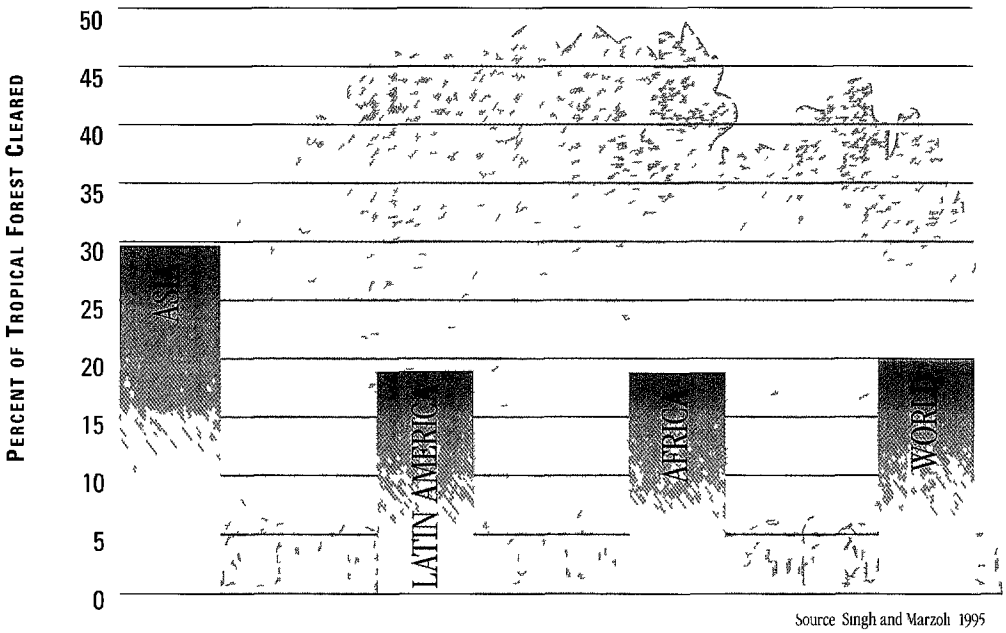


FIGURE 4

Percentage of the World s Tropical Forest Cleared Between 1960 and 1990



Source Singh and Marzoli 1995

2 FRONTIER FOREST MYTHS

As places that conjure up images of vast empty spaces frontiers are associated with many popular myths that contribute to their destruction In each case the reality is far more complex Three of the more common myths about frontier forests are

MYTH Frontiers are comprised of empty wilderness

REALITY People have lived in many forests for hundreds of generations mostly in small groups Forests today house several hundred million people in Asia alone,[25] while at least 20 million people live in the Amazon Basin [26] Low level human activity over thousands of years within these areas has helped shape the forest structure and species mix in frontier ecosystems

MYTH Forest peoples live in utopian harmony with nature

REALITY Long before European colonization forest peoples managed their natural resources according to customary practices Evidence suggests that some human cultures destroyed their own forest ecosystems through abuse and others in tribal warfare [27 28] Today rising populations land shortages and access to sophisticated technologies pose further management challenges for forest peoples

MYTH Frontiers consist of fertile land ripe for development

REALITY In many places frontier forests remain undeveloped because their soils are poor and they don't have much commercially valuable timber per hectare In many tropical forests for instance intensive agricultural activity can rapidly deplete soils that need natural debris from the tree canopy Then too forests are finite, and some are inaccessible Forests in Amazonia and in Central Africa for example, are rich in biodiversity but they often lack high densities of valuable timber species or good soils [29]

Today's Threats

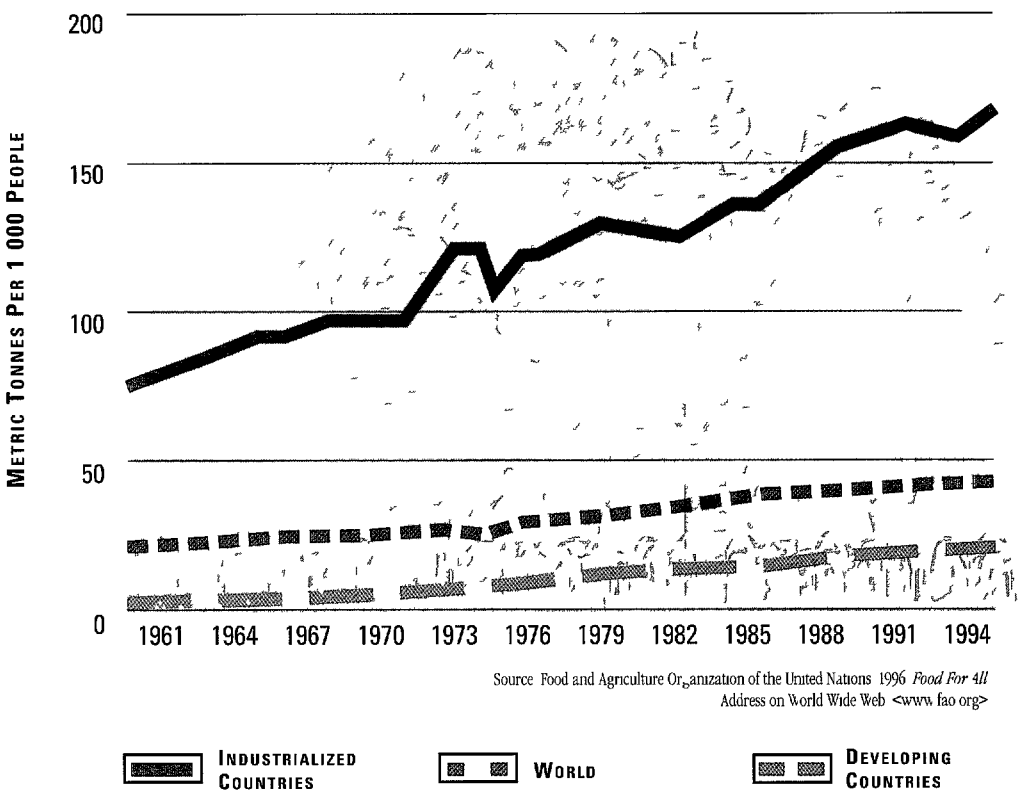
Many of the frontier forests that have survived into this century may not make it into the next. Results from this study suggest that 39 percent of the world's remaining frontiers are threatened – that is, under moderate or high threat – by logging, agricultural clearing, and other activities, often along the forest edges. Many frontier forests not yet threatened – particularly those in the tropics – are still vulnerable because they contain valuable timber, oil, or minerals.

Most of the safest frontier forests are in the far north, where resource extraction costs are high. Taking these forests out of the global calculus changes it significantly: outside Russia and Canada, three quarters of the world's frontier forests – including virtually all temperate forest frontiers – are at risk.

The most important threats to frontier forests are described below.

FIGURE 5

Example of Pressures on Forests: People are Using More Paper Products



Source: Food and Agriculture Organization of the United Nations, 1996. *Food For All*. Address on World Wide Web: <www.fao.org>

■ **Logging.** This study suggests that commercial logging poses by far the greatest danger to frontier forests. In all six regions assessed, WRI's advisors cited logging as the predominate threat to forests – affecting more than 70 percent of the world's threatened frontiers. *(See Table 2.)* Logging can significantly 'rewrite' the structure and composition of forests. Yet, some of its most negative effects are indirect: logging offsets the cost of road building to extract the timber, which in turn opens forests to hunting, fuelwood gathering, and clearing for agriculture. Widely considered the primary cause of tropical deforestation (when frontier and non-frontier forest are taken together), agricultural clearing, in particular, is hastened once loggers open forests up.[30,31]

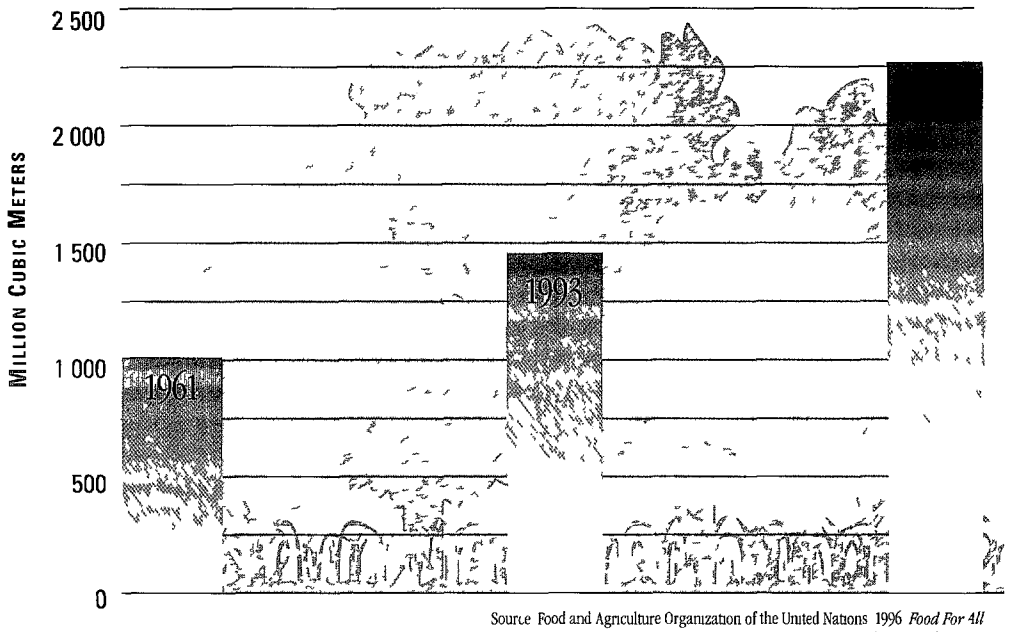
■ **Energy development, mining, and new infrastructure.** Large-scale mining and exploration for petroleum and natural gas also bring new roads and settlements that open once inaccessible forests to other human activities. Damming rivers for hydroelectric power floods millions of hectares of forest and disrupts freshwater ecosystems. These operations also take up forest land and spew pollution into the environment. Energy development, mining, and the roads, pipelines, and settlements that come with it represent the second biggest threat to frontier forests globally, affecting close to 40 percent of all frontiers classified as under moderate or high threat.

■ **LAND CLEARING FOR AGRICULTURE** One fifth of the world's threatened frontiers are directly endangered by farmers who clear forest for cropland and pasture Land clearing is particu larly rapacious in Asia Africa and Latin America This threat can only grow as population increases For the record results from WRI's study suggest th it non frontier forests – often criss crossed by roads and easily access sible – are under much greater pressure from farmers than are frontier forests

■ **EXCESSIVE VEGETATION REMOVAL** Apart from logging and outright clearing humans are removing millions of tons of vegetation from frontier forests, pulling at the fabric of these ecosystems WRI found that about 14 percent of the world's threatened frontiers are being degraded by overgrazing or the overcollection of firewood build ing materials, and other vegeta tion Besides damaging terrestrial habitats, excessive vegetation removal causes the rivers and streams that run through these forests to silt up

FIGURE 6

Wood Consumption Projected to Increase by 56% by 2010



Source Food and Agriculture Organization of the United Nations 1996 *Food For All* Address on World Wide Web <www fao org>

■ **OVERHUNTING** As ecosys tems, frontier forests comprise more than just trees Local extinctions of animal species can affect the integrity of the entire forest Many species – including elephants in Africa and beaver in North America – distribute tree seeds and otherwise shape forest structure In Africa, one third of the forest frontier which is threatened is at risk through commercial hunting, driven largely by urban demand for bushmeat

■ **OTHER THREATS** On a smaller scale other activities also endanger frontier forests They range from the obvious – forest conversion to say tree planta tions or ski resorts – to the not so obvious Among the latter are forest managers who suppress natural fires which help shape many frontier ecosystems far off factories that emit wind borne pollutants harmful to trees, and exotic animal species introduced either accidentally or deliberately by people who don't know or don't care that the newcomers can outcompete native plants and animals for scarce resources (In New Zealand our advisors con cluded that introduced and feral species – domestic species gone wild – pose the single greatest danger to frontier forests)

In most cases, frontier forests are endangered by more than one of these threats One future threat not covered in this study is the potential impact of global warming on forest ecosystems Native species that can't adapt or migrate to new habitats quickly enough could die out rapidly as climate changes and new diseases pest infestations and natural distur bances increase as a result [32]

