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Note

Tropical Forest

Background information for earth observation research scientists

Note no SAMBA/56/08

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Front cover picture

"Aerial view of a mangrove forest on the island of New Caledonia. The heart formation is not human made, but occurred naturally, as mangroves require brackish or saltwater contact at all times and the sandy, heart-shaped area rises above the water table." (Newman, 2002, p. vii; Photo by Yann Arthus-Bertrand.)

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Abstract

This note is intended to be a short introduction to tropical forests, with the main focus on tropical rain forest. Primal tropical forest is threatened with extinction if not current deforestation practices are stopped. In addition to being excellent carbon storage, primal tropical forests have a unique biological diversity of both flora and fauna, prevent erosion and flooding, etc. In order to stop deforestation, the following can be done. (1) Protect large areas of primal forest as national parks, (2) create forest plantations in deforested areas, and (3) develop sustainable agriculture. In order to monitor this, remote sensing imagery could be used. In order to monitor large rain forest areas for land use changes, the use of satellite images is essential. The detection of land use changes requires an image acquisition frequency for monitored areas of at least twice a year, since gaps in the canopy, resulting from selective logging or otherwise, are sometimes closed after only one year. In order to detect ongoing illegal activities and make arrests on-site, one should run detection methods on new images in near real time.

Keywords	Deforestation, monitoring, satellite images
Target group	Earth observation research scientists
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Contents

Executive summary

This note is intended to be a short introduction to tropical forests, with the main focus on tropical rain forest. This note relies heavily on two textbooks (Turner, 2001; Newman, 2002).

Primal tropical forest is threatened with extinction if not current deforestation practices are stopped. Primal moist tropical forest has many assets, including:

1. The most diverse collection of flora and fauna, which may provide a number of valuable resources indefinitely, if harvested sustainably: medicines (both from plants and animals), plant species that may be hybridized into new food crops, rubber, latex, fruit, vegetables, meat, etc. Many of the species are interdependent on other species in the ecosystem, so entire ecosystems must be preserved to preserve the individual species.

2. Indigenous people live in the forest, and have a thorough knowledge of possible uses of a large number of local flora and fauna for food and medical purposes.

3. The habitat for many beautiful mammals and birds.

4. High carbon density (in tons per hectare).

5. Prevents soil erosion.

6. Binds water: reduces flooding after heavy rainfall, endures seasonal dry periods, participates in cloud formation, preserves constant air humidity within the forest.

7. High capacity for production of oxygen.

The following can be done (simultaneously) to stop deforestation of primal tropical forest.

1. Protect large primal tropical forest areas by creating new national parks. These need to be managed properly to avoid unsustainable logging and other disturbing activities, whether legal or illegal.

2. Create forest plantations in areas that have already been deforested

3. Develop sustainable agriculture, also for use in deforested areas.

4. Ban construction of new roads into primal tropical forest

In order to monitor large rain forest areas for land use changes, the use of satellite images is essential. The detection of land use changes requires an image acquisition frequency for monitored areas of at least twice a year, since gaps in the canopy, resulting from selective logging or otherwise, are sometimes closed after only one year. In order to detect ongoing illegal activities and make arrests on-site, one should run detection methods on new images in near real time.

By preserving primal tropical forests, existing carbon stocks with large carbon density will be kept. By creating forest plantations, where commercial timber is grown and harvested, additional amounts of carbon are bound, and at the same time the pressure on the primal tropical forest is reduced. By developing sustainable agriculture, the devastating practice of large-scale “slash-and-burn” of primary forest, followed by a few years of agriculture before the plot is abandoned, may be stopped. Sustainable agriculture includes an investigation of which plants to grow and which animals to raise. Previous practices have demonstrated that beef cattle ranching is most likely the worst idea for land use in the tropics, creating meat of low nutritional value and achieving low productivity.

1 Introduction

The following few paragraphs have been taken verbatim from Chomitz (2007).

> "Satellites allow us to watch forests burn in real time. The tropical forest estate, extraordinarily large [around 1950], is shrinking at about 5% a decade. By [2050] only shreds […] may be left. Unless trends change, the consequences will be severe: 3 billion tons of carbon dioxide added to the atmosphere each year, intensifying climate change; loss not only of many species but also entire ecosystems; and across the tropics, widespread changes in water flows, scenery, microclimates, pests and pollinators. These environmental damages would touch people near and far.
>
> Pressures on forests will not disappear soon. Croplands, pastures, and plantations are expanding into natural forests and will likely do so for the next 30-50 years. Expansion is driven by both wealth and poverty. A huge rural population relies on low-productivity agriculture for subsistence. A growing, increasingly wealthy urban population demands commodities produced at the forest's edge: beef, palm oil, coffee, soybeans, and chocolate.
>
> The Food and Agriculture Organization predicts that the growth in such demand will slow – but still expects croplands in the developing world to expand by a net 3.8 million hectares a year over the next three decades (Bruinsma, 2003). Gross expansion will be even greater, because some farmland is abandoned. And these estimates do not include expansion of pastures and planted forests.
>
> Forests are also under pressure from loggers. Poor people need fuelwood, and a wealthier world demands more wood and pulp – demands only partly met by plantations. Logging thins and degrades forests and helps finance and provide access to farmers and entrepreneurs who burn unsellable trees to establish agriculture.
>
> Forests play a crucial role in the lives of many poor people. Almost 70 million people – many indigenous – live in remote areas of closed tropical forests. Another 735 million rural people live in or near tropical forests and savannas, relying on them for much of their fuel, food, and income – or chopping them down for crops and pasture."

2 Definitions of tropical forests

2.1 Tropical rain forest.

A tropical rain forest has a closed, evergreen canopy, or crown cover. The canopy is at least 25 meters high and is dominated by mesophyll-sized leaves. There is an abundance of thick woody lianas; and of epiphytes, i.e., plants that grow on other plants for mechanical support.

2.1.1 Lowland tropical rain forest

Annual rainfall is at least 1700 mm per year (Newman, 2002, p. 12), or generally at least 2000 mm per year (Turner, 2001, p. 1), and never less than 100 mm per month during the year. Altitude is below 1500 m. A large number tree species co-exist, typically more than 100 species per ha.

2.1.2 Montane tropical rain forest

Due to higher altitude, average daily temperature is lower. Compared with lowland tropical rain forest, both tree height and the number of trees are reduced. The reduced canopy cover results in more sunlight reaching the ground, and thus more shrub growth. Also, the diversity in animal and plant species is reduced.

One kind of montane tropical rain forest is *cloud forest*. Due to lower temperature and lower air pressure, the forest is covered in almost permanent mist ().

2.2 Moist deciduous forest

If there are several consecutive months with less than 100 mm rain per month, and the root system of the trees do not have access to ground water, then the evergreen trees are replaced by drought-deciduous trees. During the drier period, the trees would loose much water as vapor from the leaves had they not been felled.

2.3 Dry deciduous forest

Dry deciduous forests are tropical forests that have too little annual rain fall to remain moist. Dry deciduous forest is often mixed with open savanna.

2.4 Mangroves

One special forest type that is often mentioned in connection with tropical forests is *mangroves*. However, the below definition does not limit mangroves to the tropics.

”Mangroves are salt-tolerant forest ecosystems commonly found along sheltered coastlines, in deltas, and along river banks in the tropics and subtropics. These trees and shrubs have developed morphological adaptions to tidal environments, such as aerial roots, salt excretion glands, and, in some species, vivipary of seeds.” (FRA 2005, p. 28).

Mangroves are more homogeneous than other lowland tropical forest, typically with one dominant tree species. Mangroves provide the last frontier to prevent massive soil erosion from the ocean.

2.5 Subtropical rain forest

Forests outside the tropics, which have an annual rain fall of at least 2000 mm are considered subtropical (or boreal) rain forests. Such rain forests are outside the scope of this note.

3 Typical characteristics of tropical rain forest

3.1 Layers of forest tree heights.

The uppermost layer consists of scattered tall trees, reaching up to around 60 m and averaging 37 m. Below these, there are up to five layers, making up the dense forest canopy. Each tree refrains from branching until it reaches the height at which the tree's canopy spreads out. The forest canopy absorbs 99% of the sun light on a cloud free day, leaving only 1% to reach the forest floor.

3.2 Diversity of tree species

Outside the tropics, each species is believed to fill a certain niche in the ecosystem, meaning that it has adapted some sort of specialization in competition with other species in order to survive as a species. However, in the tropical rain forest, the diversity of tree species is striking, growing conditions are superb, and the notion of niche for a species does not seem to make sense. Rather, it seems that individual trees from different species have equal opportunities, as long as they can find a free spot in the forest canopy.

3.3 Diversity of other species

It has been estimated that at least 50%, but maybe as much as 90%, of the stipulated 100 million species of our planet are located in the tropical forests. Biologists have yet only described about 1.75 million species, including approximately 750,000 insects, 270,000 plants, and 47,000 vertebrates. At the current rate of deforestation of the tropical forests, an accumulated 10 million species will have been lost by 2020, the majority of which have not been discovered and described yet.

Figure 1. The golden toad. (Image from Wikipedia.)

Many tropical rain forest species are so specialized that the entire population of a species is limited to a few square kilometers. One example is the golden toad (*Bufo periglenes*, Figure 1), which was discovered in 1964, and inhabited a single mountain top in Costa Rica. It has not been seen since 1989 and is now declared extinct (Newman, 2002, p. 112).

The extinction of a single species is in itself a sad fact. However, more importantly, a potential source of future food, raw material or medicine is lost. An example of medicine derived from rain forest animals is tetrodotoxin, which is used as a pain killer and muscle relaxant for neurogenic leprosy and terminal cancer patients (Newman, 2002, p. 112).

80% of the developed world's diet is derived from plants originating in the tropics. Tropical plants are also used for spices, gums, latex, perfume oils, medicines, flavoring, wood, and houseplants, to name some uses (Newman, 2002, p. 111).

3.4 Temperature

The mean temperature is at least 18˚C, and typically close to 27˚C all year around. The temperature variation between day and night is larger than the variation of daily average during one year. This results in very stable growing conditions.

3.5 Humidity

The air inside the forest is constantly very humid, and works as a temperature regulator. If an area of rain forest is destroyed, the local humidity will disappear, and the temperature may rise to 40˚C on open land in the warm season.

3.6 Water

Flooding is common due to the large amounts of heavy rainfall. The tropical rain forest has a sponge effect on water. It binds water after heavy rainfall, reducing flooding downstream, as well as releasing water during dry seasons (Newman, 2002, p. 135).

