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Measurement and Reporting of Forest Carbon in Guyana: Preparing for REDD Implementation

by Jonas Cedergren

country study

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Table of contents

1. Summary

1.1The Mission

The mission had three objectives. The first objective was to assess state and change of carbon pools including a review of data available and relevant work done. The second was to identify change processes – deforestation, conversion and degradation, including impact of logging practises on diversity and other ecosystem services. The third was to evaluate institutional capacities for MRV including institutional arrangements for MRV systems, governance and implementation.

1.2 State and Change of Carbon Pools

No biomass study has been conducted in Guyana.

Two assessments of carbon stocks and pools have been made using data from other countries (ter Steege 2001 & Schoch, D., *et al*. 2009). Differences between the studies are to a large extent explained by the different equations used.

Two studies are under way. One is an initiative from IUCN and the Guiana Shields Programme. No details of the study other than that it will be published early 2010 have been revealed (Chesney 2009. Personal Communication). The other is a large scale study biomass study carried out by the Guyana Forestry Commission (Alder and Kuijk 2009a).

Preliminary baseline calculations, mainly based on three more or less national inventories, have been made by the Forestry Commission study (Alder & Kuijk 2009b). Results from those calculation are those adopted in the present report.

Main results follow below:

Vegetation Class	**Area**	**Carbon tonnes per hectare**					**Total carbon, millions tonnes**					**CO_2 equiv.**
	km^2	*Above ground biomass*	*Roots*	*Necro-mass*	*Soil carbon*	*Total*	*Above ground biomass*	*Roots*	*Necro-mass*	*Soil carbon*	*Total*	*Gigatonnes*
Lowland Mixed Forest	100,408	180	40	19	33	271	1,810	398	190	326	2,725	9.99
Hill/Montane Forest	45,190	171	38	18	33	259	774	170	81	147	1,172	4.30
Wallaba Forest	10,867	230	51	24	33	337	250	55	26	35	366	1.34
High forest subtotal	156,465	181	40	19	33	272	2,834	623	297	509	4,263	15.63
Dakama Forest	4,234	92	20	10	22	143	39	9	4	9	61	0.22
Scrub or Savannah	17,562	38	8	4	22	72	67	15	7	38	127	0.46
Swamp/Marsh Forest	26,899	96	21	10	84	211	259	57	27	225	568	2.08
Cultivated/urban/cleared	4,687		-	-		-	-	-	-	-	-	-
Total land area	209,847	152	34	16	37	239	3,199	704	336	780	5,018	18.40

Source: Alder & Kuijk 2009b

Inventory data from the early sixties and from 2003 suggest that an average loss of 640 square kilometres has been going on since the late fifties, corresponding to a loss of 0.4 per cent on a current area basis. This is a gross figure that needs to be investigated further.

Logging and shifting cultivation are at present assumed to cause no forest degradation. Degradation is mainly caused by mining, expansion of settlements, infrastructure development and some, limited, conversion to agriculture. Road construction often cause hydrological changes and increased fire frequency.

The endpoint of deforestation/degradation is typically scrub/savannah with 72 tonnes of carbon per hectare. Total carbon loss is thus 200 tonnes per hectare, on a national level 12.8 million tonnes, assuming a “worst case scenario” of 640 square kilometres of deforestation per year.

1.3 Change Processes

Selective logging in Guyana is currently done at a level well within the realms of sustainability in terms of timber production and follows a stringent Code of Practice. Illegal logging occurs but at a relatively modest rate. It is difficult to see that selective logging would cause deforestation. Repeated re-entries could cause forest degradation.

The effects of selective logging on biodiversity, soil and water has been given much attention in Guyana. Studies conclude that the physical environment as well as biodiversity can cope with logging as long as operational standards are high.

Shifting cultivation as done today in Guyana is on a small scale, and can be regarded as a balanced system. It is doubtful whether the shifting cultivation of today qualifies as forest degradation. It is highly unlikely that it causes deforestation. This could change to the worse if mining communities are formed or with other major development activities in the interior of the country.

A study in 2007 – 2008 found that 24 428 hectares had been cleared by mining, mainly in the northwest of the country where there is also a concentration of logging roads. Small and medium scale mining is most likely the chief driver of deforestation and degradation.

There is talk about Brazilian interests in establishing agricultural plantations in south Guyana. That is has yet to take place. There is land suitable for agriculture, so this is a scenario that may well materialise.

Forest plantations cover some 12 000 hectares (Anonymous 2005). There are no plans to expand forest plantations.

Sugar plantations have partly been converted to townships.

It cannot be ruled out that there are plantations that have been abandoned and “recaptured” by natural forest.