Destruction's Roots

Frequently, governments and industry reap the profits while frontier peoples receive only a sliver of the benefits but bear the environmental brunt of forest mismanagement

Like symptoms of disease, visible threats to forests are often best treated by addressing their underlying causes Behind the obvious activities endangering the world's frontier forests are a nest of interrelated root causes

■ **Growing economies and consumption** Even in parts of the world where population is not growing significantly, demand for certain forest resources – for both local and export markets – is intensifying as economies expand Between 1961 and 1994, per capita consumption of paper increased by 86 percent globally and by 350 percent in developing countries *(See Figure 5)* Industrialized countries still use more than 10 times as much paper per person than people in developing regions do Global consumption of industrial wood products is expected to jump by more than 50 percent by 2010 *(See Figure 6)*

■ **Population growth and demand for new land** Just since 1950 the world's population has more than doubled [33] As a result, in many regions forests have been cleared to grow food and to make way for new settlements Population growth also drives up demand for timber paper fuelwood, and other products from an ever shrinking forest base

TABLE 2

Threats to Frontier Forests

Region	Percent of Frontier Forest Under Moderate or High Threat (i)	Percent of Threatened Forest Frontiers at Risk From: Logging	Mining, Roads and Other Infrastructure	Agricultural Clearing	Excessive Vegetation Removal	Other (ii)
Africa	77	79	12	17	8	41
Asia	60	50	10	20	9	24
North & Central America	29	83	27	3	1	14
Central America	87	54	17	23	29	13
North America	26	84	27	2	0	14
South America	54	69	53	32	14	5
Russia & Europe	19	86	51	4	29	18
Europe	100	80	0	0	20	0
Russia	19	86	51	4	29	18
Oceania (iii)	76	42	25	15	38	27
World	39	72	38	20	14	13

Notes (i) Frontier forests considered under immediate threat as a percent of all frontier forest assessed for threat Threatened frontier forests are places where ongoing or planned human activities are likely if continued over coming decades to result in the significant loss of natural qualities associated with all or part of these areas (for example causing declines in or local extinctions of wildlife and plant populations or large scale changes in the age and structure of these forests)

(ii) Other includes such activities as overhunting introduction of harmful exotic species isolation of smaller frontier forest islands through development of surrounding lands changes in fire regimes and plantation establishment

(iii) Oceania consists of Papua New Guinea Australia and New Zealand

See Technical Annex

■ **BAD ECONOMIC POLICIES** In weighing land management options economists and policy makers often overlook the costs of losing frontier forest Such costs may come in the form of soil erosion the loss of water for agriculture and release of carbon into the atmosphere Lost opportunities should count too including foregone income from ecotourism 'bio-prospecting' and other lucrative uses of whole and healthy forests Even logging mining and other exploitative uses often don't bring in the revenues they could trying to attract foreign investors, many national governments all but give away valuable rights to exploit their forests Such economic decisions are common because the costs of destruction are not felt or paid by those doing the damage Frequently governments and industry reap the profits while frontier peoples receive only a sliver of the benefits but bear the environmental brunt of forest mismanagement

3

DIFFERENT WAYS OF RANKING COUNTRIES

WRI's Forest Frontiers Index speaks volumes about the countries' opportunities to protect frontier forests and about the immediacy of threats to these frontiers Alternative methods for ranking countries tell different stories Table 4 for example identifies the 12 countries with the largest area of frontier forest All told these countries account for 90 percent of what remains on Earth Table 5 lists countries with frontier forest likely to be of exceptional biodiversity value (based on the large numbers of plant species estimated to be found within them)

One important story – beyond the scope of this assessment – would be to rank countries according to the amount of threatened forest lying outside frontiers Such an index would be useful for identifying countries where unique forest ecosystems are on the verge of extinction

■ **SHORT-SIGHTED POLITICAL DECISIONS** In much of the world frontier forests are sacrificed for short term political gain – to appease interest groups or to line the pockets of politicians and their allies In endangered U S and Canadian old growth forests for example, governments allow logging to provide questionable job security for a very small number of people who may soon be sidelined by technological and market changes within the industry anyway In tropical countries such as Brazil Indonesia, and Malaysia decision makers attack poverty by moving millions of people to the forest frontier, even though this approach is only a temporary fix for the poor and can permanently destroy the forests

■ **CORRUPTION AND ILLEGAL TRADE** Corruption among officials in government industry and other organizations often hastens frontier forest loss In Cambodia, for example the military takes part in a thriving illegal timber trade with neighboring Thailand [34] In Burma the government and rebel groups have both financed a decades long civil war with illegal logging proceeds [35] In Alaska Malaysia Suriname and elsewhere, timber companies have been accused of engaging in timber smuggling trying to bribe government officials to procure lucrative concessions and other illegal practices [36 37] Even demand for illegal drugs fuels forest destruction in Colombia, for example, clearings are carved out of remote frontier forests to grow coca marijuana and opium poppies [38]

■ **POVERTY AND LANDLESSNESS** In Brazil Guatemala and elsewhere the poor flock to frontier forests in search of agricultural land and other economic opportunities Rather than grapple with such politically thorny issues as land redistribution and tenure governments often encourage the clearing of forest lands poorly suited to agriculture In Brazil for example migrants have had to clear forest to establish land ownership, a don't think twice policy that spawned more deforestation and discouraged settlers from managing frontiers for their forest products [39]

THE FRONTIER FOREST INDEX

WRI's Frontier Forest Index shows that most of the world's nations have already lost or might soon lose, their last frontier forests *(See Table 3)* The index ranks countries according to the percentage of frontier forest lost and to the proportion of remaining frontier that is moderately or highly threatened – in other words high scoring countries have lost much of their frontier, and most of what remains is threatened

Seventy six countries have lost it all These include almost all of the countries of Europe and Eastern Africa and all of North Africa and the Middle East For these countries forest restoration should be a priority *(See Box 4)*

Another 11 countries – including Nigeria, Thailand Sweden, Finland and Guatemala – are classified as on the edge They have at most 5 percent of their original frontier left and it is threatened While core areas of these isolated frontiers may be protected in parks or reserves, logging and other activities out side (and sometimes inside) protected areas threaten the ecosystems as a whole Unless these countries act immediately they are likely to lose most of the little frontier they have left

In 28 countries there is not much time to protect remaining frontier forests Most of these nations have lost most of their original frontier and much of the remainder is threatened These countries include the United States (which if not for Alaska's vast boreal forest would rank among countries 'on the edge), Papua New Guinea Malaysia Panama, Mexico, Argentina, India, and Australia

Only seven countries – Brazil Suriname, Guyana Canada, Colombia Venezuela and Russia – and one Overseas Department of France (French Guiana), still have a large proportion of their original forest cover remaining in an unthreat ened state These nations have great opportunities to sustain large areas of frontier forest if they begin to follow stewardship principles now *(See Box 5)*

Even in these eight places some frontiers are under siege In Canada two thirds of British Columbia's temperate coastal rainforest – one of Earth's biologi cally richest temperate ecosystems – has been degraded by logging or other development and much of what remains intact outside protected areas is slated for logging in coming years [40] International timber companies have been trying to negotiate contracts to log much of the remaining Amazon and Guyana Shield frontier – including one third of Suriname's forests [41] Decisions made within the next few years will decide the fate of frontier forests within these countries

TABLE 3

Frontier Forest Index

Country	Percent of Original Frontier Forest Lost	Percent of Current Frontier Forest Threatened	Frontier Forest Index (99 = worst possible score)
Lost It All *(These countries have lost all of their frontier forest. Restoration should be a priority.)*			
Afghanistan, Albania, Algeria, Angola, Armenia, Austria, Azerbaijan, Belgium, Benin, Botswana, Bulgaria, Burundi, Byelarus, Czech Republic, Denmark, El Salvador, Equatorial Guinea, Eritrea, Estonia, Ethiopia, France, The Gambia, Georgia, Germany, Ghana, Greece, Guinea, Guinea Bissau, Hungary, Iran, Ireland, Italy, Japan, Kenya, Democratic People's Republic of Korea, Republic of Korea, Kyrgyzstan, Latvia, Lebanon, Liberia, Lithuania, Luxembourg, Madagascar, Moldova, Morocco, Mozambique, Namibia, Nepal, Netherlands, Pakistan, Paraguay, Philippines, Poland, Portugal, Romania, Rwanda, Sao Tome and Principe, Senegal, Sierra Leone, Slovakia, South Africa, Spain, Switzerland, Tajikistan, Tanzania, Togo, Tunisia, Turkey, Turkmenistan, Uganda, Ukraine, United Kingdom, Uzbekistan, Yugoslavia (former), Zambia, Zimbabwe			
On The Edge *(Unless they act immediately, these countries risk losing much of their remaining frontier forest.)*			
Nigeria	99	100	99
Finland	99	100	99
Vietnam	98	100	98
Laos	98	100	98
Guatemala	98	100	98
Cote d'Ivoire	98	100	98
Taiwan	98	100	98
Sweden	97	100	97
Bangladesh	96	100	96
Central African Republic	96	100	96
Thailand	95	100	95
Not Much Time *(Frontier forest in these countries will continue to fall without further action.)*			
Argentina	94	100	94
New Zealand	91	100	91
China	98	93	91
Costa Rica	90	100	90
Cambodia	90	100	90
Cameroon	92	97	90
Brunei	89	100	89
Honduras	84	100	84
United States	94	85	79
Nicaragua	78	100	78
Bhutan	76	100	76
Mexico	92	77	71
Gabon	68	100	68
Sri Lanka	88	76	67
Panama	65	100	65
Ecuador	63	99	63
Zaire	84	70	59
India	99	57	56
Bolivia	56	97	55
Burma	94	56	52
Australia	82	63	52
Papua New Guinea	60	84	50
Congo	71	65	46
Belize	65	66	43
Malaysia	85	48	41
Peru	43	95	41
Indonesia	72	54	39
Chile	45	76	35
Great Opportunity *(Given careful stewardship, these countries have a real chance to keep most of their original frontier forest.)*			
Brazil	58	48	28
Venezuela	41	37	15
Russia	71	19	13
Colombia	64	19	12
Canada	42	21	8
Guyana	18	41	7
Suriname	8	22	2
French Guiana	8	0	0

TABLE 4

Countries With Most of the World s Remaining Frontier Forest

Global Rank	Country	Total Frontier Forest (000 Km²)	Percent of the World's Total Frontier Forest
1	Russia	3 448	26
2	Canada	3 429	25
3	Brazil	2 284	17
4	Peru	540	4
5	Indonesia	530	4
6	Venezuela	391	3
7	Colombia	348	3
8	United States	307	2
9	Zaire	292	2
10	Bolivia	255	2
11	Papua New Guinea	172	1
12	Chile	162	1
Total frontier forest area of the top 12 countries as a % of the global total			90

TABLE 5

Ten Countries with the Highest Plant Biodiversity in Their Frontier Forest

Global Rank	Country	Frontier Forest (000 Km²)	Estimated Number of Plant Species Within Frontier Forests (thousands)	Percent of the Country's Plant Species Found Within Frontier Forests
1	Brazil	2 284	36	~65
2	Colombia	348	34	~70
3	Indonesia	530	18	~65
4	Venezuela	391	15	~75
5	Peru	540	13	~75
6	Ecuador	80	12	~65
7	Bolivia	255	10	~60
8	Mexico	87	9	~35
9	Malaysia	47	8	~50
10	Papua New Guinea	172	7	~70

Note Forest frontier plant species richness was estimated by multiplying the country s higher plant species totals per unit area (standardized for size using a species area curve) by the country s total frontier forest area

Regional Overviews

North and Central America

After Russia's the world s largest expanse of frontier forest is an unbroken 6 500 kilometer arc of boreal forest stretching from Newfoundl and to Alaska These North American forest ecosystems – still vast and relatively undis turbed in northernmost Can ada and interior Al aska – store a sig nificant proportion of the global total of biotic carbon and supply much of the world's growing demand for forest products They also provide livelihoods for thousands of indigenous people and a refuge for woodland caribou, grizzly bear, grey wolf, and other large mammals that once ranged widely across the continent [42] As a group these frontiers rank among the least threatened in the world (approximately a quarter of the area is threatened) Even so they are being pushed steadily northward by mineral extraction hydroelectric development and skyrocketing demand for wood fiber especially paper products

To the south North America's temperate frontier forests have retreated to a few remote mountainous pockets in the western United States and Canada Within the lower 48 U S states, frontiers account for about 1 percent of original forest cover