3.7 Geographical extent

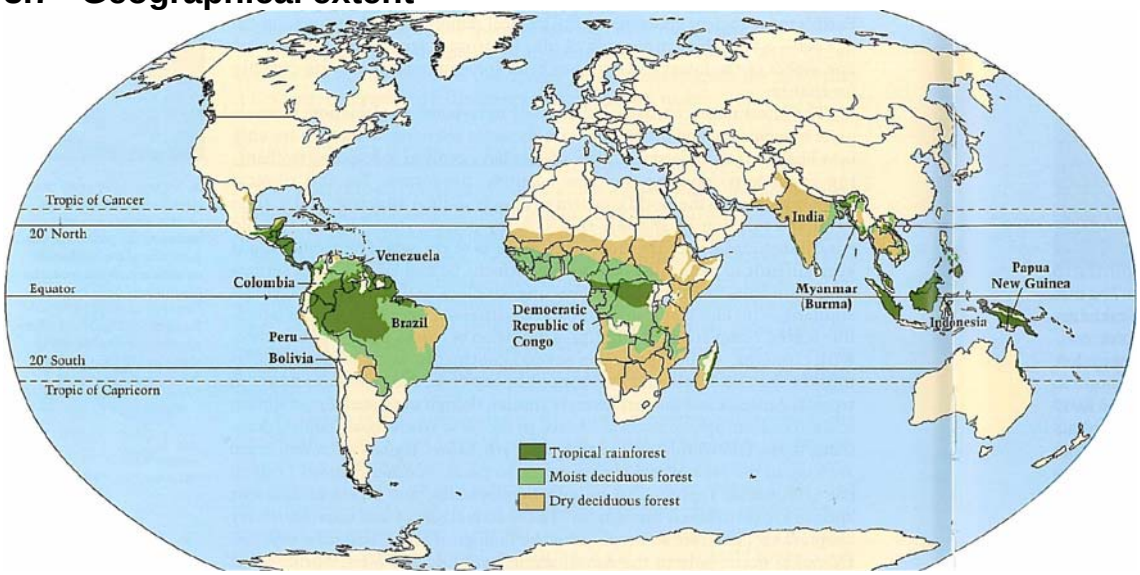

Figure 2. Geographical extent of tropical rain forests, moist deciduous forests, and dry deciduous forests (figure from Newman (2002), pp 12-13).

4 Trees in the tropical rain forest

4.1 Diversity

Many lowland tropical rain forests contain more than 100 tree species within one hectare, and in some forests, more than 200 tree species may be found. (Turner, 2001, p. 6-7). The reason for this diversity is still being discussed (Turner, 2001, pp. 7-9).

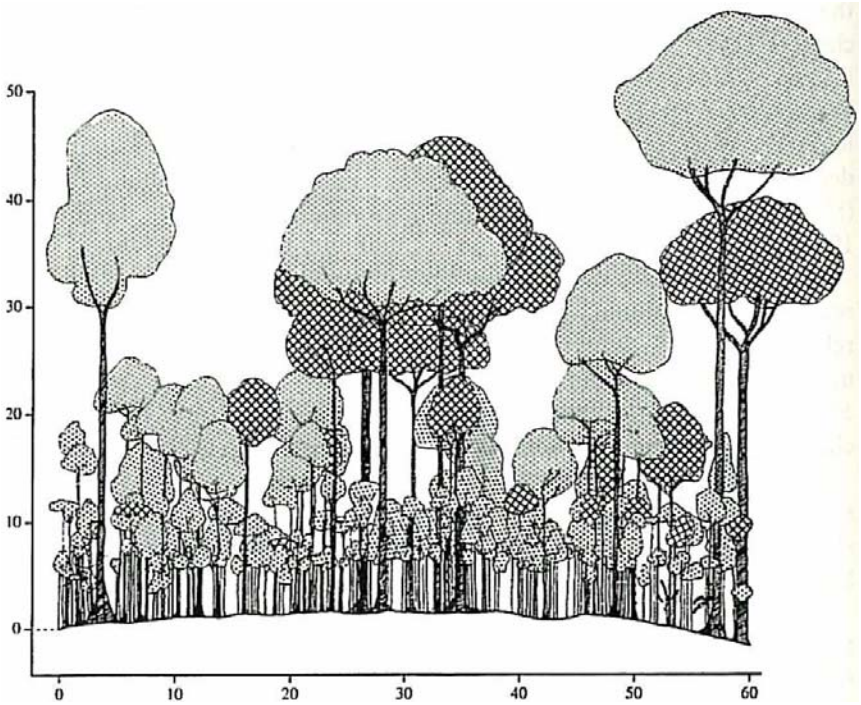

Figure 3. Profile diagram of a rectangular area of 60 m x 8 m at Ulu Dapoi, Tinjar, Borneo. (From Turner, 2001, p. 16.)

4.2 How trees grow

Individual trees of a large range of size exist side by side in tropical rain forests (Figure 3). Each tree species has a characteristic height at maturity. Species are often divided into stature classes, like understorey trees, canopy trees, and emergents. However, there is no discrete clustering of tree species into size classes (Turner, 2001, p. 15).

A tree has to support its own weight and withstand wind forces (Turner, 2001, p. 24). This is achieved in a number of ways.

1. Passive bending of flexible parts. This strategy is limited to thin trees, thin branches of large trees, and bamboos.

2. The design of the wood. Most of the strength of the stem is from axial arrangement of fibers and tracheids. In addition, ray fibers resist torsion and shear stresses. An exception to the latter is dendroid monocotyledons, which lack efficient cross bracing in the wood, which is probably the reason why they are unbranched.

3. Optimized outer tree shape and internal wood quality. Tree trunks are circular. Wood is denser near the periphery than in the center.

4. Reaction wood at points of high stress intensity, typically at branches.

5. Internal pre-stressing of tree trunks.

6. Buttresses (Figure 4).

7. Crowns are attached to each other by woody vines.

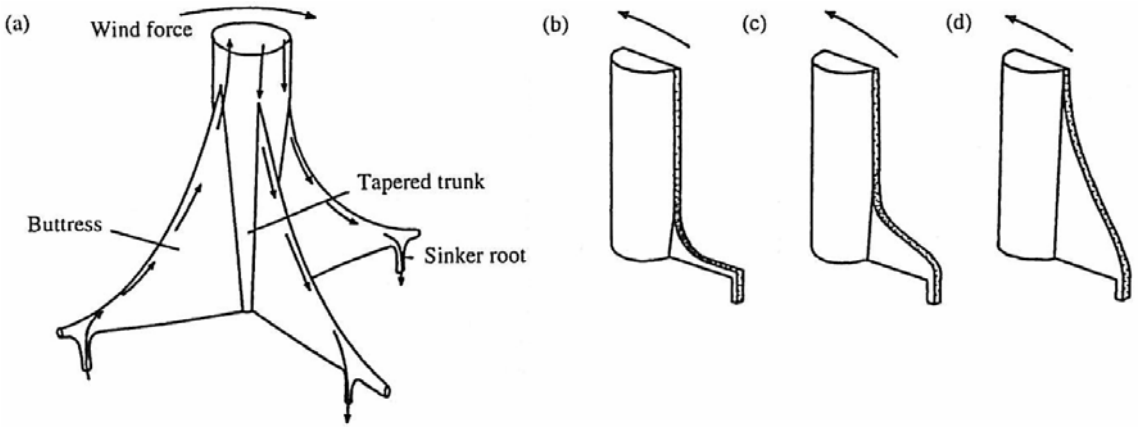

Figure 4. Buttresses. (a) If the tree is pushed by the wind, the bending force is transmitted smoothly to lateral sinker roots by the buttresses. (b)-(d) Successive stages in buttress development. (From Turner, 1991, p. 30; Ennos, 1995.)

The understorey species rarely receive more than 5% of the sun light arriving at the canopy layer. However, the increase in relative illumination with height is largest near the forest floor. This steep gradient may facilitate partitioning of the light resource among species.

Most trees stand upright, even on sloping ground, because it is mechanically more efficient. However, some trees do lean. Fast-growing species may risk death through shading if they do not lean into nearby gaps. The cost of leaning in small trees is less than in large ones. Riverbank trees often lean out over the river (Turner, 2001, p. 34).

Crown asymmetry may be quite common in trees in the tropical rain forest. In a study at Barro Colorado Island, Young and Hubbel (1991) noted that trees tended to develop crowns into nearby gaps or away from larger neighbors. On a typical tree, three quarters of the crown were on the heavy side. However, emergent trees were more symmetric than trees of lower stature (Turner, 2001, p. 31).

Tree fall is common in tropical rain forests, despite many strategies to reduce localized stress intensities (Turner, 2001, p. 35). Some fast growing light-wooded tropical trees favor a 'low cost – high risk' strategy for juveniles to quickly obtain height in the stiff competition for sun light, before growing denser wood as the tree ages (Turner, 2001, pp. 26-27).

4.3 Pioneers versus climax trees

Tree species can be categorized into four classes (Figure 5):

1. understorey

2. canopy

3. small pioneer

4. large pioneer

However, there are no definite borders between these classes. This means that individual tree species can be more or less small (as opposed to large), and more or less climax (as opposed to pioneer).

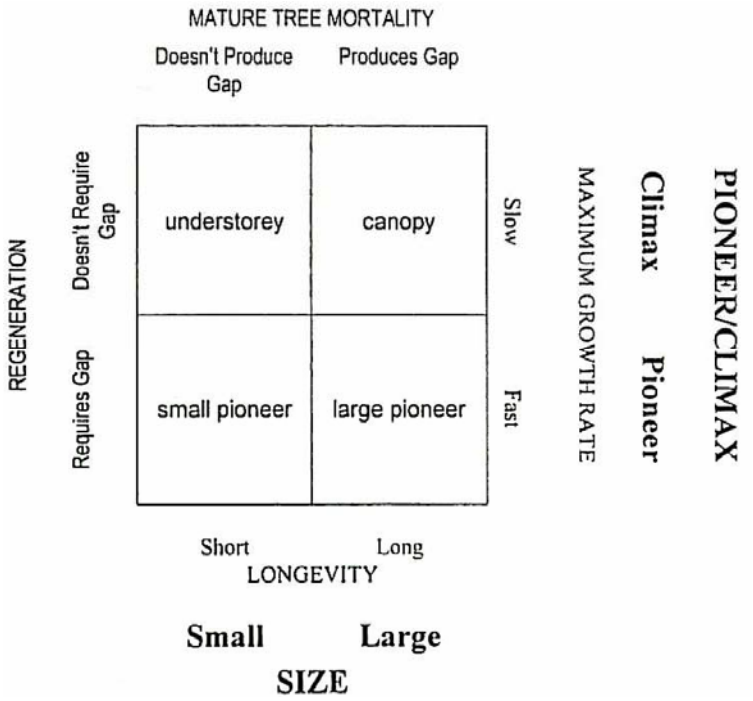

Figure 5. Two-way classification of tree species from the tropical rain forest. (From Turner, 2001.)