Infrastructure development makes areas available for development. Connecting Guyana with Brazil and making a large part of the interior available for various activities will of course have consequences for e.g. forestry, mining and agriculture.

1.4 Recommendations and Institutional Capacities for MRV

A REDD-reference level for Guyana must take assumptions on future development into account. Natural resources must be declared to the degree possible. Forest land with high potential for other uses, e.g. oil palm plantations and hydropower, should be identified and mapped. An effort has already been done, but facts and figures need to be substantiated.

Different total forest areas for Guyana have been reported to different organisations. A reference total area must be agreed upon. Differences in figures can be partly, but not entirely, be explained by differences in definitions and calibrations for e.g. inland waterways. Reference levels for deforestation and degradation need to be set. At present there is no definitive data on rate of

deforestation and degradation. Deforestation and degradation are further difficult to distinguish from each other. A calculated gross value has been used in the present study. This is an issue that need to be addressed.

Forest types relevant to carbon measurement need to be defined and studied. A baseline should contain a transparent statement of carbon stocks, and a reliable method to monitor their change over time. Change patterns in land use and their rates, and what implications ongoing land use processes have on greenhouse gas emissions. A mechanism to regularly report and verify ongoing development is also needed.

Forest management is practiced only on parts of the Guyana forest. Forest management however is not the only human activity applicable for forest land. Information on carbon stocks is thus needed from all parts of the country. Field data with national coverage is needed. The biomass study currently conducted by the Guyana Forestry Commission is an effort that will provide field data from all parts of the country. What is important is that a solid base of knowledge based on data collected on the ground is established for all parts of the country. Remote sensing is of limited value on areas barely inventoried in the past.

A problem for REDD is that there is at the moment no comprehensive land use plan for Guyana. This means that the legal status of forest land is undefined. Several rights may apply to the same piece of land. This must be resolved if a REDD mechanism is to be launched.

Developments that typically follow improvements of infrastructure must not catch agencies concerned with surprise if a REDD mechanism is to be launched. Institutional preparedness is required. Inter agency co-operation will prove necessary.

The party paying revenue and the party receiving them must ensure that expectations are mutually understood.

An agency to work with REDD needs to be established. Such an agency should consist of staff from all agencies concerned by REDD. A council of representatives from the main groups of stakeholders to advice the “REDD Agency” would be helpful, as well as a steering committee made up of representatives for agencies involved, including the party paying the revenues. This would be helpful in handling and modifying expectations from parties concerned, and in making sure that all concerned are given opportunity to voice concerns, even after the launch of a REDD mechanism

A successful launch of a REDD mechanism requires high capacity in a number of fields, e.g. land use planning, mapping, remote sensing, mining, forest biometrics, forest management. When planning for REDD, capacity building needs careful consideration.

Current adherence to forestry laws and Code of Practice needs to be evaluated. Work to ensure a high standard of forest management and to control illegal logging needs to continue. A capacity to address training needs as they are identified in the field needs to be put in place in combination with enforcement of regulations. Other forest management related factors that should be given special attention is forest management on smaller concessions, Amerindian land and other private land. The size and existence of a backlog of overlogged areas, i.e. areas logged before today’s practice was introduced, also needs to be investigated.

Small- and medium scale mining is an issue that must be addressed. In the meetings held it was often quoted as the foremost driver of deforestation and degradation. Environmental standards in mining should be documented and, if needed, improved.

A REDD mechanism will have effects beyond carbon. In general it will help install low carbon thinking in society. It will also be important in promoting co-operation between agencies and authorities. This will prove helpful also in non-carbon issues. A REDD mechanism will force the setting up of land use plans for areas concerned, and such plans are helpful also in non-carbon issues.

2. Summary of meetings

An important part of the mission in Guyana has been to meet with representatives of agencies involved or concerned by REDD. Valuable information, documents and comments have been obtained through these meetings. Below follows a summary of the meetings. A more complete account is found in Appendix 2 of the main report. Please note that opinions expressed are those of the individual(s) and agencies with whom meetings were held, not those of the consultant or FAO.

Guyana Forestry Commission.

Deforestation & Degradation. Deforestation is low. Mining is a main driver. Shifting cultivation is limited and balanced.

Changes. The commission will probably have to expand, e.g. to enable a National Forest Inventory. REDD will probably require Guyana to improve resource utilisation and to invest in forest industry.

Comments. Forestry will continue on areas allocated as concessions even after the launch of REDD.

Forest Product Development and Marketing Council Incorporated

Problems. Worries about restrictions that may be brought about by REDD.