North American forest ecosystems store a significant proportion of the global total of biotic carbon and supply much of the world's growing demand for forest products

What remains lies primarily with in three assemblages of national parks and wilderness areas in the northern Rockies and one block in the North Cascades of Washington state While each forest block is largely protected, they are classi fied as threatened because they are becoming too isolated to sup port populations of some of their large mammal species over time [43]

In Mexico one relatively large frontier remains in the Sierra Madre Occidental, a biolog ically diverse temperate conifer forest severely threatened by rapidly expanding logging and road construction Mexico's other frontier forests are in Oaxaca, Chiapas, and the Maya forest region (which extends into Belize and Guatemala) These tropical forests – along with a chain of others stretching south through the Miskito coast of Honduras and Nicaragua, the La Amistad region on the Costa Rican Panamanian border and the Darien forests on Panama's border with Colombia – are almost all highly threatened

Central America s frontier forests are under many kinds of assault In the Darien region the major threat is completion of the Pan American highway *(See below)* In other areas agricultural expansion logging, and infrastructure development are the dangers Guatemala s for est frontier for example, shrank dramatically in the past decade as logging roads opened the area to landless peasants and to wealthy agricultural business interests

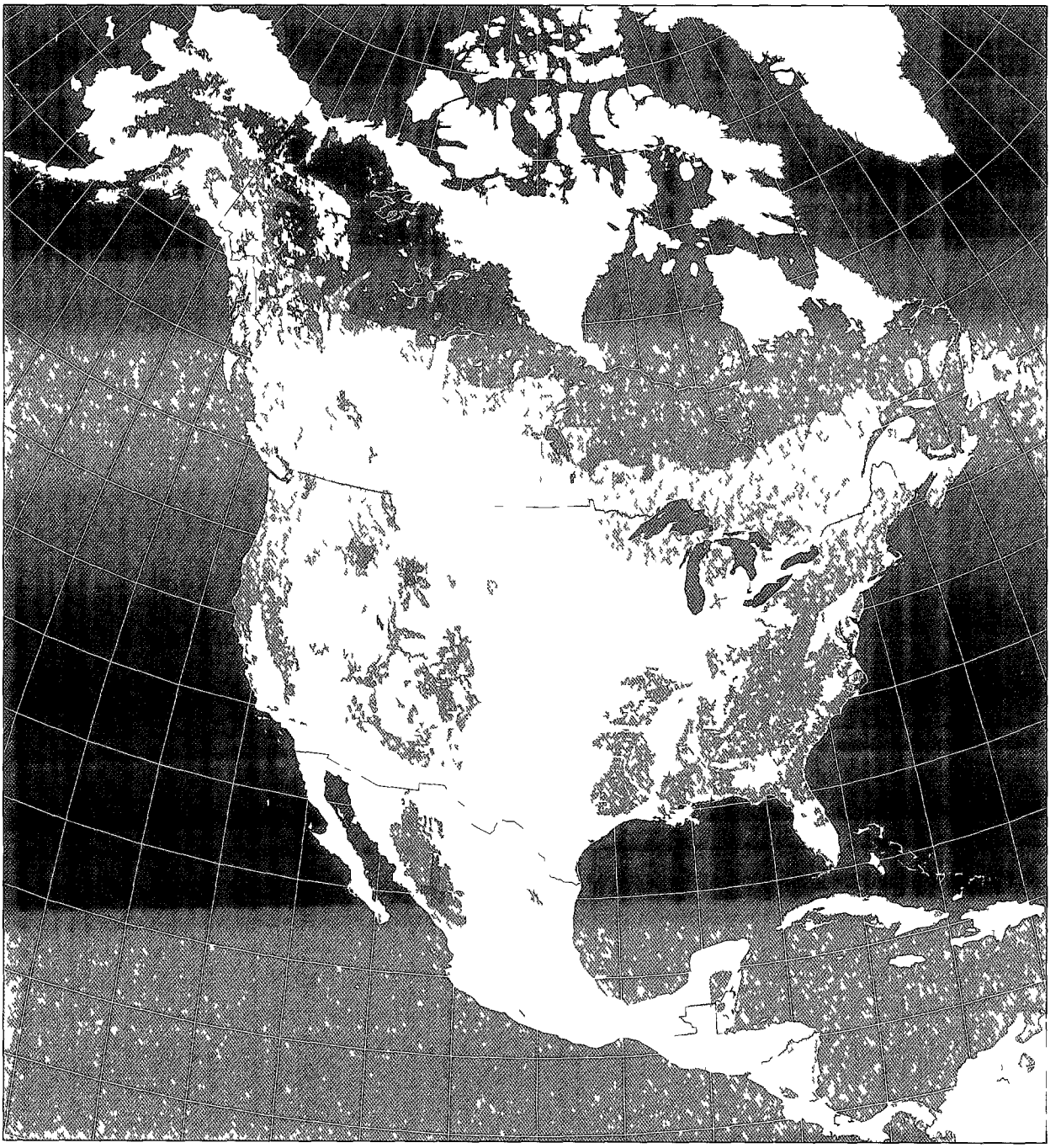
On the whole North America still has a good number of frontier forests in its northern most regions that remain rela tively safe Yet from its southern band of boreal forests all the way to Panama's Darien Gap, virtually all the rest of the conti nent s frontiers stand to lose their frontier status within the next decade or two

Threatened frontiers include

Frontier
1 Tongas National Forest
Forest type Temperate
Geographic location Alaska United States
Threat Logging
At risk One of the world's largest tracts of temperate old growth forest as well as a unique ecosys tem type coastal temperate rain forest

Frontier
2 Forests of the Darien Gap
Forest type Tropical
Geographic location Panama and Colombia
Threat Logging, other wood removal, proposed highway con struction and coca cultivation
At risk A proposed highway across the Darien Gap would provide a route for non-indigenous species – such as organisms that cause hoof and mouth disease – with potentially disastrous long term biological and economic consequences to both regions [44,45] Road construction, logging and other activities threaten forests that are home to three indigenous cultures and rich native biodiversity

THREATENED FRONTIER FORESTS OF NORTH AMERICA



FRONTIER FORESTS UNDER LOW OR NO THREAT
large intact natural forest ecosystems that are relatively undisturbed and large enough to maintain all of their biodiversity

FRONTIER FORESTS UNDER MEDIUM OR HIGH THREAT
ongoing or planned human activities (e g logging agricultural clearing mining) will if continued significantly degrade these frontiers

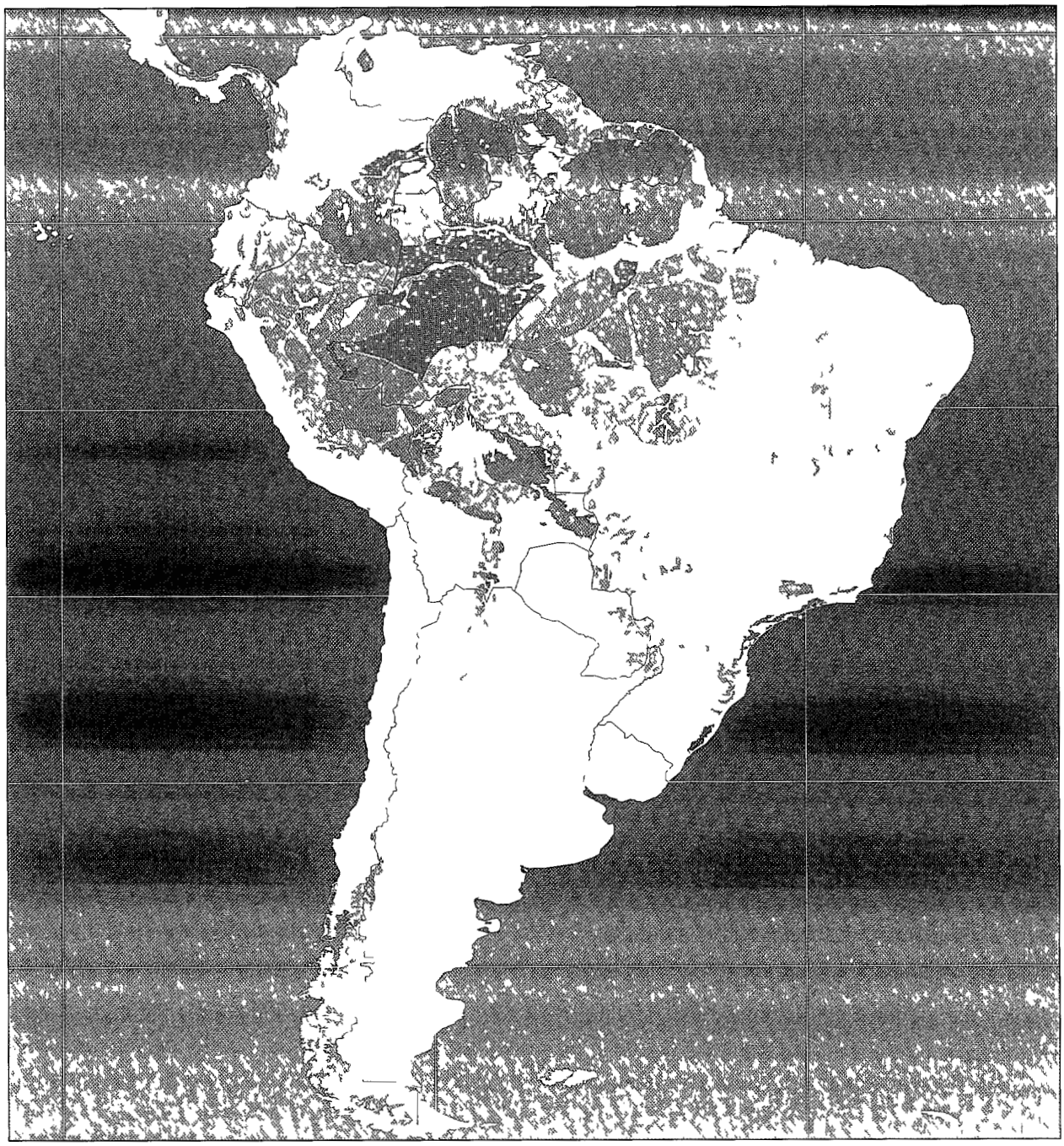
NON FRONTIER FORESTS
secondary forest plantations degraded forest and patches of primary forest not meeting this study s criteria as frontier

FRONTIER FORESTS UNASSESSED FOR THREAT
insufficient information prevented evaluating the threat level of these frontiers

Map Projection Lambert Azimuthal Basemap data from ArcWorld Assistance in data preparation mapping and analysis provided by World Wildlife Fund & World Conservation Monitoring Centre
Data sources (i) Forest cover data provided by World Conservation Monitoring Centre (ii) Frontier forest data derived through expert assessment and from other sources

WORLD RESOURCES INSTITUTE FOREST FRONTIERS INITIATIVE

THREATENED FRONTIER FORESTS OF SOUTH AMERICA



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WORLD RESOURCES INSTITUTE FOREST FRONTIERS INITIATIVE

Logging is the main threat to South America's frontier forests

South America

Throughout South America large-scale resettlement and agricultural and resource development projects claimed much of the 645,000 square kilometers of forest lost in this region between 1980 and 1990 – the greatest amount of forest loss in the world during these years Brazil alone lost close to 370,000 square kilometers – more than a fifth of all tropical forest lost worldwide during that time [46]

Still, South America maintains vast areas of intact tropical and temperate forest The Northern Amazon Basin and the Guyana Shield house the largest tropical frontier forests anywhere [47]

On the rim of the Amazon Basin forests of the Northern Andes (Peru Ecuador and Colombia) rank among Earth's biologically richest [48] Chile and Argentina share the largest single block of remaining temperate frontier forest in the world

Logging is the main threat to South America's frontier forests endangering about 70 percent of all frontiers classified under medium or high threat Energy exploration mining and new roads are encroaching on about half the region's threatened frontiers Clearing for agriculture jeopardizes almost a third of all threatened frontier forests

In recent decades national development policies have fueled much of the region's deforestation During the 1960s and 1970s, the Brazilian government's modernization policy prompted major forest clearing in the Amazon The government had hoped to solve land tenure problems in other regions by establishing colonies of small holder farmers in the forests to integrate the region into the rest of the country with a massive road network, earn revenues by developing natural resources and strengthen Brazil's borders by populating its frontier Government policies triggered both planned and spontaneous immigration of landless peasants from throughout the country and resulted in large scale clearing of the forest by land speculators hoping to profit from subsidies provided to cattle ranchers [49,50]