Pioneer trees require sun light in order to grow, usually provided by occasional gaps in the canopy. Secondary forest that appears on deforested land is typically dominated by pioneer trees, before climax trees gradually appear after some time. This results in a gradual transition from dominance of pioneer trees to climax trees over many years, if not decades (Turner, 2001, chapter 6).

5 Indigenous people

Indigenous people have lived in the tropical rain forests for thousands of years, and have learned to harvest the forest in a sustainable way. These people, and their knowledge, are facing extinction as forest is cleared.

"An unacceptably high percentage of the traditional tribal people who do survive the immediate effects of invasion of their lands, and forced transportation to relocation settlements, die in plagues of new diseases […] to which they have no natural resistance. A series of epidemics often result in 85-90 % mortality. Moreover, […] the survivors of this morbid gauntlet of assimilation into the modern world all too often become the dregs of civilization, riddled particularly with alcoholism and venereal disease, often unable, even in the long run, to adjust and become useful members of the new society."

This is in stark contrast with their traditional way of life, in which they have relatively uniform excellent physical and mental health, and general well-being.

"The erosion of these cultures, principally through deforestation, entails the very real and major loss for global society of literally thousands of years of diverse traditions, languages, and philosophies, as well as vast unwritten catalogs of botanical, animal, and mineral pharmaceuticals and foods. Invading agriculturists are, to be conservative, having a very difficult time finding any meaningful measure of success in developing sustainable colonization in the moist tropics. As the interior-forest people of these zones have evolved, out of sheer necessity, an infinite understanding of the ecological interdependencies and resources available there, and moreover, how to ply them without degrading the environment, there is ample justification to view them as tenured professors." (Newman, 2002, pp. 147-149).

6 Threats to the tropical rain forest

6.1 How much is left?

Since 1950, more than half of the tropical moist forest in the world has been removed. Tropical moist forest includes tropical rain forest and moist deciduous forest. In historical times, some 25,000,000 km^2 of the earth's land surface was covered with tropical moist forest, in 2002 only 11,500,000 km^2 remained.

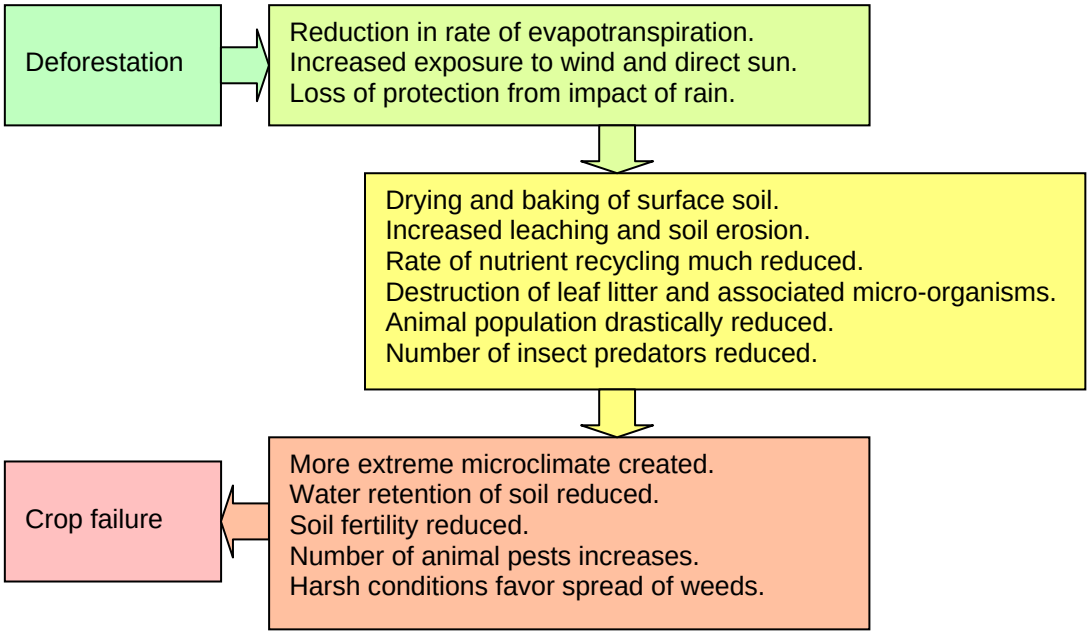

Figure 6. Downward progression from deforestation to total crop failure or land exhaustion is an inescapable consequence of short cycle shifting cultivation and cattle raising on tropical forest soils. (From Newman, 2002, p. 138.)

6.2 Agriculture

The typical method to convert tropical rain forest to agricultural land is 'slash-and-burn', in which sellable trees are felled, and the remaining trees and biomass is burned (Figure 7) to prepare for planting. This method has also been used by indigenous people, but on a much smaller scale, so that the forest had a chance to recover. When done on a large scale, permanent damage is done.

"Critical changes take place in the biomass when primary forest is cut down, used for agriculture, and then abandoned. Nutrients are stored in the living biomass and the forest-floor litter. When the forest is cut and burned, its mass is reduced to almost nothing and its nutrients exploited briefly before the plot is abandoned (Figure 8). Even 30 years later, the secondary forest that takes its place (Figure 9, right) bears little resemblance to the original (Figure 9, left). It is poor in total biomass and also in species diversity." (Newman, 2002, p. 79).

Figure 7. Burning of forest in Rondônia, Brazil. (From Newman, 2002, p. 88.)

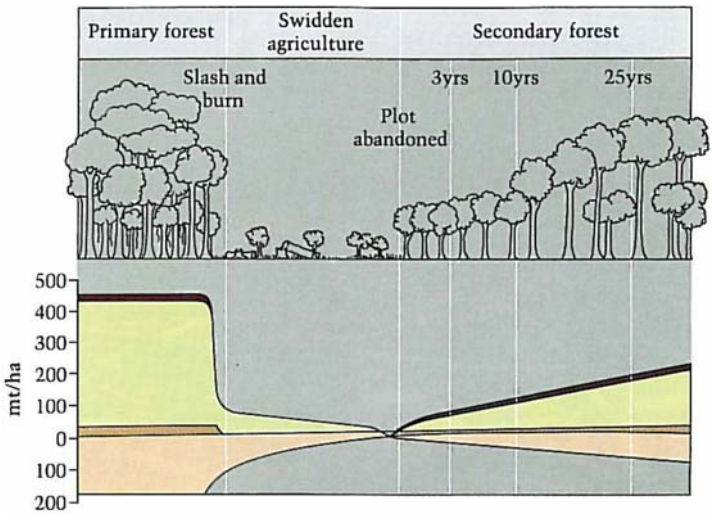

Figure 8. The myth of 'recovery'. (From Newman, 2002, p. 79.)

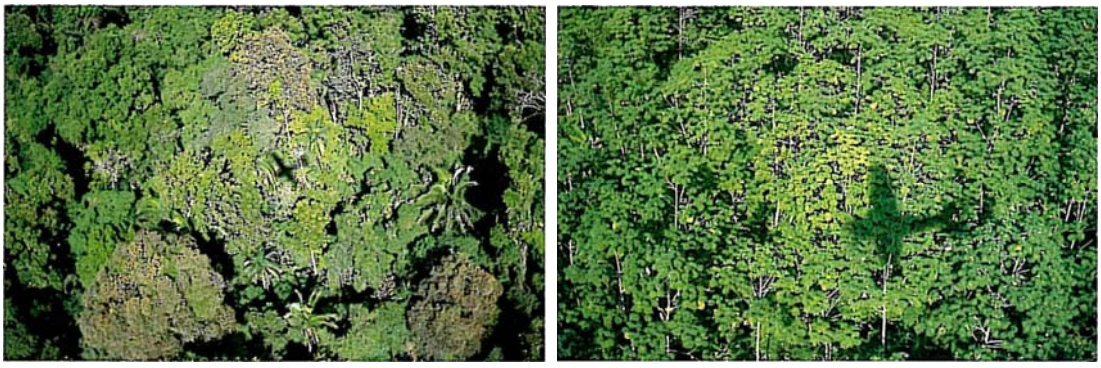

Figure 9. To the left, the rich diversity of primary forest in the Cathedral Rain Forest Science Preserve in Costa Rica, contrasted with, to the right, an area of secondary forest, a vast expanse covered by just one species, *Cecropia*. (From Newman, 2002, p. 79.)

In other cases, the forest does not return. "The bare, ravaged landscape of Haiti provides a stark contrast to the dense forest cover of the neighboring Dominican republic (Figure 10). Only 0.8 percent of natural forest remain in Haiti, and with soil fertility washed away, the nation – now down to bedrock in many areas – is one of the world's poorest countries and is reliant on imports of much of its food." (Newman, 2002, p. 92.)

Figure 10. The border between Haiti, left, and the Dominican Republic, right. (From Newman, 2002, p. 92.)

6.3 International logging

"Clear felling is not generally practiced in the tropical forests, as only a small portion of the many species are commercially useful at present. Yet the damage levels to primary forests, even with selective logging, are of considerable magnitude […]. Combining the effects of felling large trees, (which have both a knock-on and drag-on consequence to other trees in their path as well as to other neighboring trees due to the woody vines that bind them), destruction from skidding logs through the forest as well as clear felling for logging roads, the cumulative mortality to all tree size classes is on the order of 50 percent. […] The need for tropical forest products is a reality, yet it is generally acknowledged that the logging industry could enjoy a longer and more profitable life if it synchronized its consumption to regeneration cycles instead of filling sales quotas." (Newman, 2002, p. 96.)

"Although hard realities demand a clear differentiation between tropical and temperate exploitive strategies, extractive methods remain dictated by the price tag of each cubic meter of wood. Temperate trees produce seed yearly, but many tropical species flower and produce seeds infrequently, some only once in 35 years. To ignore reproduction cycles in the planning of cutting schedules is to ensure the demise of these and other species within a span of only a relatively few years." (Newman, 2002, p. 93.)

6.4 Fuelwood collection

"Deadwood collected as fuelwood in tropical wet and very moist regions, usually by rural households, does not contribute significantly to deforestation beyond the removal of

nutrritients from the biome. However, some 3 billion people in developing countries worldwide depend on fuelwood […] for all their household energy needs and consume half of all wood produced globally. […] In tropical regions, especially in the dry formations, as much as 90 percent of total forest production is consumed as fuelwood." (Newman, 2002, p. 100.)