Comments. Given present logging rates, it is difficult to see that REDD should be a problem.

Forestry Training Centre

Changes. The institute may be utilised more as logging may have to become more professional

Problems. Turnover rate among forest workers.

Comments. The institute could expand its activities without too much problems.

Chainsaw milling project (associated with Forestry Training Centre)

Changes. Even more important to improve quality of forest management by communities

Problems. Communities are worried about restrictions they fear may come with REDD

Comments. Demanding information campaign needed. Professionalism needed.

Department of Amerindian Affairs

Changes. Land use issues need to be addressed.

Comments. Communities need to diversify and develop their livelihoods and it is hoped that REDD will be helpful in this.

Iwokrama

Deforestation & Degradation. Mining is by far the most serious forest degrader in the country.

Changes. REDD will require more stringent stakeholder processes. It is essential that REDD is taken to the heart by rural population.

Problems. There is high pressure to get permits to log. Reduced impact logging is under introduction in the country as a whole, but will continue to face opposition from the loggers.

Comments. Vegetation mapping and ground truthing are expensive but necessary.

Guyana Geology and Mines Commission

Deforestation & Degradation. A mine is an example of disturbance, not degradation.

Changes. REDD mechanisms are welcome as long as they do not reduce people's income. The commission is also strongly against deforestation. Mining should be done in a responsible way.

Problems. Little work done on site restoration after mining. Use of heavier machinery e.g. excavators is on the increase, and they cause more damage. Some 250 excavators are active in mining.

Comments. Mercury is not seen as a problem.

Guiana Shields Project

Deforestation & Degradation. Mining. Extent and seriousness must be better verified. Hydropower projects discussed in the south. Savannahs could be converted to plantations. Brazilian companies interested in land for soy and rice cultivation. Oil could be found in South Guyana.

Changes. Lots of work is done by the Guyana Forestry Commission to raise operational standards. Verification of progress in these efforts is greatly needed.

Problems. Guyana suffers from lack of baseline data. Another thing that is lacking is a legal status for forest land. A comprehensive land use plan is also lacking

Comments. Policy workers need to be trained. There is more or less no data at all from large parts of the country, the reason being that they have never been studied. A road from Georgetown to Lethem could have an impact on land use and carbon emissions.

Guyana Manufacturing and Services Association Limited

Changes. REDD will mean change in that rules will be implemented with greater stringency. Poorest practices have been checked by a stringent log tracking system, and regulations against land lording.

Problems. It is hope that a REDD mechanism will not reduce log production, which must already be considered low.

Comments. Things happening so fast that it is difficult to keep track, and formulate opinions. Money distribution from REDD is going to be difficult. It is essential to get that right, from the very start.

Office of the President

Changes. The mechanism still needs to develop. No working model exists. It will be up to Guyana to pave the way.

Problems. There is uncertainty about what rules will ultimately apply for REDD. It is impossible to make any statement on what changes will be necessary before the rules are known.

Comments. Markets should recognise future projected deforestation.

World Wildlife Fund

Deforestation & Degradation. Mining is the main agent of deforestation. Mining practices are also detrimental to human health, mainly due to mercury pollution. Agriculture cannot at the moment be said to be a competitor to forestry. Shifting cultivation is to some extent.

Changes. Miners should be helped by prospecting to reduce unnecessary digging.

Problems. New technology for small scale mining has made practices even more destructive. Illegal and legal mining are equally destructive

Comments. Capacity building is a priority. Indeed REDD must have capacity as one of its components.

Conservation International

Deforestation & Degradation. The Georgetown – Lethem road, the driver of drivers. Unregulated mining. Intensive and unregulated logging. Ongoing efforts to shorten cutting cycles are a cause for concern. Shifting cultivation on the savannah is a danger to forest cover. pressure for land from Brazilian interests.

Changes. A major effort in awareness and information regarding REDD will be required for it to have any chance of success. REDD could instigate good governance.

Problems. REDD will force Guyana to review its natural resource management and land use planning.

Comments. Should REDD fail, there will be major implications for the forest of Guyana. How money is spent will also have implications. A top – down approach means that people may feel alienated. REDD money must be enough to constitute an incentive.

Forest Producers Council

Deforestation & Degradation. Mining!

Changes. REDD has to be better understood before they are willing to take a firm stand on it. They do not know how much money REDD might give, and that is something that matters.

Problems. It is unfair that they should have to comply with high standards when miners can come and do as they please. They also feel that small scale loggers get away from the stringent standards prescribed by Code of Practice.

Comments. Guyana should make up its mind on the future of commercial forestry.