In Bolivia Guyana, and Suriname a drive to exploit natural resources over the past decade – partly to respond to economic crises – has accelerated the loss of frontier forests Only Venezuela and Colombia have strongly restricted logging mining, and other extractive activities and Venezuela may soon buckle under severe economic pressure to exploit its rich natural resources

Chile's temperate frontier forests are increasingly threatened primarily by logging to provide wood chips (for export mainly to Japan) and fuelwood While Eucalyptus and pine plantations provide much of the timber needed for export and industry precious native forests are cleared to make way for new plantations [51,52]

Threatened frontiers include

Frontier
1 The Atlantic Rainforest
Forest type Tropical
Geographic location Coastal Brazil
Threats Logging agricultural clearing, excessive vegetation removal pollution
At Risk Only 5 percent of the original Atlantic Rainforest is left, and just a fraction of this vestige can be considered frontier The Atlantic Rainforest is particularly rich in biodiversity 70 percent of its plants and most of its 20 primate species are found nowhere else in the world, and the wild relatives of many important food crops (including pineapple, cassava sweet potato, and papaya) are found there

Frontier
2 Coastal Chilean Forests
Forest type Temperate
Geographic location Southern Chile
Threats Clearing for plantations logging for the wood chip industry, fuelwood production
At Risk One third of the world's largest tract of relatively undisturbed temperate forest Chile s temperate forests contain at least 50 species of timber trees (95 per cent of them endemic) and more than 700 vascular plant species (half of them endemic) [53] The alerce cedar the Southern Hemisphere's largest conifer and a tree that can live over 3 000 years, is found here [54] More than 35 000 families in this region face severe poverty and expulsion as large timber companies buy land for wood-chip production and tree plantations

Frontier
3 Bolivar State
Forest type Tropical
Geographic location Southeastern Venezuela
Threats Logging mining (gold and diamonds) and oil exploration
At Risk Venezuela's Bolivar State is a part of the Guyana Shield Amazon Basin complex, the largest tropical frontier forest Rich in species, the area is home to the Pemon and several other indigenous groups

Only Brazil, Suriname, Guyana, Canada Colombia, Venezuela, Russia, and French Guiana still have a large proportion of their original forest cover remaining in an unthreatened state

Africa

Except for the Congo Basin, Africa's frontier forests have largely been destroyed primarily by loggers and by farmers clearing land for agriculture In West Africa nearly 90 percent of the original moist forest is gone and what remains is heavily fragmented and degraded Today West African frontiers are restricted to one patch in Cote d'Ivoire and another along the border between Nigeria and Cameroon

To the east, very little remains of Madagascar's once magnificent tropical forests Long isolated from mainland ecosystems these forests are home to an exceptional number of plants and animals found nowhere else Unfortunately, none of Madagascar's forest fragments is large or natural enough to qualify is a frontier today

Large blocks of intact natural forest do remain in Central Africa particularly in Zaire, Gabon, and the Congo In Zaire – which contains more than half this region's forest cover – many forests remain intact, in part because the nation's poor transportation system can't easily handle timber and mineral exploitation [55] Some areas have fewer passable roads today than in 1960, the year the country became independent, and some frontiers have lost population during this period

Today most of Africa's remaining frontier forests are at risk The two major threats are logging and commercial hunting to meet growing urban demand for bushmeat (Overhunting removes populations of key species that help maintain natural forest ecosystems) In Central Africa over 90 percent of all logging occurs in primary forest – one of the highest ratios of any region in the world [56] In some areas logging itself causes relatively little damage because only a few high value tree species are removed Still, logging roads open up a forest to hunters, would be farmers and other profit seekers One region warranting special concern is eastern Zaire Civil unrest in Rwanda, Burundi Sudan and Zaire has driven hundreds of thousands of people into this area, where they escalate demands on the forest

Threatened frontiers include

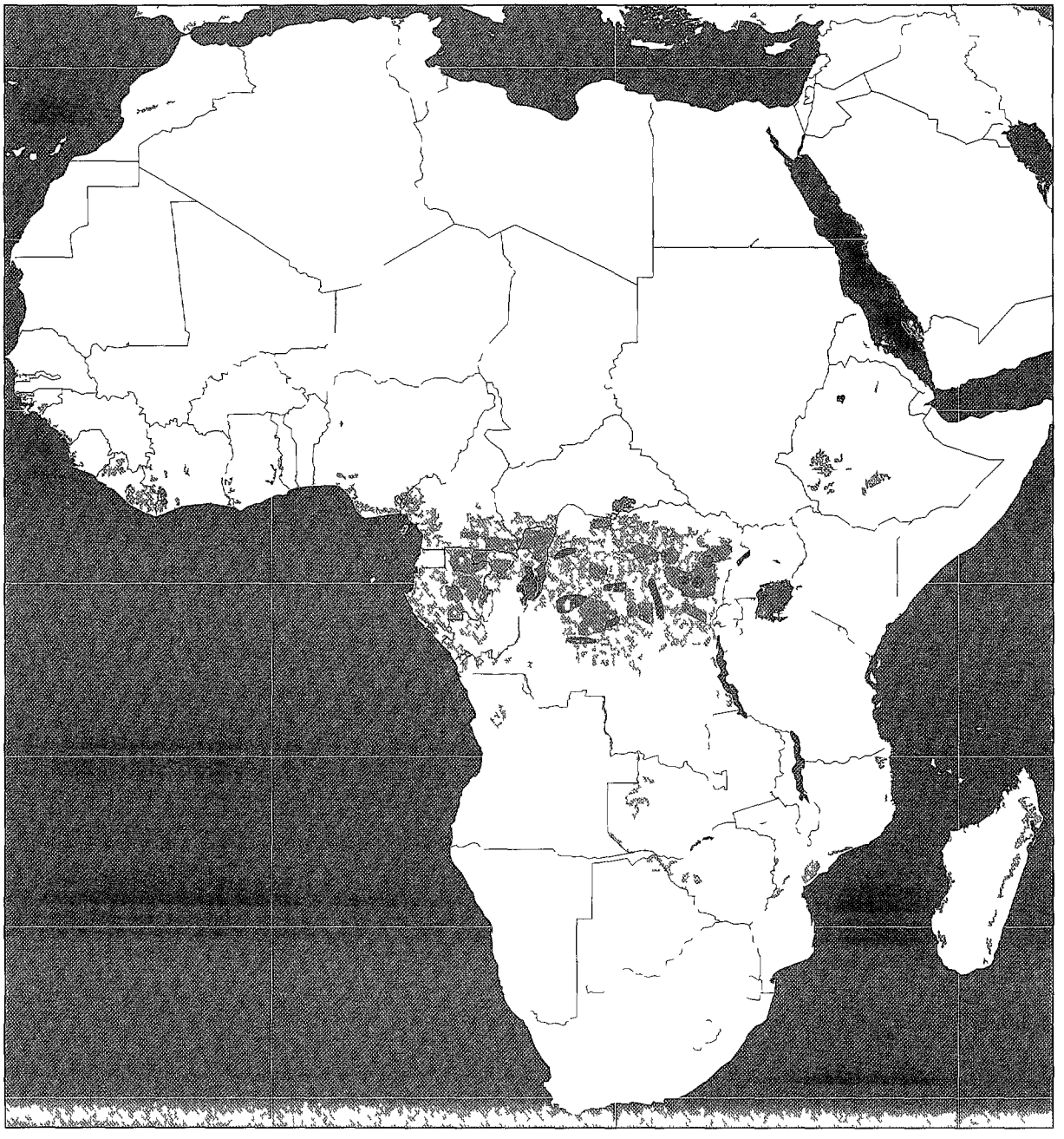
Frontier
1 Tai National Park and surrounding forests
Forest type Tropical
Geographic location Cote d'Ivoire
Threats Logging agricultural clearing hunting potential invasion by war refugees
At Risk The only remaining large and relatively intact piece of a forest block that once covered more than 830 000 square kilometers in eight countries west of the Dahomey Gap (a natural savanna that divides West Africa's forests into two distinct sections)

Frontier
2 Cross River and Korup National Parks and surrounding forests
Forest type Tropical
Geographic location Border between Nigeria and Cameroon
Threats Logging by Asian and European timber companies in unprotected forests, new settlements, agricultural clearing, hunting
At risk Rich in plant species this forest may provide a wealth of potential new drugs and industrial products Extracts from the newly discovered Ancistrocladus korupensis vine, for example offer hope for a new AIDS treatment

Except for the Congo Basin, Africa's frontier forests have largely been destroyed; and most of those remaining are at risk

Frontier
3 Eastern Zaire forests
Forest type Tropical
Geographic location Zaire
Threats Agricultural clearing, invasion by throngs of war refugees
At risk The greatest biological diversity of any forests on the continent Also, the Ituri forest (found within this frontier) is home to many of Africa's remaining pygmy peoples

THREATENED FRONTIER FORESTS OF AFRICA



FRONTIER FORESTS UNDER LOW OR NO THREAT
large intact natural forest ecosystems that are relatively undisturbed and large enough to maintain all of their biodiversity

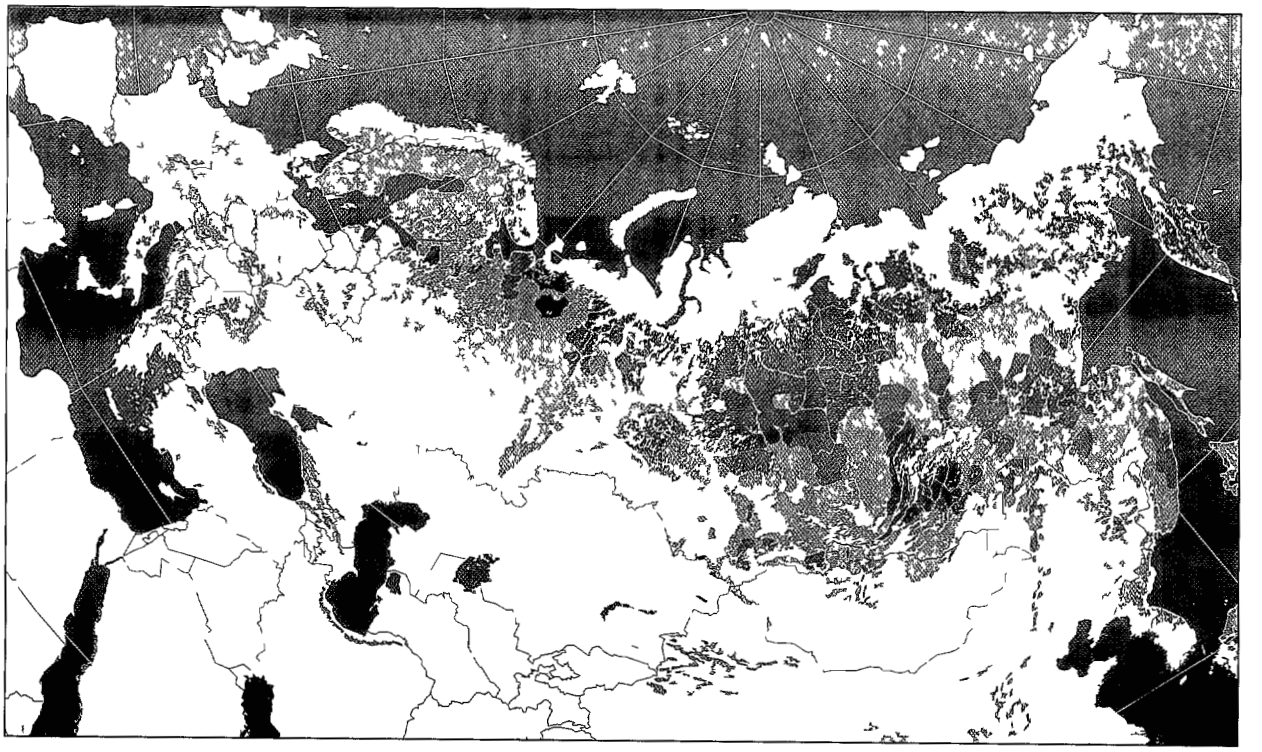
FRONTIER FORESTS UNDER MEDIUM OR HIGH THREAT
ongoing or planned human activities (e g logging agricultural clearing mining) will if continued significantly degrade these frontiers

NON FRONTIER FORESTS
secondary forest plantations degraded forest and patches of primary forest not meeting this study s criteria as frontier

FRONTIER FORESTS UNASSESSED FOR THREAT
insufficient information prevented evaluating the threat level of these frontiers

Basemap data from ArcWorld Assistance in data preparation mapping and analysis provided by World Wildlife Fund & World Conservation Monitoring Centre
Data sources (i) Forest cover data provided by World Conservation Monitoring Centre (ii) Forest frontiers data derived through expert assessment and from other sources

THREATENED FRONTIER FORESTS OF EUROPE & RUSSIA



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Map Projection Equidistant Basemap data from ArcWorld Assistance in data preparation mapping and analysis provided by World Wildlife Fund & World Conservation Monitoring Centre
Data sources (i) Forest cover data provided by World Conservation Monitoring Centre (ii) Forest frontiers data derived through expert assessment and from other sources

Europe and Russia

Once blanketed by forest, Europe and Russia have both lost virtually all of their temperate frontier forest. Most of Europe's forests were leveled centuries ago. Although forest area within the region has increased since 1950, nearly all of it consists of plantation or highly managed forest.[57]

Europe's last few large tracts of relatively natural forest are in Sweden and Finland. Significant portions of this frontier fall outside parks and reserves, and all frontier forests are threatened by road development, fire suppression, grazing, logging, and other activities.