6.5 Paper

"The consumption of paper (which includes newspaper and paperboard) is increasing faster than any other forest product; in fact, present [year 2000] consumption is five times the amount used in 1950. This volume is projected to double again by 2010. […] Quite soon more than one-half of global industrial wood harvested will go toward paper production" (Newman, 2002, p. 103.)

6.6 Mineral extraction

"The extraction of mineral resources from forest lands is often accompanied by circumstances that produce far more damage than the mining process itself. The […] Grande Carajás Project in Brazil's eastern Amazon pursues the exploitation of considerable deposits of iron ore, copper, manganese, bauxite, and nickel. The pig iron production scheme at full operation […] implies a charcoal demand equivalent to 1000-1500 square kilometers per year of deforestation. […] It has been estimated that 1000-2000 tons of poisonous mercury has been released into the Amazon through mining, mostly for gold." (Newman, 2002, p. 103.)

6.7 Hydroelectric power

"It is understandable that tropical nations with major rivers will wish to consider their hydroelectric alternatives. A disturbing pattern emerges, however, of vast projects launched without a thorough evaluation at the outset of factors such as the projected longevity of the dam, the actual need for electricity production, environmental destruction, and the displacement of indigenous cultures with few satisfactory options for their future. […] In Bolivia, more plant and animal species grace the new Madidi National Park than any other preserve in South America. Yet the government plans to build a new hydroelectric dam there, endangering this pristine ecosystem." (Newman, 2002, p. 104.)

6.8 Ethanol for automobile fuel

Production of ethanol from sugar cane increases the demand for farm land in Brazil. In 2007, Brazil produced 1.8×10^{10} liters of ethanol, of which 4×10^{9}, or 22%, was exported. An agreement with the USA gives Brazil a 1.36×10^{11} liters annual market in the future. The USA has decided that 20% of all cars must use E85 fuel (85% ethanol) by 2020 (Borgelid, 2008).

6.9 Population growth

"Of all the major environmental debacles plaguing the Earth, overpopulation is the greatest. In many respects it is the fundamental disease; most other problems are in reality only the symptoms." (Newman, 2002, p. 106)

7 Sustainable use of the tropical forest

The key to sustainable use of the tropical forest is to understand what and how much can be harvested from the primary forest without disturbing it, use of sustainable agriculture and forest plantation techniques adapted to local conditions, and understand what crop and tree species to grow at each localization.

7.1 Habitat preservation

Establishment of tropical forest reserves is the best way of securing the biomas stock, and thus, the carbon stock, and at the same time, preserving the diversity of both plant and animal species. However, the reserve needs to be large enough to ensure stable animal populations. For example, a population of 300 jaguars need an area of no less than 7500 square kilometers.

In 1990, "the World Conservation Monitoring Centre reported that 8 percent of the world's tropical moist forest, 9 percent of mangroves, and 5 percent of tropical dry forests are under some form of protection. […] However, many of these are 'paper parks', protected in theory, but not in practice, that is, inadequate patrol and enforcement of laws, or in some cases, government-sanctioned logging or other development within 'park' borders. It should be further noted that most preserves are in mountainous regions, not species-rich lowland forests which justifiably demand a greater proportion of protection." (Newman, 2002, p. 164).

7.2 Sustainable use of the primary forest

"Tropical forest reserves can in many cases be put to multiple use as a much preferred alternative to destruction. In addition to providing gene pool perpetuation, watershed protection, tribal culture insulation, tourism, and educational uses […], other less conventional uses may also be allowed. These may include minimal, non-commercial selective forestry and game cropping, and use by local people for fruit and other forest product gathering. Buffer zones of no disturbance may surround or be imbedded in these areas of light disturbance. In many areas the more the resident population is integrated into the forest reserve the more chance the forest will have for survival in the long run: far more so than under the protection of typical inadequate ranger patrols." (Newman, 2002, p. 166.)

"While the cattle baron power structure that killed [rubber tappers' union leader] Chico Mendes is still destroying vast tracts of forest, yielding a meager US $47 per hectare for seven years at best, rubber tapping (Figure 11) leaves the virgin forest unscathed, and yields US $50 per hectare indefinitely. The gathering of Brazil nuts from virgin tropical forest (Figure 12) accounts for 50 percent of household income in some areas. Attempts to establish plantations failed, however, because the trees' pollinator lives only in the primary forest." (Newman, 2002, p. 167.)

7.3 Sustainable agriculture

Instead of the usual 'slash-and-burn' clearing of primal rain forest, followed by a few years of agriculture, and then abandonment, sustainable alternatives should be used. In this way, more of the primal forest is preserved, while at the same time the cultivated land yields more. For example, one could simulate a natural forest succession after the initial clearance. A managed system of garden and field crops, pig forage, and forest species, replaces forest vegetation with analogous plantings of greater economic value (Figure 13). Incorporating a commercial tree species such as paraiso (*Melia azedrach*) would give an additional long-term cash return (Newnam, 2002, p. 172).

Figure 11. Rubber tapping. (From Newman, 2002, p. 167.)

Figure 12. Collection of nuts. (From Newman, 2002, p. 167.)

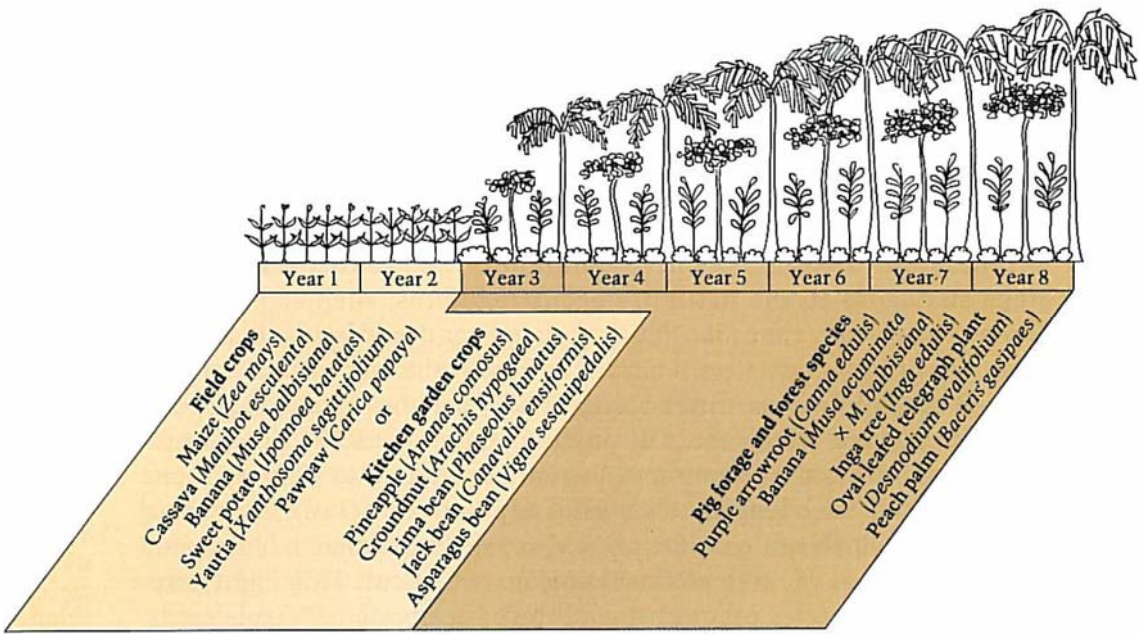

Figure 13. Agriculture by simulating natural forest succession. (From Newman, 2002, p. 172.)

7.4 Sustainable logging

Strip cutting is one method by which valuable timber can be extracted sustainably, especially on undulating terrain. Mature forest left intact on the uphill side provides a source of seed for natural forest regeneration, while gravity feeds litter and nutrients into the logged strip (Figure 14). Line planting of other useful tree species and crops may be integrated (Newman, 2002, p. 194).

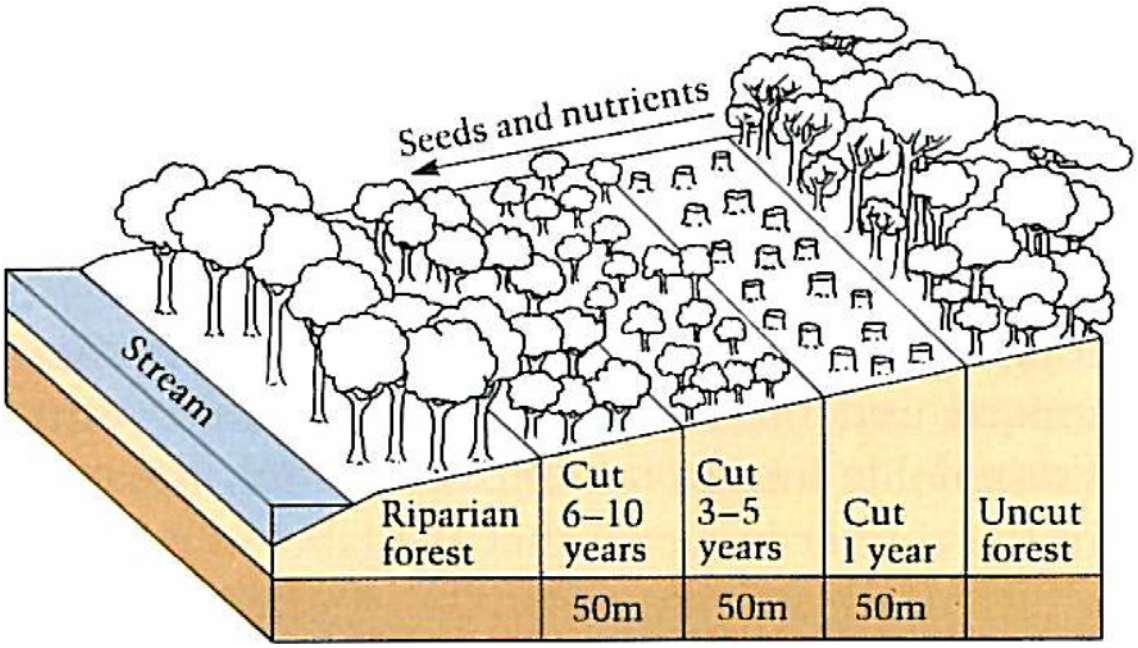

Figure 14. Strip cutting of forest. (From Newman, 2002, p. 194.)

Instead of logging primary forest, secondary forest could be logged, or forest plantation be established on deforested areas, especially bare, abandoned land. The latter is possible only by carefully selecting the tree species to grow.