Amerindian organisations

Deforestation & Degradation. Great concern about mining among Amerindians. Shifting cultivation as presently done by Amerindians is rather benign in comparison to mining.

Changes. It seems that droughts and floods have increased. This has been particularly pronounced since 2004. New crops may have to be considered, and new land may have to be tilled.

Problems. The REDD process is little understood by the Amerindian community. There is the impression of a complex process that goes without the involvement of Amerindians.

Comments. Communication with Amerindians requires professionalism. Interpreters needed in consultations not only to have translation, but rather to have it translated into words that make sense to Amerindians. more information and time to comment on REDD. There is concern that REDD may mean restrictions on their land use.

University of Guyana

Deforestation & Degradation. Mining, shifting cultivation, expansion of communities and roads are what causes deforestation and degradation. Illegal logging was at its peak 1992 to 1994.

Changes. If REDD is launched, that will affect teaching in e.g. inventory and ecology. New courses will also have to be tailored to REDD. REDD will need a national forest inventory

Problems. REDD will require highly qualified staff.

Environmental Protection Agency

Problems. The role of EPA is unclear. Another thing that is unclear is how to distribute the money earned through REDD.

Comments. Less employment in forestry and mining will have implications for traditional life. REDD cannot be permitted to stop people from earning a living.

2.1 List of Tables

2.2 List of Maps

2.3 The mission in short

Together with experts and institutions in Guyana make preliminary assessments of forest carbon stock and changes, and evaluate institutional capacities for Measuring, Reporting and Verifying (MRV). Based on these findings make recommendations on the next steps to prepare a REDD mechanism. The complete Terms of Reference are found in Appendix 1.

2.4 Main issues to be covered

The mission can be broken down into three main parts:

1. State and change of carbon pools. A review of data available and relevant work done. Results will be analysed and evaluated
2. Change processes – deforestation, conversion and degradation. Work also includes impact of logging practises on diversity and other ecosystem services.
3. Institutional capacities for MARV. Options at different ambition levels, national and sub-national, should be defined. Institutional arrangements for MARV systems, governance and implementation investigated.
4.

Work has been based on a review of existing literature on Guyana's forests and through contacts with relevant authorities and stakeholders and experts. Accounts of meetings held are found in Appendix 2, and literature consulted is briefly described in Appendix 3.

2.5 Context of mission

The United Nations Collaborative programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN-REDD Programme, www.un-redd.net) is a collaboration between FAO, UNDP and UNEP. A multi-donor trust fund was established in July 2008 that allows donors to pool resources and provides funding to activities towards this programme.

Based on request from Governments of Norway, Guyana and Surinam, FAO, as partner of UN-REDD, will field a consultant to work with institutions and experts in Guyana and Surinam to make preliminary national assessments of forest carbon stock and changes, evaluate the institutional capacities for Measuring, Reporting and Verifying (MRV) for REDD and make recommendations on next steps to prepare for a REDD mechanism.

3. State of knowledge and efforts under way on carbon pools in Guyana's forest ecosystems

Biomass estimates are necessary for quantifying carbon stocks and pools. No direct estimates are available for Guyana. Nonetheless efforts to assess carbon stocks have been made, and there is work in progress. Below follows a review of work done, and work in progress.

The earliest is ter Steege (2001). Another effort is a project by Conservation International, "Biodiversity Mainstreaming Through Avoided Deforestation, Guyana Case Study. Guyana Forestry Commission is conducting a study as parts of its effort to launch a REDD mechanism. The Guiana Shield Project is conducting a study in collaboration with IUCN.

Below follows an account of efforts done or under way. Sections are deliberately kept short to enable comparisons.

Preliminary results from the Guyana Forestry Commission study are used as estimates of carbon stocks and pools in the present study.

3.1 Materials and methods

Ter Steege (2001)

Ter Steege (2001) uses biomass estimates from Brazil, French Guyana and Venezuela. Data from Guyana emanate from an FAO project, covering eight of ten regions of the country. Data from central Guyana were used to develop stand tables per combination of soil type and forest type. Data originated from the Great Falls inventory. Both inventories start recording tress at 30 cm dbh. Lower size classes were constructed based on exponential decline, determined using regression.

Below ground biomass was estimated with a constant root-shoot ratio of 0.22 for mixed forest (Russell 1983, Jordan 1989). For forests on white sand root-shoot ratio may higher than 1. Large, woody litter was estimated to be 20 t/ha in undisturbed forest. Soil organic matter in the first 100 cm of the soil was calculated from soil carbon content of soil layers (van Kekem *et al*. 1996; with additional data from Khan *et al*. 1980, Gross-Braun 1965). The amount in the layer from 100-700 cm was calculated according to Nepstad *et al*. (1994) for forests in which deep rooting is expected. Dead biomass (leaf and woody litter), may amount to another 150-200 t/ha in high forest. The standing stock of small litter (leaves, flowers, fruits, small twigs) is assumed to be in the order of 6 to 10 tonnes per hectare. Results are against this background often presented as a range rather than average.