Containing Earth's largest expanse of frontier forest (mostly in Siberia), Russia's boreal forests are still largely intact. The country houses almost three quarters of all boreal forest and nearly one fifth of the world's total forest area.[58] An immense storehouse of living carbon, the nation's frontier forests cover more than 4 million square kilometers. Clearing them could contribute significantly to global warming. Russia's Far Eastern frontier is also the last habitat for such highly endangered species as the Amur tiger, the Far Eastern leopard, the Far Eastern forest cat, the red wolf, and the sikha deer.[59]

Endangered frontier forests in Russia are threatened mainly by logging, named by WRI's advisors as the chief risk in about 85 percent of the region's threatened frontier forest. Mineral and energy exploration and set fires also impinge.

Already, portions of Russia's Far East and much of European Russia (west of the Ural mountains) have been heavily logged. Until now, lack of infrastructure and outmoded harvesting practices kept much of Siberia's frontier forest undeveloped. Recent economic and political liberalization may change the situation, however. International timber and trading corporations, particularly Asian companies, are looking to Siberian forests as a new source of supply as burgeoning global demand for timber strips other regions of valuable, accessible trees.[60] Over the next decade or two, foreign capital, machinery, and road building could open much of Siberia's forest to logging, mining, and other damaging activities.

Threatened frontiers include

Frontier
1 Northern Primorski Krai
Forest type Temperate and boreal
Geographic location Russian Far East
Threats Logging, mining, and road development
At risk Habitat for some of the world's rarest species, including the Amur tiger. This forest also is home to Udege, Nanai, Ul'ta, and other indigenous groups.[61]

Frontier
2 Frontiers encompassing the Green Karelian Belt
Forest type Boreal
Geographic location Russia and Finland
Threats Logging for export to Finland and related road construction
At risk One of Europe's last remaining frontiers and the traditional home of the Karelian people

Asia

Asia has lost almost 95 per cent of its frontier forests Apart from the Mediterranean and Middle East – where all such forests have disappeared – this represents the world's greatest loss of frontier forest outside of Europe China and India today have just 20 percent of their original forest cover Of these remaining forests less than 10 percent can be classified as frontier In the 20 years between 1960 and 1980 alone Asia lost almost a third of its tropical forest cover the highest rate of forest conversion in the world [62]

On mainland Southeast Asia most frontiers are gone The isolated pockets left are confined primarily to Burma, Laos, and Cambodia, where war and civil unrest until recently inhibited development With peace have come new threats from commercial loggers who have already exhausted forests in Thailand and peninsular Malaysia – where harvest and import restrictions now encourage logging companies to move on to neighboring nations

Most of Asia's remaining frontier forest is confined to the islands of Borneo Sumatra, Sulawesi and Irian Jaya Even here however loggers have exploited most accessible forests along coasts and major rivers Agriculture and poorly planned resettlement programs also take a toll Between 1969 and 1994 Indonesia's transmigration program moved 8 million people to the nation's forested islands where 1 7 million hectares of tropical forest were soon stripped [63]

More than half of Asia's last frontiers are under moderate to high threat particularly from logging An even greater long-term worry is Asia's burgeoning population and its ever increasing demand for food and agricultural land Between 1990 and 1995 alone, the region's largely rural population grew by more than 270 million people The world's most densely populated region Asia had more than 1 person for every hectare of land in 1995 [64]

Threatened frontiers include

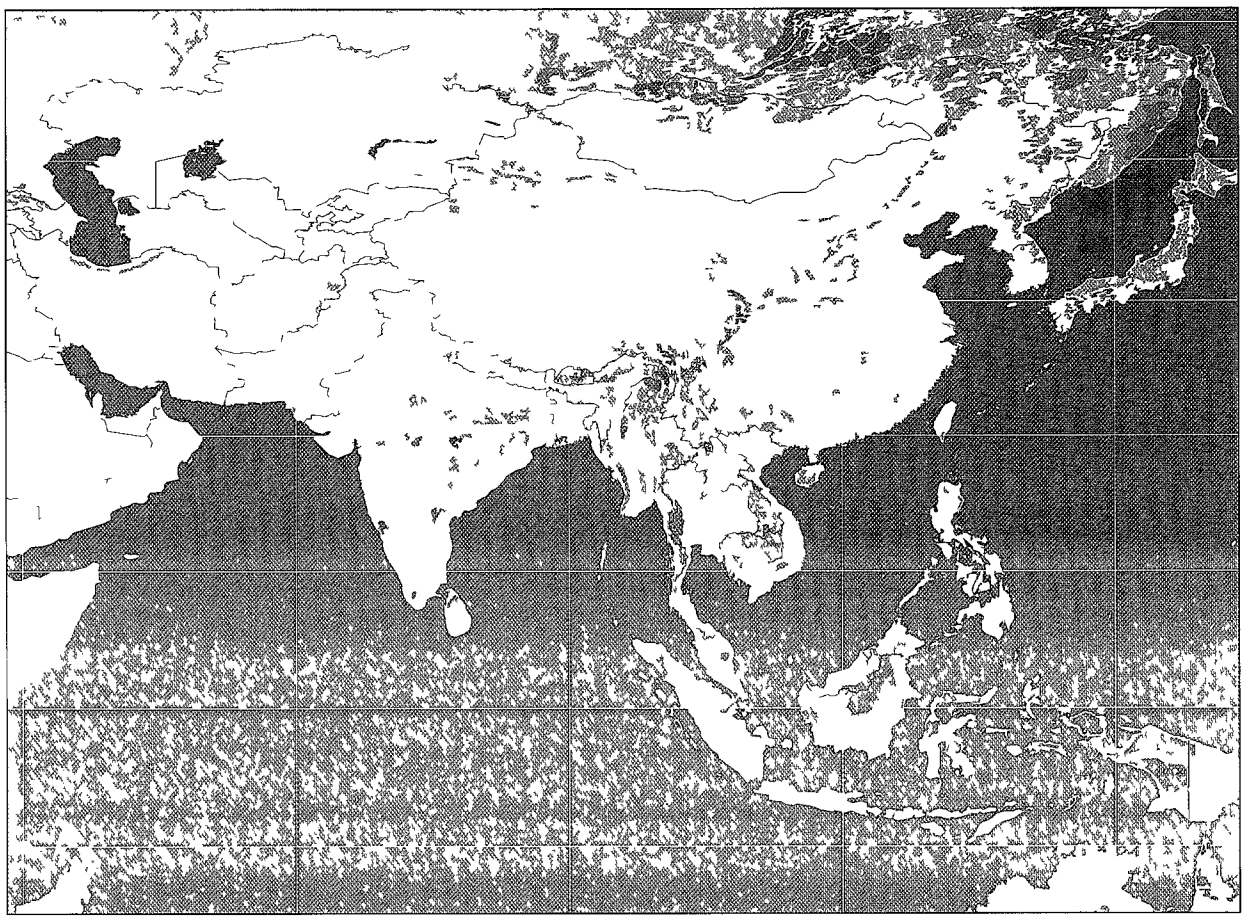
Frontier
1 Ratanakiri Province
Forest type Tropical
Geographic location Cambodia
Threat Illegal logging for export to Vietnam Outside protected areas most of the province is already under concession to foreign logging companies
At risk Resident minority groups already evicted from other areas by logging companies Rice farming and local fishing here and elsewhere in the Mekong River watershed Kouprey and other highly endangered species

Frontier
2 Sundarbans
Forest type Tropical
Geographic location Bangladesh and India
Threat Logging fuelwood collection
At risk The world's largest mangrove forest Habitat for the world's largest – and possibly only viable – population of the Bengal tiger Fish and forest products provide a living for up to 300,000 local families [65]

Frontier
3 North Heilongjiang Province
Forest type Boreal
Geographic location China
Threat Logging 80 percent of this frontier is slated to be cut
At risk One of China's few remaining large intact tracts of primary forest Habitat for several important wildlife species Protection for the headwaters of the Amur River

Asia has lost almost 95 percent of its frontier forests, and most of what remains is confined to the islands of Borneo, Sumatra Sulawesi, and Irian Jaya

THREATENED FRONTIER FORESTS OF ASIA



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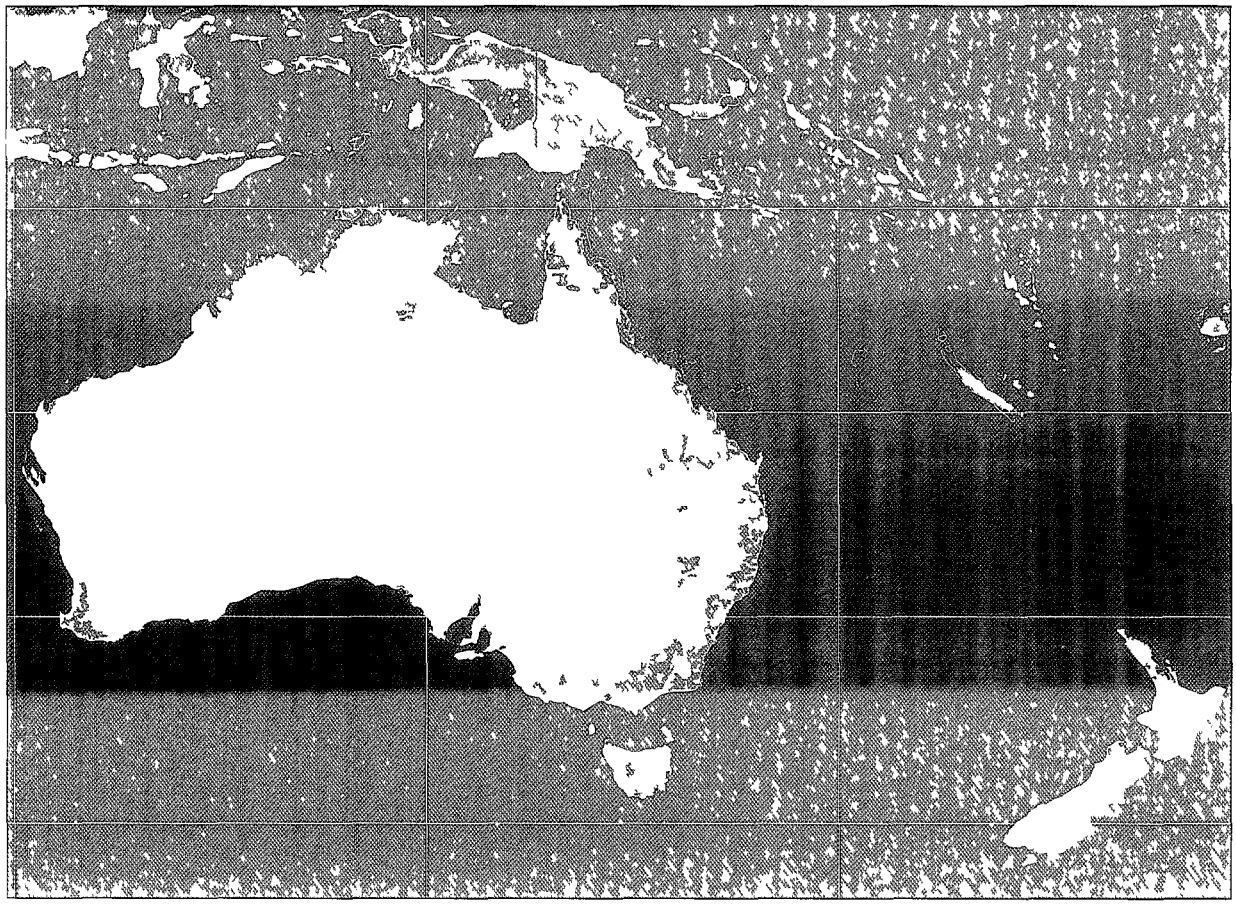
THREATENED FRONTIER FORESTS OF OCEANIA



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A high percentage of Australia's native species live nowhere else on Earth

Oceania (Papua New Guinea, Australia, and New Zealand).