8 What would we like to be able to see in satellite images?

The author would like to suggest the following list of land use types that a satellite system should ideally be able to distinguish between, in order to monitor tropical forest. The list is only preliminary. It represents what one may think is interesting to measure from the satellite images.

1. Primary tropical moist forest, possibly including subclasses:
    a. Tropical rain forest (lowland / montane)
    b. Moist deciduous forest
2. Dry deciduous forest
3. Savanna
4. Selectively logged moist forest
5. Clear cut forest
6. Burning area
7. Newly burned area
8. Cattle ranch
9. Growing of crops
10. Newly abandoned land (on which secondary forest will appear)
11. Bare, abandoned land (on which secondary forest could not establish)
12. Secondary forest (possibly with different age groups as subclasses)
13. Forest plantation (possibly with different age groups as subclasses)
14. Road
15. Houses
16. River
17. Flooded forest

Other considerations of a satellite monitoring system for tropical forests are:

1. Frequency of coverage

2. Ground pixel size

3. Whether to use optical images (with possible problems with cloud cover), and/or SAR

4. Imaging wavelengths

    a. For optical: panchromatic, natural colors, infrared bands, hyperspectral bands.

    b. For SAR: X band, C band, L band, and P band; and whether to include multiple polarization modes (VV, HH, VH, HV).

One problem with detecting selective logging is that the canopy closes over holes and gaps in one to five years (Newman, 2002, p. 227).

9 Forest as carbon deposits

		Forest				
	Total Forest area	Carbon in above-ground biomass	Carbon in below-ground biomass	Carbon in dead wood	Carbon in litter	Soil carbon
	1000ha	M t	M t	M t	M t	M t
Brazil	477698	38 480	10 855	3 056	1 958	50 289
Bolivia	58740	3 926	1 370	581	-	-
DR Congo	133610	18 688	4 485	1 216	281	7 482
Indonesia	88495	4 434	1 463	649	179	-
India	67701	1 852	491	258	222	7 181
Kenya	3522	268	66	37	-	-
Russia	808790	25 787	6 423	12 198	4 500	137 000
Slovakia	1929	167	36	16	21	270

Table 1 Carbon deposits in forests of some selected countries. Extracted from (FRA 2005).

In FAO's global forest resources assessment 2005 (FRA 2005), the carbon stock in forest per country is tabulated. We have extracted the information for a few select countries (Table 1) and computed the corresponding carbon stock per area (Table 2).

	Forest					
	Carbon in above-ground biomass	Carbon in below-ground biomass	Carbon in dead wood	Carbon in litter	Soil carbon	Total
	t/ha	t/ha	t/ha	t/ha	t/ha	t/ha
Brazil	81	23	6	4	105	219
Bolivia	67	23	10	-	-	100
DR Congo	140	34	9	2	56	241
Indonesia	50	17	7	2	-	76
India	27	7	4	3	106	148
Kenya	76	19	11	-	-	105
Russia	32	8	15	6	169	230
Slovakia	87	19	8	11	140	264

Table 2 Carbon deposits in forests per area.

It should be noted that these values (Table 2) are nation-wide averages, and that large local variations may exist within each country. Also, the accuracy of the estimates may vary from country to country. In many boreal forests, one or a few tree species are dominant, whereas in tropical rain forests, the diversity of tree species makes it challenging to obtain reliable estimates.

"Burning of tropical forests globally contributes 27 percent of total atmospheric carbon, or 2.0 gigatons per year. […] Fossile fuel use contributes 5.5 gigatons annually. After accounting for the capacities of Earth's vegetation and oceans to absorb carbon, we are still left with a net flux into the atmosphere of approximately 3.3 gigatons of carbon per year due to human activities (Houghton, 1999)." (Newman, 2002, p. 200.)

Nation, location	biomass measurement	biomass average	biomass range		carbon average	literature reference
			low	high		
		t/ha	t/ha	t/ha	t/ha	
Brazil, Central Amazonia, Reserve Florestal Adolpho Ducke	above ground live tree, >1 cm dbh	328	211	426	164	Castilho 2006
Brazil, southern Amazon, open forest	forest biomass, >5 cm dbh	240			120	Nogueira 2008
Brazil, southern Amazon, dense forest	forest biomass, >5 cm dbh	232			116	Nogueira 2008
Brazil, southwest Amazon, bamboo dominated	forest biomass, >5 cm dbh	118			59	Nogueira 2008
Kenya, natural stand, Rhizophora muronata		240			120	Bosire 2008
Kenya, mangrove plantation, 12 year old Rhizophora muronata		107			53.5	Bosire 2008
Bolivia, natural stand in timber concession. Moist semi-deciduous.			73	190		Broad-bent 2008
Slovakia, 9.5 years old Norwegian spruce	Above and below ground, live tree	44			22	Pajtik 2008
Slovakia, 1.5 years old Norwegian spruce	Above and below ground, live tree	1			0.5	Pajtik 2008

Table 3 Carbon deposits per area in investigated areas

Detailed in situ measurements of individual forests have been performed by a number of research groups (see, e.g., Castilho, 2006; Nogueira, 2008; Bosire, 2008; Broadbent, 2008; Pajtik, 2008; Merino, 2007). The above ground biomass (Table 3) is much higher for natural forest stands than the respective national average, and for plantation the above ground biomass is much lower.

In a study of beech forests in Spain, the presence of large, old trees in unmanaged forests resulted in a more than doubled amount of stored carbon per hectare, as compared to partially cut stands (Merino, 2007).

Glossary

This glossary includes many words not present in the current note. However, it may be useful if trying to read the referred textbooks (Turner, 2001; Newman, 2002)

Anemochorous – adjective: (of a fruit, seed, or spore) adapted for dispersion by wind.

Angiosperm – noun: a plant having its seeds enclosed in an ovary; a flowering plant.

Araliaceae – noun: mostly tropical trees and shrubs and lianas: genera Panax and Hedera .

Arborescent – adjective: treelike in size and form.

Archipelago – noun: a large group or chain of islands.

Buttress – noun: any external prop or support built to steady a structure by opposing its outward thrusts, esp. a projecting support built into or against the outside of a masonry wall.

Cambium – noun: a layer of delicate meristematic tissue between the inner bark or phloem and the wood or xylem, which produces new phloem on the outside and new xylem on the inside in stems, roots, etc., originating all secondary growth in plants and forming the annual rings of wood.

Canopy – noun: also called crown canopy, crown cover. The cover formed by the leafy upper branches of the trees in a forest.

Cavitation – noun: the rapid formation and collapse of vapor pockets in a flowing liquid in regions of very low pressure.

Comminute – verb: to reduce to minute particles, or to a fine powder; to pulverize; to grind; as, to comminute food with the teeth.

Conduit – noun: a pipe, tube, or the like, for conveying water or other fluid.

Conifer – noun: any of numerous, chiefly evergreen trees or shrubs of the class Coniferinae (or group Coniferales), including the pine, fir, spruce, and other cone-bearing trees and shrubs, and also the yews and their allies that bear drupe-like seeds.

Clade – noun: a group of organisms, such as a species, whose members share homologous features derived from a common ancestor.

Cotyledon – noun: the primary or rudimentary leaf of the embryo of seed plants.

Cycad – noun: any of various palm-like gymnospermous cone-bearing evergreen plants of the division Cycadophyta, native to warm regions and having large pinnately compound leaves.

Deciduous – adjective: shedding the leaves annually, as certain trees and shrubs.

Dendroid – adjective: treelike; branching like a tree; arborescent.

Dicot – noun: a dicotyledon.

Dicotyledonous – adjective; dicotyledon: noun: A flowering plant with two embryonic seed leaves or cotyledons that usually appear at germination.

Diurnal – adjective: showing a periodic alteration of condition with day and night, as certain flowers that open by day and close by night.

Edaphic – adjective: related to or caused by particular soil conditions, as of texture or drainage, rather than by physiographic or climatic factors.

Endemism – the ecological state of being unique to a place. Endemic species are not naturally found elsewhere.

Endocarp – noun: the hard inner (usually woody) layer of the pericarp of some fruits (as peaches or plums or cherries or olives) that contains the seed

Epigeal – adjective: living near the surface of the ground.

Epiphyll – noun: an epiphyte that grows on the surface, esp. the upper surface, of leaves, as a lichen.

Epiphyte – noun: a plant, such as a tropical orchid or a staghorn fern, that grows on another plant upon which it depends for mechanical support but not for nutrients. Also called *aerophyte*, *air plant*.

Facies – noun: general appearance, as of an animal or vegetable group.

Fern – noun: any of numerous flowerless, seedless vascular plants having roots, stems, and fronds and reproducing by spores.

Fig – noun: any tree or shrub belonging to the genus *Ficus,* of the mulberry family, esp. a small tree, *F. carica,* native to southwestern Asia, bearing a turbinate or pear-shaped fruit that is eaten fresh, preserved, or dried.

Foliar – adjective: of, pertaining to, or having the nature of a leaf or leaves.

Folivore – noun: any chiefly leaf-eating animal or other organism.

Genus – noun: the usual major subdivision of a family or subfamily in the classification of organisms, usually consisting of more than one species.

Gymnosperm – noun: A plant, such as a cycad or conifer, whose seeds are not enclosed within an ovary.

Haustoria – noun, plural; haustorium – noun: a specialized absorbing structure of a parasitic plant, such as the root-like outgrowth of the dodder, that obtains food from a host plant.

Heath – noun: (1) a tract of open and uncultivated land; wasteland overgrown with shrubs. (2) any of various low-growing evergreen shrubs common on such land, as the common heather, *Calluna vulgaris.* (3) any plant of the genus *Erica,* or of the family Ericaceae.

Herbaceous – adjective: (1) of, pertaining to, or characteristic of an herb; herblike. (2) of plants or plant parts: (a) not woody; (b) having the texture, color, etc., of an ordinary foliage leaf.

Herbivore – noun: an animal that is adapted to eat primarily plant matter (rather than meat).

Hygrophilous – adjective; hygrophyte – noun: a plant that thrives in wet or very moist ground.

Inundation – noun; inundate – verb: to flood; cover or overspread with water; deluge.

Invertebrate – noun: not vertebrate; without a backbone.

Lamina – noun: the blade or expanded portion of a leaf.

Leach – verb: To remove soluble or other constituents from by the action of a percolating liquid.

Legume – noun: an erect or climbing bean or pea plant of the family Leguminosae.

Lichen – noun: any complex organism of the group Lichenes, composed of a fungus in symbiotic union with an alga and having a greenish, gray, yellow, brown, or blackish thallus that grows in leaf-like, crust-like, or branching forms on rocks, trees, etc.