Biomass carbon content was assumed to be 50 %, and soil organic matter had an assumed carbon content of 58 per cent.

Conservation International

The Conservation International project (Alexander, E.,*et al*. 2009, Killeen, T., *et al.*, 2009 & Schoch, D., *et al*. 2009) based their biomass estimates on data from a CIDA supported national prism sampling project (the Interim Forestry Project) conducted 1990 to 1993, a management level inventory at Iwokrama conducted in 2003 and from permanent sample plots at Iwokrama established in 2007. The prism sampling was done using basal area factors of 2 to 9, with a minimum dbh of 10 cm for a tree to be included. The interim Forestry Project included 7943 sample plots along transects covering the country. Dbh of "in" trees was measured. The Iwokrama inventory consisted of 150 transects with 1451 plots in four forest types. Data from 13 permanent sample plots of 1 hectare were also used.

Dbh or diameter class midpoints were used to estimate live above ground biomass. The standard equation for moist broadleaf forest (Brown 1997 & Brown unpublished) was used with a correction factor for wood density. Wood densities are higher in Guyana than for the average tropical rain forest (Hammond 2005 & Baker, et al 2004). Special equations were used for species with exceptionally low wood density (Pourouma spp & Cecropia spp).

No direct measurements of root biomass are available for Guyana. The equation developed by Cairns et al. (1997) for upland forest was therefore used to estimate root biomass, it results in a ratio of 0.22 – 0.23 i.e. not unlike ter Steege. Field measurements of dead wood and litter were made using Alexander (Unpublished). After consulting studies made, it was concluded that forest floor litter carbon stocks do not surpass 2 % of live tree biomass carbon stocks. Soil carbon was assessed through a review of studies on the subject. Results vary considerably, maybe due to methodological differences.

Studies are in the process of being published. The consultant has been granted copies of drafts. Thus, it cannot be ruled out that changes in estimates will be made.

Guyana Forestry Commission

A major effort to study biomass is under way at the Guyana Forestry Commission (Alder & Kuijk, 2009a). 900 permanent circular plots of 0.1 hectare, grouped as 180 clusters and 60 transects will be established nationally in all major forest types to measure and detect changes in forest biomass. Trees over 20 cm dbh will be measured on the main plot, and over 5 cm dbh on the subplot (0.02 hectare). Plots will be organized in clusters of 5, based on a cross design with a central plot, and four plots on 100 m arms at right angles. Clusters will themselves be organised into transects of 3 clusters in a line, one km apart.

In addition data will be collected to establish coefficients and allometric functions for the major biomass pools. Two types of sampling units will be used. (1) Associated with monitoring plots will be 4 temporary 3 x 3 m quadrats which will be destructively sampled by weight for fallen deadwood, litter, and small plant biomass. Soil samples will be taken for organic carbon determination. These data will provide data that can be correlated with scores for deadwood and litter depth on the monitoring plots to derive biomass estimates for these carbon pools. (2) Detailed measurement of felled trees and tree roots to establish a data set of 300 plus sample trees for crown, bole and root biomass. Tree root excavations will be facilitated in cooperation with mining communities using hydraulic hoses.

Guiana Shield/IUCN

No details of the study have been revealed to the consultant other than that the work will be published early 2010.

3.2 Results and comments

Teer Steege (2001)

Results. A typical Guyanan forest was found to have an average carbon stock of 351 tonnes per hectare. This is made up of 150 tonnes from above ground tree biomass (including dead wood), 30 tonnes below ground, litter of 15 tonnes and 156 tonnes from soil organic matter.

Carbon stocks of biomass below and above ground including litter and dead lying wood were estimated for six soil types. Estimates ranged from 150 tonnes of carbon per hectare (laterite) to 195 (loam). Soil carbon storage estimates down to 800 cm soil depth ranged from 141 tonnes per hectare (white sand) to 490 (pegasse). Second highest was 163 tonnes per hectare (brown sand and loam). No measurements below 100 cm soil depth could be made for clay, laterite and pegasse.

Table 1 summarises carbon content over soil- and forest type.