Oceania has lost almost 80 percent of its frontier forests About three quarters of what remains is under moderate or high threat Within the region the status of forests varies greatly by country and forest type

New Zealand has lost the highest percentage of frontier forest less than 10 percent of its original forest cover remains as a frontier Colonized by the Maori about a thousand years ago these forests were the last of the world's large land areas to be settled by humans, but clearing for agriculture has destroyed about two thirds of all frontier forests since that date and another 5 percent or so has been converted to plantations Although most of New Zealand s remaining frontiers are legally protected all are threatened by introduced species such as the Australian brush tailed possum which are taking a heavy toll on the nation's endemic flora [66,67]

A high percentage of Australia's native species live nowhere else on Earth and much of this biodiversity resides within the nation's forests To date the continent has lost more than 80 percent of its original frontier forest including large areas of species rich unique forest types Three fourths of Australia's tropical rainforest for example has been cleared since the late 1700s [68]

Australia's remaining frontier forests are confined largely to Tasmania, Cape York, and the northwestern region [69] Grazing by feral and domestic animals poses a major threat and fire management practices are also a major concern in some areas Logging's toll within many non frontier areas is a serious problem Temperate rainforests now largely fragmented, are still cut in Tasmania and southeastern Australia – fodder for woodchips for export to Japan, which converts them into paper packaging materials and other products [70,71]

Papua New Guinea (PNG) still possesses large areas of intact tropical forest – 40 percent of its original forest Along with neighboring Irian Jaya PNG is considered a global biodiversity hotspot The country probably contains at least 5 percent of the world's species within less than 1 percent of its land area [72]

About 85 percent of PNG's frontier forests are under moderate or high threat primarily from logging agricultural clearing and mining One legacy of large clear felling operations is soil erosion Sediment washed by rivers to the sea threatens PNG's species rich coral reefs and coastal fisheries

Threatened frontiers include

Frontier
1 Central North Island (Kaweka/Ruahine range)
Forest type Temperate
Geographic location New Zealand
Threat Introduced species (Australian brush tailed possum and feral horses)
At risk A high concentration of indigenous species as well as a globally unique forest ecosystem with great biodiversity recreational, and scenic value

Frontier
2 Western and Gulf provinces
Forest type Tropical
Geographic location Papua New Guinea
Threats Logging and pipeline development (A large oilfield has been discovered about 180 miles inland)
At risk A vast tract of relatively undisturbed tropical forest of exceptionally high species richness Homelands for several groups of indigenous people

THE CLOSING FRONTIER A CALL TO ACTION

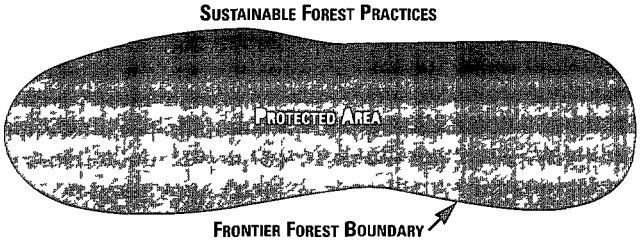
The news is not all bad The opportunity to protect a priceless natural inheritance for ourselves and future generations is still ours

This assessment found that few large intact forest ecosystems are left on the planet and that many of these last frontiers are threatened by logging agricultural clearing and other activities But the news is not all bad even after thousands of years of forest clearing and degradation some frontier forests remain The opportunity to protect a priceless natural inheritance for ourselves and future generations is still ours

But this assessment also suggests that unless we take action quickly, this opportunity is likely to pass Against a backdrop of population growth and mounting human needs, preventing further frontier losses will require a new and balanced approach to forest management – one that protects forests' biodiversity and other assets while simultaneously providing for people and ecosystem services

FIGURE 7

Stewardship Options for Managing Frontier Forests

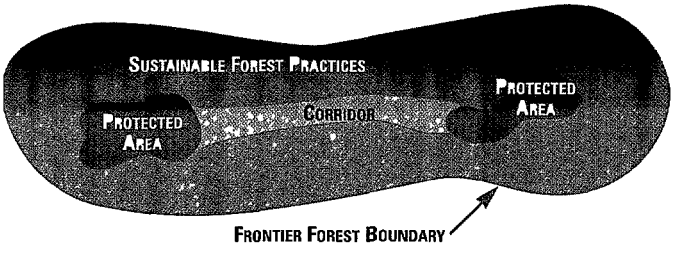


OPTION ONE

- Maintain the entire frontier forest as a protected park or reserve
- Develop sustainable land use practices in surrounding non frontier forest so that this forest serves as a buffer zone
- Retain biodiversity carbon balances and watershed quality as they are now

OPTION TWO

- Establish protected areas where needed within large portions of the frontier forest to preserve biodiversity
- Connect these areas with corridors or bridges of land that remain in natural intact forest
- Introduce sustainable forest use practices in the remaining frontier forest whether timber extraction hunting tourism and ecotourism fishing bioprospecting or the gathering of traditional medicinal and ritual items of value to local communities
- Ensure the maintenance of biodiversity retention of carbon and watershed protection



4 RESTORING FRONTIER FOREST THE GUANACASTE EXAMPLE

Even a degraded and fragmented once frontier forest invaded by exotic species may not necessarily be gone forever scientists practicing restoration ecology are developing techniques to regrow native forests

One of the world's most ambitious – and thus far successful – forest restoration efforts is in northwestern Costa Rica, where local national and international researchers are together restoring a large tract of tropical dry forest in Guanacaste Conservation Area [73]

Launched in the mid 1980s the project features a three pronged approach

First participants kicked off an aggressive fire control program to stop human caused fires which were encouraging the growth of exotic grasses in cleared forest areas and killing native seedlings Once fires were stopped scientists allowed wind and animals to carry in native tree seeds from an adjacent national park helping nature when there was money by planting typical species in appropriate places and combinations They brought in cattle to help control the grasses

Today the incidence of fire in Guanacaste is down 90 percent and the introduced grass jaragua is virtually gone from the area Thickets of 10 to 15 foot native trees now dominate the landscape Within 20 to 50 years researchers expect the canopy to close killing off all remaining jaragua and stopping set fires completely They also hope that by then the forest will house viable populations of all the plant and animal species that once inhabited the area [74]

A stewardship approach to forest management would achieve such badly needed balance *(See Box 5)* Such an approach should in fact, be applied to all of the world's forests because non-frontier forests also provide humans with a range of important functions and many are high conservation priorities Stewardship will mean pursuing different options in different parts of the world Where few large, intact forest ecosystems remain – in temperate regions, for example – frontier forests should be largely protected in parks or reserves Where human needs are pressing and where very large tracts of frontier forest remain careful development is still an option if ecologically viable core areas of forest are protected and surrounding lands managed sustainably *(See Figure 7)* Activities such as logging should cause minimal environmental damage and return maximum economic benefits to local people Figure 7 illustrates how various development activities can be balanced

How much frontier forest does the world need? At a minimum, we must maintain representative samples of all types of forest ecosystems There are no substitutes for living examples of how each system functions or for refuges for most of the world's forest species

As insurance, we recommend that nations

- Maintain more than one tract of each ecosystem type
- Protect frontiers even when neighboring countries maintain ecologically similar forests
- Manage land outside protected areas in ways that protect the ecological integrity of forest frontiers, and
- Try to restore fragmented and degraded forests *(See Box 4)*

If forest management is to reflect the needs of all, successful stewardship must include the active participation of these and other stakeholders

National and local governments

Government policies must promote economic development without destroying the resource base and the environmental services provided by forests Specifically, they should

- Immediately halt further loss of frontier forests and restore degraded forests
- Expand and better manage protected area systems,
- Create incentives for the private sector to manage frontier forests sustainably
- Monitor forest quality to measure the success of management programs, and
- Encourage stewardship and educate the public about frontier forests

5 A New Vision of Frontier Forest Stewardship

Forest management based on stewardship should include

- Collecting all relevant information on forests and how they are being used and making it readily available to anyone with a stake in forests
- Managing forests for long term economic and other benefits and involving stakeholders and the public in forest management decisions
- Charging fees for using public forest lands and returning revenues to both the nation and local communities
- Designing and enforcing fee regulations that discourage corruption and wasteful use of forests for short term gain
- Developing balanced land use plans that set aside portions of forests for tourism, biodiversity conservation and watershed protection
- Attracting investors interested in using forests sustainably and making their continued access to forests contingent upon their environmental and social record
- Including an unambiguous role for government in all large scale forest development plans – including authority to ensure equitable distribution of revenues and long term ecosystem viability
- Developing capacity in public private or non governmental forest agencies to plan negotiate implement monitor and enforce forest management agreements and
- Setting aside and conserving special forested areas in well delineated national parks, indigenous reserves or other protected areas

National and International Donor Organizations

To promote the survival of global treasures that also provide significant environmental benefits – including carbon storage and biodiversity protection donors should

- Increase support for forest rich countries particularly neglected ones,
- Coordinate efforts among donors to maximize impact
- Form partnerships among organizations – including the private sector – working toward forest stewardship, and
- Support projects that promote both conservation and the sustainable use of frontier forests

Business and the Private Sector

Traditionally viewed as enemies of conservation private industry – from logging, mining and oil companies to trade and retail industries – can become an agent of sound forest management if it is willing to protect jobs and cultivate long term profits by

- Working with non governmental organizations, governments and others to develop markets for products from well managed forests
- Avoiding investments in projects that degrade or destroy frontier forests, and
- Lobbying and encouraging governments to try policies that promote forest stewardship

Citizens

As voters and consumers partly responsible for the fate of the world's last large intact forests citizens should

- Ensure that decision makers manage forests with the general public's needs in mind (at least in countries where citizens have voting power and can directly influence their leaders)
- Keep informed about policy issues affecting frontier forests, and
- Voice their concerns – through protests and boycotts, if necessary – when governments mismanage these forests

Especially within wealthy countries consumers can create demand for products that come from well managed forests if they

- Purchase only wood, paper and other forest products that are independently certified as sustainably harvested [75]
- Demand that retailers make such products available and
- Reduce pressure on frontier forests by recycling and limiting consumption – not only of wood and paper but also of energy and mineral resources from forested regions

Frontier Peoples

People who live within and near the world's last frontier forests stand to lose the most if these ecosystems are destroyed Managing forests for non timber products ecotourism or even sustainable logging and other resource extraction could both protect these forests and provide local income now and for future generations As on the spot forest stewards local populations should demand that the government and private sector provide opportunities for long term economic and cultural security without environmental destruction

Non Governmental Organizations Including Advocacy Groups

Non-governmental organizations (NGOs) can mobilize critical support for conservation and stewardship Information is one of their most powerful tools By assessing and monitoring forest health and use, for example NGOs can uncover evidence that governments private industry, or others are mismanaging forests – or for that matter, doing their jobs These organizations also should collect and disseminate information on forest stewardship in practice Given limited time and financial resources NGOs must coordinate their efforts and form partnerships with government agencies and private businesses

6 Plan Piloto Sustainable Forest Development

In Mexico's state of Quintana Roo an organization of 16 communal groups or ejidos is managing 560 000 hectares of subtropical moist forest to benefit their members and at the same time maintain the forest [76 77] Of the total forest area 150 000 hectares are set aside for permanent production primarily of mahogany and cedar After negotiating with logging companies participants – 3 000 as of 1991 – began to process logs which adds value to their product and brings communities more income than shipping out raw timber does