LMA – leaf mass per area

Mammoth – adjective: immensely large; huge; enormous.

Mesic – adjective: of, pertaining to, or adapted to an environment having a balanced supply of moisture.

Mesophyll – noun: the parenchyma, usually containing chlorophyll, that forms the interior parts of a leaf.

Monocot – noun: a monocotyledon.

Monocotyledon – noun: any of various flowering plants, such as grasses, orchids, and lilies, having a single cotyledon in the seed.

-**morphic** – suffix: having a specified shape or form.

Mycelia – noun, plural; mycelium – noun: the mass of fine branching tubes (known as hyphae) that forms the main growing structure of a fungus. Visible structures like mushrooms are reproductive structures produced by the mycelium.

Mycorrhizal – adjective; mycorrhiza – noun: a symbiotic association of the mycelium of a fungus, esp. a basidiomycete, with the roots of certain plants, in which the hyphae form a closely woven mass around the rootlets or penetrate the cells of the root.

Myrmecophyte – noun: plant that affords shelter or food to ants that live in symbiotic relations with it.

Orthotropic – adjective: noting, pertaining to, or exhibiting a mode of vertical growth.

Pantropical – adjective: living or growing throughout the tropics.

Parenchyma – noun: the fundamental tissue of plants, composed of thin-walled cells able to divide.

Pathogenic – adjective: capable of producing disease.

Pericarp – noun: the tissue that arises from the ripened ovary wall of a fruit; the fruit wall. In fleshy fruits, the pericarp can often be divided into the exocarp, the mesocarp, and the endocarp. For example, in a peach, the skin is the exocarp, the yellow flesh is the mesocarp, while the stone or pit surrounding the seed represents the endocarp.

Phanerocotylar – adjective: the permanence of cotyledons within the seed coat or endocarp

Phloem – noun: the part of a vascular bundle consisting of sieve tubes, companion cells, parenchyma, and fibers and forming the food-conducting tissue of a plant.

Phylogeny – noun: the evolutionary history of a group of organisms, esp. as depicted in a family tree.

Physiognomically – adverb; physiognomy – noun: the outward appearance of anything, taken as offering some insight into its character.

Pinnate – adjective: (of a leaf) having leaflets or primary divisions arranged on each side of a common stalk.

Precocious – adjective: blossoming before the appearance of leaves.

Pteridophyte – noun: any of various vascular plants that reproduce by means of spores rather than by seeds, including the ferns and related plants, such as club mosses and horsetails.

Pulp – noun: any soft, moist, slightly cohering mass, as that into which linen, wood, etc., are converted in the making of paper.

Respiration – noun: the oxidative process occurring within living cells by which the chemical energy of organic molecules is released in a series of metabolic steps involving the consumption of oxygen and the liberation of carbon dioxide and water.

RGR – relative growth rate

Sapling – noun: a young tree.

Sclero- – prefix: hard.

Spine – noun: (1) the spinal or vertebral column; backbone; (2) a sharp-pointed, hard or woody outgrowth on a plant; thorn.

Stomatal – adjective; stoma – noun: one of the minute pores in the epidermis of a leaf or stem through which gases and water vapor pass.

Tracheid – noun: a cell in the xylem of vascular plants.

Trichome – noun: an outgrowth from the epidermis of plants, as a hair.

Vascular – adjective: pertaining to, composed of, or provided with vessels or ducts that convey fluids, as blood, lymph, or sap.

Vertebrate – noun: animals having a bony or cartilaginous skeleton with a segmented spinal column and a large brain enclosed in a skull or cranium

Vivipary – noun: the condition whereby the embryo (the young plant within the seed) grows first to break through the seed coat then out of the fruit wall while still attached to the parent plant.

Xylem – noun: a compound tissue in vascular plants that helps provide support and that conducts water and nutrients upward from the roots, consisting of tracheids, vessels, parenchyma cells, and woody fibers.

Zoochore – noun: a plant whose structure adapts it for dispersion by animals.

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Appendix A: Various news reports

Third Largest Rainforest Illegally Felled for Flooring

Copied from: http://www.ens-newswire.com/ens/feb2005/2005-02-21-02.asp.

JAKARTA, Indonesia, February 21, 2005 (ENS) - Corrupt Indonesian military officers and international criminal syndicates are looting the forests of Papua, New Guinea, turning the world's third largest rainforest into a multi-billion dollar stream of illicit timber between Indonesia and China, new undercover research has found.

Figure 15. Highly prized, a merabu tree stands in an Indonesian forest (Photo cortesy ADK).

A report published Friday by the Environmental Investigation Agency (EIA) of Washington and London, and the Indonesian group Telapak, details undercover meetings with illegal loggers, traders and timber buyers that reveal exactly how the forests of New Guinea are being stolen and who is profiting by the theft.

Remote Papua province forms the western part of the Pacific island of New Guinea. This island contains the world's third largest tropical forest wilderness, exceeded only by the Amazon Basin and the Congo Basin.

With about 70 percent of its forest cover still intact, New Guinea still contains the last large stretches of undisturbed forest in the Asia-Pacific region, where 95 percent of the frontier forests have already been cut. But the Papua forest is rapidly disappearing, the trade driven by demand for a dark, luxurious looking wood called merbau.

M. Yayat Afianto of Telapak said, "Papua has become the main illegal logging hotspot in Indonesia. The communities of Papua are paid a pittance for trees taken from their land, while timber dealers in Jakarta, Singapore and Hong Kong are banking huge profits."

Posing as traders, EIA/Telapak investigators contacted a number of merbau log traders in Jakarta, China and Hong Kong.

"Sipping tea in the lobby of a five-star hotel overlooking Hong Kong bay, one such trader enthused about the money to be made in the merbau business, and spoke openly of the methods used to smuggle the illegal logs out of Indonesia, including the precise bribes paid to officials," the investigators report.

"He reckoned that around 60 large cargo vessels, each carrying around 10,000 cubic metres of merbau, arrive in China from Papua every year. They are accompanied by fake Malaysian paperwork including Certificates of Origin, Bills of Lading and Phytosanitary certificates."

EIA/Telapak investigators found that powerful syndicates pay around US$200,000 per shipment in bribes to ensure the contraband logs are not intercepted in Indonesian waters, as Indonesia currently bans the export of logs.

Julian Newman of EIA, co-author of the report, said, "Indonesia and China signed a formal agreement over two years ago to cooperate in tackling the trade in illegal timber. So far these words have not been matched by actions."

Five years ago Nanxun, China had only a handful of flooring factories. Now there are more than 500 factories being supplied by over 200 sawmills cutting only logs a dark hardwood known as merbau.

Every minute of every working day the Nanxun factories process one merbau log into flooring.

Much of this flooring finds its way to consuming countries, including the United States and the United Kingdom.

Merbau trees grow in lowland tropical rain forest, often in coastal areas bordering mangrove swamps, rivers and floodplains. Merbau once had a wide distribution stretching across Southeast Asia as far as the Philippines and Papua New Guinea, and some Pacific Islands, but heavy exploitation has led to commercial stands surviving in only three countries: Papua New Guinea, Indonesia, and Malaysia.

The EIA/Telepak report found that merbau is being smuggled out of Papua to China at a rate of around 300,000 cubic meters of logs every month. China's economic boom has led to it becoming the largest buyer of illegal timber in the world.

The majority of merbau logs stolen from Papua are destined for the Chinese port of Zhangjiagang, near Shanghai, where they are cleared through customs using false Malaysian paperwork to disguise their true origin, in violation of Chinese law.

The profits are large as local Papua communities only receive around US$10 for each cubic meter of merbau felled on their land, while the same logs fetch as much as US$270 per cubic meter in China.

The military in Papua are involved in every aspect of illegal logging, the report says.

Several forestry concessions in the province are linked to military foundations, notably the company Hanurata, which controls five concessions in Papua and shares its headquarters in Jayapura with a detachment of troops from the army's special forces.

Military personnel often are employed as security for logging operations. One timber dealer based in Jakarta told EIA/Telapak investigators that he had 30 soldiers on his payroll to secure his illicit forest concession. The army is also used to intimidate local communities opposed to logging operations on their lands.

Figure 16. Merabu flooring is in demand for its dark, luxurious appearance. (Photo courtesy Woodline)

Newman and Arbi Valentinus, Telepak's head of Forest Campaign, say the new Indonesian government of President Susilo Bambang Yudhoyono has pledged tough action against corruption and the timber mafia.

In the past four years, a host of governments have made concerned pronouncements and signed declarations and agreements to tackle the problem of illegal logging, yet little has been done.

There have been "glimmers of hope," the report said. "Some cross-border seizures of illegal timber have occurred, including record hauls in Malaysia and the UK."

The listing of ramin wood, Gonystylus spp., a valuable blond hardwood native to Southeast Asia, under the Convention on International Trade in Endangered Species has been "genuinely effective," the report says, "empowering customs officials to intercept stolen wood in at least seven countries.

Indonesia's log export ban, coupled with Malaysia's reciprocal import ban, has dramatically reduced the flow of illegal timber between the two countries.

"It is now time to draw a line in the fight against illegal logging," write Newman and Valentinus. "Time to hold the governments that pledge strong actions to account. Time to go after the timber bosses responsible for the destruction. Time for real enforcement cooperation between nations to halt the scourge of illegal logging. The forests of Indonesia and all those dependent on them cannot wait any longer."

"The smuggling of merbau logs between Indonesia and China violates the laws of both countries, so there is a clear basis for action," said Newman. "Concerted effort by both governments is needed to put the smuggling syndicates out of business."

The EIA and Telepak recommend that the governments of Indonesia and China hold urgent talks to agree an Action Plan to implement the bilateral agreement on illegal logging and associated trade which both countries signed in 2002. This should include the formation of a task force to counter illegal trade in merbau.

They would like to see the government of Indonesia immediately begin a high-level enquiry into the timber barons organizing illegal logging in Papua, including military and official involvement.

And following official identification of the culprits, the two organizations says the key timber barons and officials involved in illegal logging and associated trade should be prosecuted.

The government of China should instruct its Customs General Administration to check the veracity of documents accompanying all shipments of merbau logs claiming to be from

Malaysia. They should seize merbau log shipments from Indonesia and prosecute those involved, the report advises.

The wood consuming countries have a part to play as well, the report says. Timber consumers in China, North America, Europe and Japan should stop buying merbau flooring or wood products and purchase only wood products independently certified as legally and sustainably sourced.

Brazil Protects Vast New Areas of Amazon Rainforest

Copied from: http://protectingourenvironment.com/brazil-protects-vast-new-areas-of-amazon-rainforest/.