Table 1. Total carbon content per hectare of the main forest types of Guyana

Soil type	Carbon content (tonnes per hectare)
Mixed forest, brown sand	224
Mixed forest, loamy sands	260-358
Mixed forest, lateritic soil	286
Mixed forest, lateritic clay soils	321
Mora forest, alluvial clay soils	374
Swamp forest, pegasse soil	400-650
High forest, white sand	306
Low forest, white sand	67-306 dependent on site history

Source: ter Steege (2001)

Comments. Biomass is highly variable on a hectare basis. Thus, even if there were a few plots available in Guyana, they would only contribute to rough estimates. Reliable estimates based on total measurements will be expensive. Dbh is often the only information available in large scale data materials. Equations used to calculate biomass from Dbh have high explaining power on a tree by tree basis, but can give high errors when applied to a whole stand. There is considerable

disagreement between equations. That must be kept in mind. Regarding this study, it must be remembered that only trees with a Dbh bigger than 30 cm were actually measured, smaller trees trees were estimated based on regression assuming exponential decline.

Conservation International

Results. Data were grouped to permit estimates for the national forest classes defined by ter Steege (2001). Differences in live tree biomass carbon between forest types did not exceed 11 per cent. The lowest live biomass carbon found per hectare was forest on white sand in the prism inventory (188.9 tonnes per hectare), and the highest was 231.1 tonnes per hectare for swamp forest, the transect inventory of Iwokrama. For mixed forest, the comfortably most common forest type differences were below 5 per cent, ranging from 209.9 to 222.3 tonnes per hectare.

Lying dead wood accounted for 16 and 19 tonnes of carbon on brown and white sands, respectively. No data was found that would help estimate carbon stocks in dead standing wood. Litter carbon stocks were found to range from 1.6 to 3.4 tonnes per hectare. Data available on soil carbon range from 28 to 158 tonnes per hectare.

Comments. The prism data sets show greater variation, this is to expected. Many plots (or rather spots) may had four or fewer trees. ter Steege's estimates are lower than these (17 to 34 per cent lower). The reason is that ter Steege used the Lescure et al (1983) equation which gives lower estimates through 95 cm dbh, and real differences in biomass stock in the materials. The Cairns et al. (1997)root biomass equation is a global average. It probably underestimates biomass on white sand, where large root systems are necessary to access water and nutrients. Assumptions regarding dead wood and litter are based on limited data.

Guyana Forestry Commission

Results are not yet available. Initial results from three plots will be made available in September 2009. A preliminary baseline on carbon stocks and pools has been calculated (Alder & Kuijk 2009b).

The plots, coefficients and allometric functions will give biomass estimates, together with conventional forestry data on volume, species, forest and soil type, that are tightly geo-referenced and sampled over scales of 0.1 ha, 4 ha (clusters) and 2 km (transects). These will be used to supervise classification of LANDSAT imagery to determine areas and area changes of biomass and forest type cover classes. From this the monitoring system will be able to directly report carbon stocks and fluxes for REDD. This is the primary objective of the system. Its secondary objective is to provide a system of continuous national forest inventory providing strategic information on timber volumes and increments, NTFPs, biodiversity and other ecosystem services.

Guiana Shield/IUCN

Work will be published early 2010. Results are however reported not to differ dramatically from those of ter Steege (2001) (Chesney, personal communication 2009).

4. Large-scale forest inventories in Guyana

Lacking domestic biomass studies, volume figures have to be relied upon for assessments of carbon stocks and pools.

Three major inventories have been made in Guyana. This section is mainly based on the work of Wright (1999) and Alder & Kuijk (2009b). When other sources are used, this is indicated in the text.