Before ejidos managed the forest local communities derived no benefits from logging operations Now participants are working to maintain the natural forest by cutting trees on a 25 year cycle allowing native species to regenerate and increasing the proportion of mahogany and cedar through enrichment planting After eight years communities already are seeing good regeneration of natural forest – along with an income an incentive to keep up the good work [78]

TECHNICAL ANNEX

METHODOLOGY

CURRENT FOREST COVER

WRI used the only existing global map of current forest cover – that produced by the World Conservation Monitoring Centre (WCMC) in 1996, in collaboration with the World Wildlife Fund and CIFOR – as a base coverage for this assessment The sources for this map include many country and regional maps derived from national and international sources mostly accurate to a 1 1,000 000 scale (All coverages used in the Frontier Forest Assessment were degraded to a 1 8 000 000 scale) The quality, accuracy and dates of these national and regional maps vary For details, please refer to

The World Conservation Monitoring Centre, *The World Forest Map* (WCMC Cambridge 1996)

MAPPING OF FRONTIER FOREST AREAS

The frontier forest maps within this report reflect the knowledge and input of more than 90 experts and reviewers from around the world Work on the Last Frontier Forests assessment began in May 1996 when WRI hosted meetings and review sessions (in Washington Cambridge U K, and Rome) at which outside experts were asked to help define frontier areas and propose a methodology for mapping them Mapping itself was a three step process

1 WRI first developed regional maps of candidate frontier areas by overlaying – using a Geographic information System (GIS) – the World Conservation Monitoring Centre's current closed forest cover map with Sierra Club's 'wilderness areas map [79] to define large wooded blocks devoid of human infrastructure (roads settlements etc) where near pristine forest might be found

2 Approximately 90 regional forest experts were then asked to annotate these maps Ten to fifteen individuals per region with broad knowledge of forest extent and condition reviewed the maps of candidate frontier areas and using a checklist survey, either (i) nominated candidate sites as frontier forests (ii) redefined the boundaries of candidate sites or (iii) rejected candidate sites and

3 WRI digitized the revised boundaries of these areas

Experts were also asked to fill in a questionnaire for each frontier area assessed This survey was used to build a database for each frontier site which includes information on

i Forest type (based on survey results) Experts were asked to classify frontiers according to one or more of the following categories boreal temperate hard wood ' "temperate mixed coniferous and deciduous forest south ern temperate/astral forest ' humid tropical forest ' 'dry tropical forest

ii Size (this was calculated using a GIS) WRI also asked experts to roughly estimate the size of each frontier assessed where known

iii Threats to ecosystem integrity (based on information contained within the questionnaires) Experts were asked to rank sites as under high, medium, or low threat from commercial logging ' "other biomass harvest (removal of fuelwood and construction materials, grazing), forest clearing (for agriculture, residential housing etc)," 'road construction and other infrastructure development (e g powerlines, pipelines), and other ' and to provide additional details on known threats

iv Potential threats to ecosystem integrity (also based on information from the questionnaires) Experts were asked to (i) note where significant portions of a frontier site have been allocated for current or future harvest (e g zoned as production forest, given over to concessions) and to estimate the percentage of each site allocated for harvest, where known and (ii) indicate if a site contains high-value timber species, or other high value resources (e g gold oil), and to estimate the approximate proportion of the site within which such resources occur

v Source of expert information and level of knowledge (for most sites, based on the input of several reviewers) The names of these individuals are listed within WRI's database along with a ranking of how well these experts claim to know each frontier area (experts were asked to rank themselves on a 1-5 scale according to how well they know a given site)

In many cases sites were nominated and reviewed independently by several experts WRI harmonized these results by (i) consulting with reviewers when their results differed for a given site to come up with a consensus view, (ii) in some cases, giving extra weight to results from individuals who ranked their knowledge of a site as significantly higher than that of others who reviewed that frontier forest

WRI also held three review sessions (one covering temperate and boreal regions, a second covering tropical frontiers and a third to review all areas of the world) to help fill in data gaps and to solicit input on draft frontier maps Approximately 60 ecologists, foresters and others with broad knowledge of forest issues across various regions of the globe attended these sessions

Note that five frontier forest sites within Western Zaire were identified using maps of current road and forest cover (the latter derived from recent satellite imagery) These sites – lacking roads or significant areas of degraded forest – were added because experts working on the WRI study suggested forest in this region qualified as frontier however they were not sufficiently familiar with the area to identify the boundaries of these sites

MAPPING OF ORIGINAL FOREST COVER

As part of this project WCMC developed the first detailed map of estimated forest cover prior to the impact of modern man (circa 8 000 years ago) using many global and regional biogeographic maps These included *World Map of Present Day Landscapes* (Moscow State University/UNEP), *Ecoregions of Latin America and the Caribbean* (Dinerstein et al) *Vegetation of Africa* (White), *Review of the Indomalayan Protected Areas* (MacKinnon) *Australia Natural Vegetation* (Australian Surveying and Land Information Group), and *General Map of Natural Vegetation for Europe* (Bohn and Katenina) WRI adjusted this map – notably by using current forest cover in the northernmost 200 km of forest as a surrogate for historic cover so as to capture the natural patchy distribution of forest in this tundra forest transition zone

The WCMC map is an indicator, not a direct measure of original cover It depicts where forest might be expected to occur today in the absence of humans based on climate topography and other variables The distribution of forest cover 8,000 years ago probably varied somewhat from region to region due to long term climate change For details on the original forest cover mapping methodology, please refer to

Clare Billington, Valerie Kapos Mary Edwards Simon Blyth and Susan Iremonger *Estimated Original Forest Cover Map – A First Attempt* (WCMC Cambridge UK, October 1996)

FRONTIER FOREST INDEX

The frontier forest index ranks countries on a scale of 0 to 99 The index was created by multiplying the percentage of original frontier forest lost (that estimated to cover the country 8 000 years ago) with the percentage of remaining frontier forest area classified under moderate or high threat to total assessed frontier area

DEFINITIONS

CURRENT FOREST COVER estimated closed forest cover within the last 10 years or so (this date varies by country) Only closed moist forest is depicted for tropical Africa and Asia Woodlands and shrublands are not included in this category ORIGINAL FOREST COVER is the estimated extent of closed forest about 8,000 years ago, assuming current climatic conditions FRONTIER FORESTS are defined as being primarily forested of sufficient size to support viable populations of the full range of indigenous species associated with that particular forest ecosystem given periodic natural disturbance episodes (fire, hurricanes pests & disease etc), (note that this implies that frontier forests provide habitat for these species not that they actually contain these species) and exhibiting a structure and composition shaped largely by natural events, as well as by limited human disturbance from traditional activities (such as shifting cultivation) De facto they are relatively unmanaged (natural disturbance regimes such as fire are permitted to occur) are home to most if not all of the species associated with that ecosystem type are dominated by indigenous tree species associated with that ecosystem type, and are characterized by mosaics of forest patches representing a range of serial stages in areas where such landscape heterogeneity would be expected to occur under natural conditions

Forested areas must meet all of the following 7 criteria to qualify as frontiers They must

1 Be of sufficient size to support ecologically viable populations of the largest carnivores and herbivores associated with that particular forest ecosystem, although they may not actually contain these species

(*Rationale* range requirements of umbrella species are believed to be large enough to provide for habitat requirements of most other species within a given ecosystem)

2 Be of sufficient size to support ecologically viable populations of these species in the face of a major natural disturbance episode such as one would predict to occur once in a century, within the ecosystem in question (fire, hurricanes, pests & disease etc)

(*Rationale* If frontiers are supposed to serve as forest refugia during the next extinction crises they must be large enough to maintain their resident species in the face of periodic natural disturbance The "once in a century cutoff, although arbitrary, is a yardstick used by engineers and others in designing bridges buildings dams etc that can weather catastrophic natural events)

3 Exhibit a structure and composition shaped largely by natural events, as well as by limited human disturbance from traditional activities (such as shifting cultivation)

4 Be relatively unmanaged (natural disturbance regimes such as fire are permitted to occur across most of the area in question)

5 Be characterized by mosaics of forest patches representing a range of seral stages, in areas where such landscape hetero geneity would be expected to occur under natural conditions

6 Be home to most if not all of the species associated with that ecosystem type

7 Be dominated by indigenous tree species associated with that ecosystem type

Many temperate frontier forests do not strictly qualify according to all seven criteria, primarily due to size constraints and to fire suppression and other management For example, Clayquot Sound in British Columbia may be too small to qualify as a frontier forest, and all sites in Scandinavia may be too disturbed to meet WRI criteria After consultation with temperate experts we decided to include those temperate areas (i) that are large enough to maintain ecologically viable populations of indigenous species when the surrounding non-frontier forest matrix is considered and (ii) where fires are generally allowed to burn across at least half of the frontier site (although fire suppression may have been practiced in the past) Most temperate sites in North America and Europe consist of a mix of old growth and secondary forest Frontier sites that would not otherwise qualify using a strict interpretation of the WRI criteria are automatically listed as threatened due to lack of buffering capacity and disturbance of surrounding forest

THREATENED FRONTIER FORESTS are areas assessed by experts as under medium or high threat, where ongoing or planned human activ ities will likely result in the eventual violation of one of the seven frontier forest criteria listed above (e g cause declines in or local extinctions of plants and animals or large-scale changes in the forest s age and structure) In some cases sites listed as threat ened are currently undisturbed but are slated for logging or other development activity likely to affect the ecosystem integrity of the forest Note that many threatened frontier forests include large areas of protected forest While the core areas of these sites may be undisturbed these fron tiers are considered threatened because human activity in surrounding forest is likely to impact the integrity of the ecosystem as a whole

DATA CAVEATS AND LIMITATIONS

This assessment represents a rough first cut attempt to esti mate the status of global frontier areas, and should be viewed as a work in progress The maps and data contained within this report are not intended to be used to define conservation or investment priorities or to otherwise provide input into regional or national planning and assessment activities WRI will work with data partners over coming years to improve on the base maps and the accuracy of these results Readers should note that

- Data availability and quality varies between regions For example frontier forest is likely underestimated in Central Zaire and possibly portions of Brazil, due to the fact that few scientists have explored that region (and therefore that the status of these forests is relatively unknown)

- Naturally fragmented forest ecosystems such as areas of montane forest cover found in portions of East Africa do not register as frontier forest in this study due to their small size However, in some cases these areas may fully qualify as intact relatively undisturbed natural forests

- Comparability of results has been effected by expert bias Map reviewers varied in how strictly or loosely they have applied our criteria in defining sites and how they assessed the magnitude of any given threat As noted above, WRI attempted to minimize this bias by seeking input from at least 10 15 experts for any one part of the world (to cross check on and harmonize results), and by seek ing extensive outside review of the draft maps to insure that data are relatively comparable between regions

WRI would welcome any comments on the accuracy of these results and suggestions on how we might improve on the base maps during the next phase of this research project

NOTES

1 Food and Agriculture Organization of the United Nations (FAO) Forest Resources Assessment 1990 Global Synthesis FAO Forestry Paper 124 (FAO Rome 1995) Annex 1 p 21

2 The FAO estimate applies to annual loss of natural forest cover between 1980 and 1990 for developing countries only It does not include large areas of forest logged over and left to regenerate No data are available for developed countries of the world

3 J M Thiollay Area Requirements for the Conservation of Rain Forest Raptors and Game Birds in French Guiana *Conservation Biology* 1989 Vol 3(2) 128 37

4 William Newmark A Land bridge Island Perspective on Mammalian Extinctions in Western North American Parks *Nature* 1987 Vol 229 450 52

5 Christine Schonewald Cox Conclusions Guidelines to Management A Beginning Attempt in *Genetics and Conservation a Reference for Managing Wild Animal and Plant Populations* edited by Christine Schonewald Cox Steven Chamber Bruce MacBryde and Larry Thomas (London The Benjamin Cummings Publishing Company Inc 1983) pp 415 16 443 44

6 Larry Harris *The Fragmented Forest Island Biogeography Theory and the Preservation of Biotic Diversity* (Chicago The University of Chicago Press 1984) pp 72 84

7 Scott Robinson Frank Thompson Therese Donovan Donald Whitehead and John Faaborg Regional Forest Fragmentation and the Nesting Success of Migratory Birds *Science* 1995 Vol 267 (526) 1987

8 Elliot Norse *Ancient Forests of the Pacific Northwest* (Washington D C Island Press 1990) pp 75 84

9 Walter V Reid and Kenton Miller *Keeping Options Alive The Scientific Basis for Conserving Biodiversity* (Washington D C World Resources Institute 1989) p 15