BRASILIA, Brazil, June 6, 2008 (ENS) - Brazil commemorated World Environment Day yesterday by signing into existence four new protected areas, three of them in the Amazon rainforest.Following a speech in observance of the special day, President Luiz InÃ¡cio Lula da Silva signed the documents authorizing the three new protected areas in the Amazon, including Mapinguari National Park in Amazonas state, named after a mythical red furry creature supposedly living in the rainforest.

Figure 17. The Madeira River is the longest tributary of the Amazon River. (Photo by Eilson Dias, courtesy Agencia Brasil.)

Mapinguari National Park is designed to preserve savannah areas of the Purus and Madeira river valleys. It is an area of great biological diversity with unique ecosystems that offer great potential for scientific research and eco-tourism, according to the government of Brazil.

In addition, there are two new extractive reserves – Ituxi in Amazonas state and another on the River Xingu in Pará state.

The new areas would expand the extent of protected rainforest by 2.6 million hectares, or 10,000 square miles, an area just slightly smaller than the nation of Belgium.

The protected areas close a green circle that, beyond protecting the biodiversity inside its limits, must draw a line to contain the advance of the agricultural takeover of the Amazon rainforest At least 23 million hectares, or 89,000 square miles, of the Amazon rainforest are already protected.

President Lula's proposal must be approved by Congress and could face legal challenges.

The president also signed a decree protecting mahogany trees and another creating an inter-ministerial group to present proposals to raise financing for conservation of the Amazon rainforest. The donors would not have a say in management of the protected areas and the fund would be managed by the Brazilian Development Bank.

The president said that he is “not egoistic” and that he wants to share with all humanity the benefits of environmental preservation of the Amazon. “We want that all breathe the green air produced by our forests,” he said Thursday.

Lula said that Brazil will have to face a strong worldwide debate on environmental preservation, but that the government does not fear this debate.

The president said Brazil’s record of environmental preservation is equal to that of any country in the world. “Europe, for example, only has 0.3 percent of its native forest still standing. Brazil still has 69 percent,” he said.

Brazil faced criticism at the World Food Summit in Rome convened by the UN Food and Agriculture Organization, FAO, which concluded today. Brazil was attacked for using so much of its land for biofuels and for failing to effectively protect the Amazon rainforest.

“I felt a little in the FAO in Rome that argued food security how much we were attacked and with the most diverse arguments, also on the question of the Amazonia,” the president said.

President Lula said that many conservationists think they can dip their fingers into protection of the Amazon rainforest the way Catholics can walk into a church and dip their fingers into the holy water before they make the sign of the cross.

“I am thinking that Amazonia is equal to those blessed water glasses that they have in the churches and everybody finds that they can put their finger in. It is enough to be Catholic and to enter the church to want to place the finger to make the sign of cross itself,” he said.

Figure 18. Environment Minister Carlos Minc, wearing his trademark vest, and President Lula confer before announcing Brazil’s newly protected areas. (Photo courtesy Environment Ministry of Brazil)

The resignation in mid-May of former environment minister activist Marina Silva raised fears among environmentalists that Brazil may be turning its back on rainforest protection.

As if to show the world that this is not the case, Carlos Minc, Brazil’s new environment minister, announced the government’s commitment to create the new protected areas on May 29, at the Conference of the Parties to the Convention on Biological Diversity, CBD, in Bonn.

He also expressed commitment to zero net deforestation by 2020.

At the biodiversity conference, Minc met with WWF, the World Bank, and the German Development Bank, or KfW - all donors to Brazil’s Amazon Region Protected Areas Programme, ARPA.

“I insisted on coming to Bonn to announce the good news and restate our commitment to ARPA,” said Minc during the meeting. “We are now launching its second phase and raising the total goal for areas protected and supported by ARPA from 50 million to 60 million hectares.”

ARPA, the world's largest tropical forest conservation program, is coordinated by Brazil's Ministry of the Environment and implemented by the Chico Mendes Institute for Biodiversity Conservation in partnership with seven state governments from the Amazon region.

ARPA's second phase will be implemented over a four year period from 2009 through 2012. During this period, 20 million hectares of new protected areas are expected to be created.

Additional goals for the second phase are the implementation and consolidation of protected areas created during its first phase and the implementation of complementary financing mechanisms.

"ARPA has been a major conservation success story and remains core to WWF's overall strategy and vision for the Amazon. We see it as a powerful tool for CBD implementation," said James Leape, WWF International's director general.

WWF announced a new commitment to ARPA and intends to donate US$ 30 million. Of the total, US$10 million will be allocated for direct costs of program activities and US$15 million for long-term recurrent costs of the ARPA Trust Fund.

The remaining US$5 million will be used for products and services provided by WWF-Brazil, such as studies, reports and capacity building activities targeting the creation of new protected areas and the implementation of those already created by the programme.

For the first phase of ARPA, which ends in December 2008, WWF had already contributed US$17 million.

At the CBD conference, the German Development Bank, or KfW, pledged 10 million euros to support ARPA's second phase. The German government has already provided nearly 30 million euros towards this goal through KfW Entwicklungsbank.

"The cost of preserving biodiversity and protecting the climate cannot be borne by the developing and emerging countries alone," said Ingrid Matthäus-Maier, a member of the Board of Managing Directors of the KfW Bank Group.

"Industrialized countries need to get involved as well - in their own interest," said MatthÃ¤us-Maier. "Nature conservation in Latin America is an important concern for us. By participating in this fund we are further broadening our commitments and making a major contribution to the sustainability of protected areas."

ARPA provides financing for the required basic infrastructure, equipment for the territorial administrations, the elaboration and implementation of management plans, and the formation of so-called population committees, which give local communities a say in the management of the nature conservation areas.

"In regards to protected areas, there is good news on the horizon at long last," said Arnold Newman, executive director of the International Society for the Preservation of the Tropical Rainforest, based in Los Angeles.

The Intergovernmental Panel on Climate Change is enthused over the very good reception of the CRED program - Compensated Reduction of Deforestation. This will bring monetary

compensation from developed nations directly to tropical forest developing nations in measure to the volume of forest that they place in protected status."

"This is in response to the scientific evidence that fully 20 percent of total greenhouse gas emissions are derived directly from deforestation of tropical forests," Newman said.

"Even if we dissuade one-half of deforestation, this will reduce 12.5 percent of greenhouse gas emissions," he said, "a significant stride especially in view that we are doing rather poorly on reducing fossil fuel consumption."

BRAZIL: Amazon Tribes to Hold Mass Rally to Oppose Xingu Dams

Copied from: http://www.galdu.org/web/index.php?odas=2898&giella1=eng.

Altamira, Brazil, May, 2008 -- The largest indigenous gathering in the Brazilian Amazon in nearly twenty years will take place from May 19 to 23 in the town of Altamira, Pará, to protest against a series of huge hydroelectric dams being planned for the Xingu River.

Over a thousand Indians from the Kayapó, Ikpeng and other tribes, along with riverbank dwellers and small farmers, will gather to oppose the project, according to the London based campaign group Survival International.

The Xingu is one the Amazon's main tributaries. The Kayapó say that damming it will destroy their way of life, kill the animals and fish they rely on, and profoundly affect their health.

The Ikpeng people said in a statement, 'We are indigenous people of the Xingu and we don't want this dam on the river. We want the fish and the fauna and flora, we want the river to be clean, we want water that feeds us and quenches our thirst. We're not holding back the country's progress. We're defending our rights to life, to our land, and to our way of life.'

In 1989, at an historic gathering in Altamira, the Kayapó and other tribes from the Xingu basin rejected the Brazilian government's plans for a series of six hydroelectric dams on the river. As a result, the World Bank cancelled a loan for the dams, and plans to dam the Xingu were suspended for more than a decade. The 1989 meeting was attended by popstar Sting, and Body Shop founder Anita Roddick.

In recent years, Brazil's energy planners have once again focused on damming the rivers of the Amazon, including building what would be the world's third largest dam, Belo Monte (11,181

MW installed capacity), on the Xingu. In all, 70 large dams are being planned for the Amazon Basin by the year 2030.

Elsewhere in Brazil, the remote Enawene Nawe tribe of Mato Grosso state are also resisting plans to build hydroelectric dams on the Juruena River, upstream from their land. The 420 Enawene Nawe, who eat no red meat, say that if the dams are built, the fish they rely on will no longer be able to reach their spawning grounds.

Survival's director Stephen Corry said in a press release, 'Big dams like those planned for the Xingu have long been discredited because of their disastrous effects on local people and the environment, as well as their inefficiency. The Brazilian government must listen to the voices of the Kayapó and the other tribes of the Xingu, and drop these plans immediately.'

Background

The Xingu River flows from the tropical savanna of central Mato Grosso, Brazil northward to the Amazon for 1,979 km (1,230 miles). Some 14,000 indigenous people, from nine distinct ethnic groups, live along the Xingu. In 1989, an international mobilization, led by the Kayapó Indians, stopped state electric company Eletronorte´s plans to construct a six-dam complex on the Xingu and its tributary, the Iriri.

Now, Brazil is planning the construction of a huge dam on the Xingu, called **Belo Monte** . Belo Monte would require diverting nearly the entire flow of the Xingu through two artificial canals to the dam´s powerhouse, leaving indigenous communities along what is known as the Xingu´s Big Bend without water, fish, or a means of river transport. The dam would be highly inefficient, with its turbines grinding to a halt for three or four months every year during the river´s lowest stream flow. Facing this reality, the electric sector is now planning to build four additional dams upstream to store water during the dry season, as well as to generate electricity. Original plans for dams on the Xingu would have meant the flooding of more than 18,000 sq km (8,300 sq mi) of the rainforest. The latest dam plans would cause the flooding of indigenous villages and other protected areas, as well as irreversible impacts to the Xingu´s fish stocks.

International Rivers is working with the Kayapó and other indigenous groups and environmental and social activists to protect the Xingu River Basin from large dams. Indigenous peoples and their allies are planning a huge gathering in 2008 to voice their opposition to dams on the Xingu.

DRC's New Rainforest Reserve for the Endangered Bonobo

Copied from: http://www.ens-newswire.com/ens/nov2007/2007-11-29-02.asp.

WASHINGTON, DC, November 29, 2007 (ENS) - A vast rainforest nature reserve has been newly set aside by the Democratic Republic of Congo, DRC, to encourage improved protection for the endangered bonobo, a great ape species that few people even know exists.

Found only in the DRC, bonobos inhabit the heart of the Congo Basin, Africa's largest rainforest, now threatened by industrial logging.

DRC Minister of the Environment Didace Pembe Bokiaga officially declared the reserve earlier this month, saying, "This increases the total area of protected land in the DRC to 10.47 percent, bringing us closer to our goal of 15 percent."