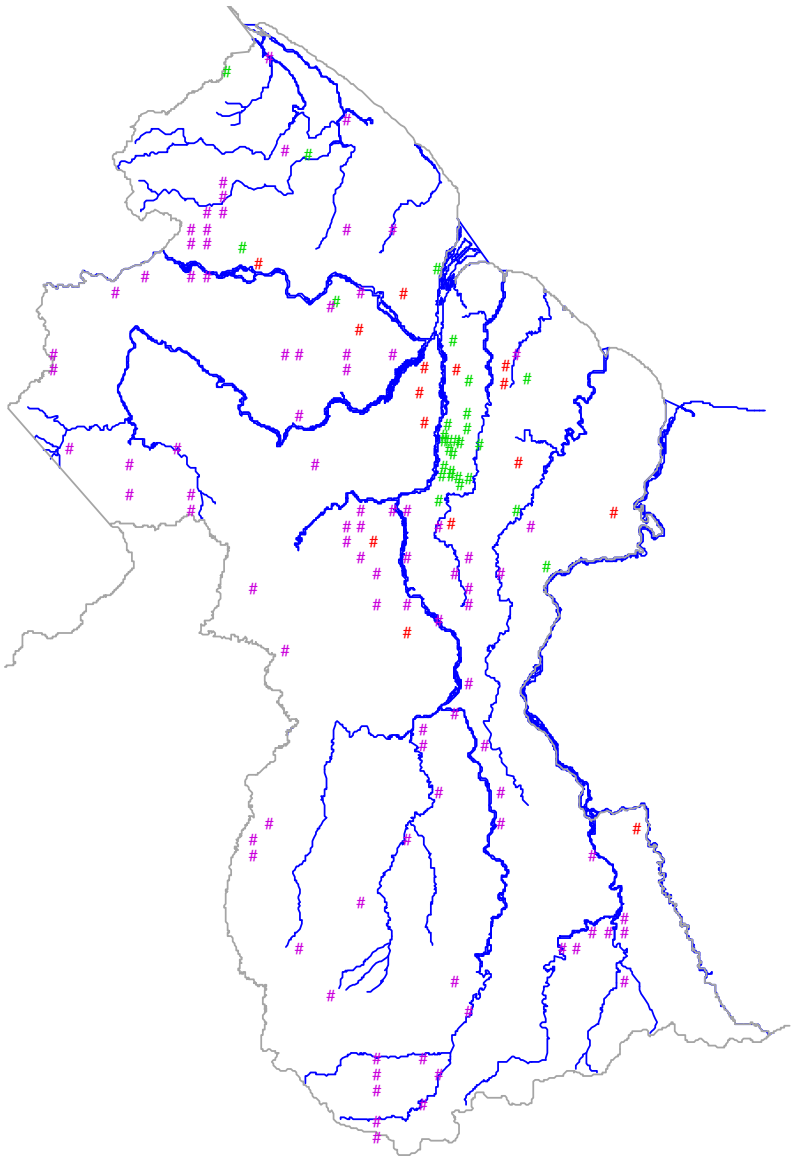
The first was done by FAO in the early seventies (Bratt 1971). Work covered the entire country, including the south. Clusters of four to five circular plots of 0.1 acres (0.04 hectares) were used. Trees with a dbh of 1 foot (30.48 cm) or more were included. A total of 854 clusters were sampled. The project resulted in a set of volume tables, grouped by species according to taper series (Bratt, 1971). Results are still used. This is the most comprehensive national inventory carried out in Guyana.

The second was a CIDA project from 1990 to1993. The project had a national coverage, with the southern parts of the country poorly represented. Fully stocked forests in the northern and central part of country were those mainly represented. There could thus be an overestimate of volumes. Prisms with basal area factors of 4 to 8 were used. A Total of 7992 spots along transect lines were measured. The CIDA project further comprised measurements on 1849 felled trees from 137 species. There seem to have been no published models or tables as an output from the CIDA-project. The data was re-analysed by Alder (2000, 2001) and forms the basis of current volume calculation methods used by GFC for forest inventory and sustained yield calculations. Use of prisms with high basal area factors mean that typically only three to four trees would be sampled per plot (actually rather a spot). The large number of observations probably compensates for this.

The third is the management inventories done by the Guyana Forestry Commission since 2004. Data has been collected on concession (thus not covering the southern parts of the country) using circular plots of 0.1 hectares. Poorly stocked forests are better represented than in the CIDA project. This is not a national inventory, nor is it meant to be. Work is concentrated on new production areas. A total of 2935 plots have been measured.

Prior to 1965 the colonial administration had undertaken numerous line surveys for individual concessions and permits, but there was no overall estimate of forest growing stock (Rees 1963).

Map 1 shows the coverage of the different inventory efforts.



Map 1. Inventory zones for FAO, CIDA and GFC surveys, purple dots depict FAO, red dots CIDA and green dots GFC. Locations shown are estimated from place names and descriptions. GFC indicates centroids of inventoried areas. Source: Alder & Kuijk (draft). Results of the inventories mentioned above are summarized in Table 2.

Table 2. A summary of calculated volumes per hectare and their distribution over diameter classes from the different large scale inventories in Guyana. Volumes are stated as gross above ground volume, over bark, 10 cm top, cubic metres per hectare by cm diameter classes.

Inv	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109	110+	Total
FAO				57,06	46,26	42,38	34,07	17,34	9,27	5,90	5,38	12,99	**230,64**
CIDA		50,90	61,91	58,71	50,48	37,44	28,34	19,62	14,89	9,58	5,97	12,03	**349,87**
GFC		36,18	47,67	51,23	38,10	31,90	24,95	15,50	12,10	8,55	5,05	7,21	**278,44**

Source: Alder, Personal communication, 2009

5. Carbon Stocks and Their Change

Below follows an estimate of carbon stocks and pools in Guyana. It is highly likely that the estimate will be replaced by a more precise estimate once data from the ongoing GFC study becomes available.