10 Calculated by multiplying regional frontier forest area by per hectare carbon estimates for forest areas presented in R K Dixon S Brown R A Houghton A M Solomon M C Trexler and J Wisniewski Carbon Pools and Flux of Global Forest Ecosystems *Science* Vol 263 185 90 Dixon et al s estimates are for closed and open forests for both soil and above ground vegetation For this reason and because these averages include degraded forest (which contains less carbon than intact forest) the figure presented in the text on total carbon stored in frontier forest is likely an underestimate Soil carbon figures include peat We used averaged per hectare carbon figures in estimating carbon stored in frontier forests that contain more than one dominant forest type (e g temperate and boreal forest)

11 John Perlin *A Forest Journey The Role of Wood in the Development of Civilization* (New York W W Norton and Company 1989) pp 18 19 42 45

12 World Resources Institute World Resources 1992 93 (New York Oxford University Press 1992) p 290

13 George Ledec and Robert Goodland *Wildlands Their Protection and Management in Economic Development* (Washington D C The World Bank 1988) pp 76 7

14 Nels Johnson and Bruce Cabarle *Surviving the Cut Natural Forest Management in the Humid Tropics* (Washington D C World Resources Institute 1993) p 7

15 Commission on Development and Environment for Amazonia *Amazonia Without Myths* Amazon Cooperation Treaty 1992 p xiv

16 Food and Agriculture Organization of the United Nations (FAO) Forest Resources Assessment 1990 Global Synthesis FAO Forestry Paper 124 (Rome FAO 1995) p 43

17 K D Singh personal communication January 1997 *Washington Post* January 1 1997

18 United States Department of Commerce *Statistical Abstract of the United States 1996* (Washington United States Department of Commerce 1996) pp 8 562

19 This study was limited to mapping frontier forests within closed forest ecosystems WRI was unable to map large natural tracts of woodland area (more open forest generally located in drier regions of the world between closed forest and savannah) because no global map exists depicting wooded areas of the world

20 Geographic Information Systems are used to store analyze and display spatially referenced (map) data

21 United Nations Environment Programme (UNEP) *Global Biodiversity Assessment* (Cambridge Cambridge University Press 1995) p 345

22 Alexander Mather *Global Forest Resources* (Portland Timber Press 1990) p 32

23 Jack Westoby *Introduction to World Forestry* (Oxford Basil Blackwell Ltd 1989) p 50

24 Jack Westoby *Introduction to World Forestry* (Oxford Basil Blackwell Ltd 1989) pp 54 5

25 Owen Lynch and Kirk Talbott *Balancing Acts Community-Based Forest Management and National Law in Asia and the Pacific* (Washington D C World Resources Institute 1995) p 21

26 Commission on Development and Environment for Amazonia *Amazonia Without Myths* Amazon Cooperation Treaty 1997 p xii

27 R B Edgerton *Sick Societies Challenging the Myth of Primitive Harmony* (New York Free Press 1992)

28 United Nations Environment Programme (UNEP) *Global Biodiversity Assessment* (Cambridge Cambridge University Press 1995) p 765

29 Duncan Poore Peter Burgess John Palmer Simon Rietburgen and Timothy Synnott *No Timber Without Trees Sustainability in the Tropical Forest* (London Earthscan Publications 1989) p 18

30 Consultative Group on International Agricultural Research (CGIAR) *Poor Farmers Could Destroy Half of Remaining Tropical Forest* media background press release (Washington D C CGIAR August 4 1996) p 3

31 Raymond Rowe Narendra Sharma and John Browder Deforestation Problems Causes and Concerns in *Managing the World s Forests* Narendra Sharma ed (Dubuque Iowa Kendall Hunt Publishing Company 1992) p 34

32 International Panel on Climate Change (IPCC) *IPCC Working Group II Second Assessment Report* (IPCC 1995)

33 World Resources Institute *World Resources 1996-97* (New York Oxford University Press 1996) p 190

34 Global Witness *Corruption War and Forest Policy The Unsustainable Exploitation of Cambodia s Forests* (London Global Witness Ltd February 1996) p 3

35 Kirk Talbott and Chantal Elkin *Logging Burma s Forests Resources for the Regime* (Washington D C World Resources Institute forthcoming)

36 Environmental Investigation Agency (EIA) *Corporate Power Corruption and the Destruction of the World s Forests The Case for a New Global Forest Agreement* (Washington D C EIA 1995) pp 6 7

37 Nigel Sizer and Richard Rice *Backs to the Wall in Suriname Forest Policy in a Country in Crisis* (Washington D C World Resources Institute 1995) p 11

38 World Press Review Colombia s Vanishing Forests *World Press Review* Vol 40 No 6 June 1993 p 34

39 Nigel Smith Paulo Alvim Emanuel Serrao and Italo Falesi Amazonia in *Regions at Risk Comparisons of Threatened Environments* Jeanne Kasperson Roger Kasperson and B L Turner II eds (Tokyo United Nations University Press 1995) pp 58 9

40 Ecotrust and Conservation International (CI) *Coastal Temperate Rain Forests Ecological Characteristics Status and Distribution Worldwide* Occasional Paper Series No 1 (Portland Ecotrust 1992) p 33

41 Jonathan Friedland and Raphael Pura Log Heaven Trouble at Home Asian Timber Firms Set Sights on the Amazon *The Wall Street Journal* November 11 1996

42 World Wildlife Fund *The Official World Wildlife Fund Guide to Endangered Species of North America* (Washington Beacham Publishing Inc 1990) pp 446 534 549

43 Development and degradation of sur rounding non protected forest area threat ens the ecological integrity of these sites which barely qualified as frontier forest under the WRI criteria Refer to Technical Annex for details

44 Chuck Carr personal communication 1996

45 Robin Hanbury Tension A Bridge Too Far? *Geographical Magazine* Vol 68 No 1 January 1996 p 35

46 Food and Agriculture Organization of the United Nations (FAO) *Forest Resources Assessment 1990 Global Synthesis* FAO Forestry Paper 124 (Rome FAO 1995) Annex 1 p 21

47 The Guyana Shield includes part or all of Brazil French Guiana Guyana Suriname and Venezuela

48 Peter Raven personal communication December 1996

49 Nigel Smith Paulo Alvim Emanuel Serrao and Italo Falesi Amazonia in *Regions at Risk Comparisons of Threatened Environments* Jeanne Kasperson Roger Kasperson and B L Turner II eds (Tokyo United Nations University Press 1995) p 41

50 Caroline Harcourt and Jeffrey Sayer eds *The Conservation Atlas of Tropical Forests the Americas* (New York Simon and Schuster 1996) pp 230 238

51 M Patricia Marchak *Logging the Globe* (London McGill Queen s University Press 1995) p 321

52 Steve Gilroy Disturbing the Ancients in *Buzzworm The Environmental Journal* Vol IX No 1, January February 1992 p 41

53 Nigel Dudley *Forests in Trouble A Review of the Status of Temperate Forests Worldwide* (Gland Switzerland World Wildlife Fund 1992) p 121

54 Steve Gilroy Disturbing the Ancients in *Buzzworm The Environmental Journal* Vol IX No 1, January/February 1992 p 38

55 Estimate of the proportion of the Congo Basin s forest cover located in Zaire is based on figures in Food and Agriculture Organization of the United Nations (FAO) *Forest Resources Assessment 1990 Global Synthesis* FAO Forestry Paper 124 (Rome FAO 1995) Annex 1 p 28

56 Food and Agriculture Organization of the United Nations (FAO) *Forest Resources Assessment 1990 Tropical Countries* FAO Forestry Paper 112 (Rome FAO 1995) Annex 1 Table 5a

57 World Resources Institute *World Resources 1996-97* (New York Oxford University Press 1996) p 210

58 World Resources Institute *World Resources 1996-97* (New York Oxford University Press 1996) pp 206 218

59 Josh Newell and Emma Wilson *The Russian Far East Forests Biodiversity Hotspots and Industrial Developments* (Tokyo Friends of the Earth Japan 1996) pp 6 46

60 World Resources Institute *World Resources 1996-97* (New York Oxford University Press 1996) pp 206 7

61 Josh Newell and Emma Wilson *The Russian Far East Forests Biodiversity Hotspots and Industrial Developments,* (Tokyo Friends of the Earth Japan 1996) pp 46 53

62 K D Singh and Antonio Marzoli Deforestation Trends in the Tropics A Time Series Analysis paper presented at the World Wildlife Fund Conference on Potential Impact of Climate Change on Tropical Forests San Juan Puerto Rico April 1995 pp 8 9

63 National Development Planning Agency Government of Indonesia *Sixth Five Year Development Plan 1994/5 1998/9* Vol III (Jakarta National Planning Agency 1994) pp 421 22

64 World Resources Institute *World Resources 1996-97* (New York Oxford University Press 1996) pp 191 217

65 World Resources Institute *Bangladesh Environment and Natural Resource Assessment* (Washington D C World Resources Institute 1990) p 27

66 World Wide Fund for Nature (WWF) and the World Conservation Union (IUCN) *Centres of Plant Diversity A Guide and Strategy for their Conservation* Vol II (Cambridge WWF 1995) p 449

67 New Zealand Ministry for the Environment *New Zealand s National Report to the United Nations Conference on Environment and Development* (Wellington Ministry for the Environment 1991) pp 47 8

68 World Wide Fund for Nature (WWF) and the World Conservation Union (IUCN) *Centres of Plant Diversity A Guide and Strategy for their Conservation* Vol II (Cambridge WWF 1995) p 439

69 Frontier forests in Northern Australia contain a mix of forest and woodland including small patches of rainforest

70 Mark Clayton Chipping Away at Australia s Old Growth Forests *The Christian Science Monitor* April 24 1996

71 Nigel Dudley *Forests in Trouble A Review of the Status of Temperate Forests Worldwide* (Gland Switzerland World Wildlife Fund 1992) pp 93 5

72 Department of Environment and Conservation Conservation Resource Centre and the Africa Centre for Resources and Environment *Papua New Guinea Country Study on Biological Diversity* (Waigani Department of Environment and Conservation 1995) p 6

73 Such as certification efforts approved by the Forest Stewardship Council (eg Smartwood) which ensure that harvest ing is environmentally responsible social ly beneficial (particularly to local commu nities) and financially viable

74 David Tenenbaum The Guanacaste Idea *American Forests* Vol 100 Nos 11 12 November December 1994 p 28

75 David Tenenbaum The Guanacaste Idea *American Forests* Vol 100 Nos 11 12 November December 1994 p 28

76 Matthew Perl Michael Kiernan Dennis McCaffrey Robert Buschbacher and Garo Batmanian *Views From the Forest Natural Forest Management Initiatives in Latin America* (Washington D C World Wildlife Fund 1991) p 5

77 Nels Johnson and Bruce Cabarle *Surviving the Cut Natural Forest Management in the Humid Tropics* (Washington D C World Resources Institute 1993) p 28

78 Matthew Perl Michael Kiernan Dennis McCaffrey Robert Buschbacher and Garo Batmanian *Views From the Forest Natural Forest Management Initiatives in Latin America* (Washington D C World Wildlife Fund 1991) pp 5 8

79 Michael McCloskey and Heather Spalding A Reconnaissance level Inventory of the Amount of Wilderness Remaining in the World *Ambio* Vol 18 No 4 1989 pp 221 27

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The Forest Frontiers Initiative (FFI) is a five year, multi disciplinary effort to promote stewardship in and around the world s last major frontier forests by influencing investment policy and public opinion The FFI team is working with governments citizens groups, and the private sector in Amazonia Central Africa, Indonesia North America and Russia We also take part in pressing international discussions on forest policy

We are motivated by the belief that there is a responsible way to use forests We also see growing interest in finding alternatives to forest destruction that take advantage of the full economic potential of forests not just immediate revenue from logging and clearing

Business has a leading role to play We are developing case studies with innovative firms to demonstrate to others the business impacts and opportunities that sustainability presents We are also working to strengthen the Forest Stewardship Council which promotes consumer awareness about products from well managed forests by certifying wood products from them

For each frontier forest region FFI builds a network of policy makers activists investors and researchers to promote policy reform Efforts to minimize the negative impacts of road building and forest clearing for agriculture and to stop illegal logging, are part of this work

To spark policy change and stimulate stewardship more generally we will collect and disseminate more information as it becomes available We are also working to build the capacity of local non governmental groups to do the same

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