Larger than the state of Massachusetts, the new Sankuru Nature Reserve encompasses 11,803 square miles of tropical rainforest that shelters forest elephants and other rare mammals alongside the remaining few thousand bonobos.

From its headquarters in Washington, DC, the nonprofit Bonobo Conservation Initiative joins in the rejoicing over the new reserve.

"This is a monumental step towards saving a significant portion of the world's second largest rainforest, of critical importance to the survival not only of humankind's closest great ape relative, the bonobo, but to all life on Earth given the increasing threat of climate change," said Sally Jewell Coxe, president and co-founder of the Bonobo Conservation Initiative.

The Sankuru reserve is the southern anchor for a constellation of linked, community-based reserves being developed by Bonobo Conservation

Figure 19.A young bonobo in the Congo Basin (Photo by Mark Attwood courtesy UNEP-WCMC)

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The Sankuru reserve is the southern anchor for a constellation of linked, community-based reserves being developed by Bonobo Conservation Initiative in the Bonobo Peace Forest, a project that Coxe says has enjoyed the support of DRC President Joseph Kabila since its inception in 2002.

The Bonobo Conservation Initiative, BCI, works with indigenous Congolese people through cooperative conservation and community development programs. The U.S.-based NGO has been working with the government of the DRC to establish new protected areas and to safeguard bonobos wherever they are found.

Bonobos are distinguished by their peaceful, cooperative, matriarchal society, intelligence, and sexual nature. Other than humans, bonobos are the only primates known to have sex not only for procreation, but also for pleasure and conflict resolution - and with members of either sex.

Coxe says bonobos can be "a powerful flagship both for conservation and for peace."

The Sankuru region was hit hard during the recent war in the Congo, which devastated the local people and claimed four million lives, she says, more than any war since World War II.

Now the humanitarian crisis must be addressed," says Coxe. "The people of Sankuru rely on the forest for every aspect of their livelihood. Helping them to develop new economic opportunities apart from the bushmeat trade is one of the most urgent priorities."

"We are proud that the Sankuru Reserve is being created in the framework of community participative conservation, and will be zoned to guarantee the rights of the local population," said Environment Minister Bokiaga.

Andre Tosumba, director of BCI's Congolese NGO partner, Community Action for the Primates of Kasai, or ACOPRIK, led the successful local effort to protect Sankuru.

"When I saw the extent to which people were hunting bonobos, okapi, and elephants, we began to sensitize them to realize the value of these animals," said Tosumba. "Once they came to understand, the people themselves decided to stop hunting these precious species and to create a reserve to protect their forest."

"BCI has helped ACOPRIK and the local people at every step of the way," said Tosumba. "We call on the international community to join our effort."

Figure 20. An okapi at the DRC's Okapi Reserve. (Photo courtesy Wildlife Direct)

Sponsored by BCI, survey teams from the Congo's Center for Research in Ecology and Forestry have found, for the first time, a population of okapi in the Sankuru Reserve.

The short necked forest giraffes are found only in the DRC but were not previously found outside of their known range far to the northeast.

Sankuru reserve is frequented by elephants, which have been hunted out in many other areas of the Congo forest.

Besides the bonobo, at least 10 species of primates are found in Sankuru, including the rare owl faced monkey and blue monkey.

"The wildlife is under intense pressure from organized hunting for the commercial bushmeat trade," BCI warns.

The report from the Congolese Institute for Conservation of Nature, ICCN, on its recent expedition to the area states that "the ecocide must be stopped" and recommends immediate action to protect this invaluable ecosystem and watershed.

A public agency, the ICCN manages seven DRC national parks and some 30 hunting and wildlife reserves - of which 14 are operational. Five of the protected areas have been raised to the status of World Heritage sites because of the wealth of their biodiversity.

Initial support for this project has been provided by the Great Ape Conservation Fund, administered by the U.S. Fish and Wildlife Service in collaboration with USAID's Central African Regional Program for the Environment.

"This is a huge victory for bonobo and rainforest conservation," Coxe said. "However our work has just begun. Now we need investment to successfully manage the reserve. And, other areas need to be protected to ensure the long-term survival of the bonobo and the integrity of the Congo rainforest."

Petrobras Abandons Plans for Oil Road in Ecuadorian Amazon Park

Copied from: http://www.ens-newswire.com/ens/apr2006/2006-04-24-02.asp.

WASHINGTON, DC, April 24, 2006 (ENS) - The Brazilian national oil company Petrobras has relinquished plans to build a new access road into Yasuní National Park, located in the megadiverse Ecuadorian Amazon. The company has not given up on oil development within the park, but now says it will employ helicopters to access the site.

For nearly two years, Ecuadorian and international conservation, indigenous, and scientific groups have been fighting to stop the road into the park, which is a designated UNESCO Biosphere and is currently roadless. They fear a road would allow land development of all kinds to penetrate the pristine rainforest that shelters a rich diversity of species as well as indigenous peoples who prefer to avoid contact and retain traditional ways.

In a written statement last week from Petrobras to Save America's Forests, a conservation group based in Washington, DC, the company explained that it will follow the advice of the Ecuadorian government not to build the road.

Figure 21. A completed portion of the Petrobras road to the boundary of Yasuní National Park, June 2005. (Photo courtesy Save America's Forests)

"The new operation will be based on helicopter transportation inside Yasuní National Park, therefore, it eliminates the access road inside the park," explained the Petrobras statement. "It includes recommendations of both the Environment and Energy Ministries and the suggestions of other organizations of civil society, which had contributed to its improvement."

"This is a huge step in the right

direction," said ecologist Dr. Matt Finer of Save America's Forests. "The two most potentially damaging components of the project - the road and the processing facility - have been taken out of the park and Huaorani territory." The Huaorani are an independent indigenous tribe of the Ecuadorian Amazon.

"Given the proliferation of oil concessions throughout the Amazon, hopefully this will set a critical precedent," said Finer. "No new oil access roads through primary rainforest."

"We applaud the Ecuadorian government's decision to insist on roadless oil development in Yasuni," said Leda Huta of Finding Species, based in Takoma Park, Maryland. "Yasuni is one of the most important national parks in the world and this road would have opened up one of the most intact sections of the park."

This outcome seemed unlikely in May 2005, when Petrobras began constructing the road through primary forest in the northern buffer zone of the park. By June, the road had reached the northern boundary of Yasuni, and Petrobras requested permission from the Environment Ministry to continue road construction into the park.

But the turning point had come just a month earlier, in April, when the Ecuadorian Congress, responding to widespread street protests, ousted Lucio Gutierrez from the presidency. The Gutierrez administration had granted Petrobras the environmental license for the project in August 2004.

Figure 22. **Left:** President of Ecuador Dr. Alredo Palacio (Photo courtesy Office of the President). **Right:** Ecuadorian Environment Minister Anita Alban (Photo courtesy Office of the Minister).

President of Ecuador Dr. Alredo Palacio took office on April 20, 2005 after the Ecuadorian Congress removed Lucio Gutierrez from the presidency.

The incoming administration of Alfredo Palacio, and in particular the new Environment Minister Anita Alban, were more sympathetic to the concerns of conservationists and scientists that a new road into the intact northeast section of Yasuni would be devastating.

A report prepared by a group of 50 park scientists in November 2004 concluded that Yasuni was one of the most biodiverse rainforests on Earth, and that new oil access roads would pose the greatest threat to that biodiversity.

The report advocated roadless oil development, a position also supported by the Smithsonian Institution based in the United States as well as and Ecuadorian nongovernmental organizations.

On July 7, 2005, Alban wrote a letter to the Petrobras President and CEO José Sergio Gabrielli de Azevedo denying the company authorization to enter the park and continue road construction.

Among the principal reasons cited for this refusal of authorization was the lack of environmental study for building the processing plant within the park, and the lack of consideration of access alternatives that would minimize impact.

The letter concluded that if the processing plant were built outside the park, as called for in the original environmental impact study, it would not be necessary to build an access road into the park.

South America's most profitable company in 2004 with net profits of $6.6 billion, Petrobras responded to Alban's letter with a lawsuit on July 28, 2005. On August 25, Petrobras' lawsuit was rejected in court, and now Petrobras has agreed to give up road construction within the park.

Still, Finer warns that several major problems still exist in connection with the oil development at Yasuni National Park.

Oil extraction is being allowed to continue within ancestral Huaorani territory despite the indigenous people's call for a 10 year moratorium on new oil activities on their lands.

Figure 23. At the symbolic globe in Quito, Huaorani women protest oil development in their traditional territory in Yasuni National Park. July, 2005. (Photo courtesy Finding Species)

The Huaorani demanded the moratorium last summer when 150 Huaorani marched through the streets of the capital, Quito, to protest widespread oil extraction in their territory. Huaorani leaders presented their plan for a moratorium to Congress and high-ranking officials in the Palacio administration.

"The Huaorani have made it clear they oppose new oil activities," said Brian Keane of the indigenous rights group Land is Life, based in Cambridge, Massachusetts. "They complain of widespread illnesses due to contamination and fear for the survival of their brother clans living in voluntary isolation," Keane said.

"Allowing Petrobras to drill in Yasuni would be a gross violation of the rights of the Huaorani and Taromenane peoples. In fact, it would most likely be the end for the Taromenane," he said. The small group of Taromenane still live by choice as one of the world's most isolated tribes.

In addition, conservationists worry that the petroleum processing facility is planned for construction just two kilometers (1.24 miles) from the park boundary in a primary rainforest environment.

Nonetheless, says Finer, given the "extremely difficult task" of persuading an oil giant such as Petrobras to make costly adjustments to minimize environmental damage in an oil dependent

country such as Ecuador, many people in the environmental community consider Petrobras' decision to stop the road a major victory, especially in view of the fact that the road is constructed right up to the boundary line of Yasuni National Park.

Huta of Finding Species says, “That’s snatching victory from the jaws of defeat."

Yasuni National Park encompasses a large stretch of the world’s most diverse tree community, has the highest documented insect diversity in the world, and has many diverse species of mammals, birds, amphibians, and plants.

Eight species of monkeys live in Yasuni along with the golden-mantle tamarin, the giant otter and two other otter species, endangered tapirs, deer and anteaters, peccaries and sloths, racoons, armadillos, and in the rivers, pink dolphins and dwarf dolphins.

Harpy eagles and king vultures soar above the canopy, while scarlet macaws as well as blue and yellow macaws feast on clay licks. Well known cats such as jaguars and ocelots inhabit the Yasuni rainforest, which they share with lesser known species such as the jaguarundi and the oncilla.