The estimate is based on the work in Alder & Kuijk (2009). Other sources will be specifically indicated.

Conversion of Dbh to Volume

Gross bole volume is the over bark volume to the highest point of measurement, typically 10 cm top diameter. This is the appropriate volume to estimate expansion factors.

Using data of all species (1849 trees) from the CIDA inventory in a general regression on volume on diameter gives the following equation:

Ln V=-7.60027+2.2055ln(D), r2=0.92 {equation 1}

Transforming this equation to an unbiased volume equation requires Meyer's (1944) correction. This gives a final corrected equation of:

V=0.0005107*D2.2055 {equation 2}

This equation can be used to validate accuracy of pan-tropical equations for above ground biomass.

Estimating Above Ground Biomass from Volume

A number of approaches are available for Guyana. Below follows brief accounts of the options.

Brown (1997, §3.1.3) proposes an empirical equation in the absence of more detailed information. This is an IPCC Tier 1 method that provides acceptable estimates when information is scarce.

ter Steege (2001) estimated average biomass stocking for Guyana using Lescure's (1983) equation for French Guyana. Lescure requires no information on wood density or bole volume. Application in Guyana is therefore based on the assumption of similar species composition and stem form as in French Guyana.

Another approach is that of Chave et al. (2005). Data from 2410 trees from 27 study sites across the tropics. The study concludes that differences in the biomass equations between study sites are small if wood density variation is accounted for. The major significant factor is forest type. Equations for dry, moist, wet and mangrove forests are produced in the study. These equations will be those used for the present report. The general equation is as follows:

$$W = \rho.exp(\beta_0 + \beta_1.ln(D) + \beta_2.ln(D)^2 + \beta_3.ln(D)^3) \quad \{equation\ 3\}$$

where W is tree above ground biomass in kg, □ is wood specific gravity, D is tree diameter at dbh in cm, and the βi are coefficients which depend on forest type, as tabulated in Table 3 below. Note that the β2 and β3 coefficients are common across forest types, and β1 is the same for mangrove and wet forest.

Table 3: Pan-tropical biomass equation coefficients for major forest types

Tropical Forest type	β_0	β_1	β_2	β_3
Dry. Over 5 months dry season, with marked water stress, rainfall below 1500 mm per year, may be semi-deciduous	-0.667	1.784	0.207	-0.0281
Moist. Marked dry season 1-4 months, rainfall 1500–3500 mm per year	-1.499	2.148		
Wet. Marked dry season 1-4 months, rainfall 1500–3500 mm per year	-1.349	1.980		
Mangrove. Coastal forests dominated by mangrove species	-1.239			

Source: Chave *et al*, 2005

Dry and wet tropical forest types in Chave *et al*. models show lower biomass for a given diameter than the other equations. This is probably due to differences in average tree height on these less productive forest types. This emphasises the importance of correct forest classification especially relative to average height.

Below Ground Biomass

Below ground biomass is usually expressed as a root: shoot ratio relative to above ground biomass. This is also implicit in IPCC (2006).

Brown (1997) found that the mean root: shoot ratio for tropical lowland moist forest is 0.12.

Higher values are found in ter Steege's (2001) review of data from Suriname and the Brazilian Amazon. This is particularly true for drier forests and forests on poorer soils, where root systems need to be large to search for water and nutrients . For other forests a root: shoot ratio of 0.22 is assumed.

In the present report 0.22 will be used. Data for drier forests and those on poor soils is limited. This ratio may well be changed by results from the work outlined in Alder & Kuijk (2009).

Necromass

Necromass data is limited to studies from adjacent countries. Values range from 11.8 to 34.8 tonnes per hectare, with an average of 27. This is applied in this report as an expansion factor of 8.6 per cent.

Soil Organic Matter

Results are available for Guyana. Results are reviewed in ter Steege (2001). Results are presented in Table 4.

Table 4. Soil Organic Matter to 1 meter depth

Soil type	Tonnes per hectare
Brown sand	65
Clay	167
Laterite	136
Loam	65
Pegasse	190
White sand	43

Source: ter Steege (2001)

Forest soils are assumed to hold 65 tonnes of organic matter per hectare, swampy and marshy areas 167 and scrub, savanna and Dakama formations 43 tonnes per hectare. These estimates are most likely conservative.

Biomass and Carbon Equivalent Ratios

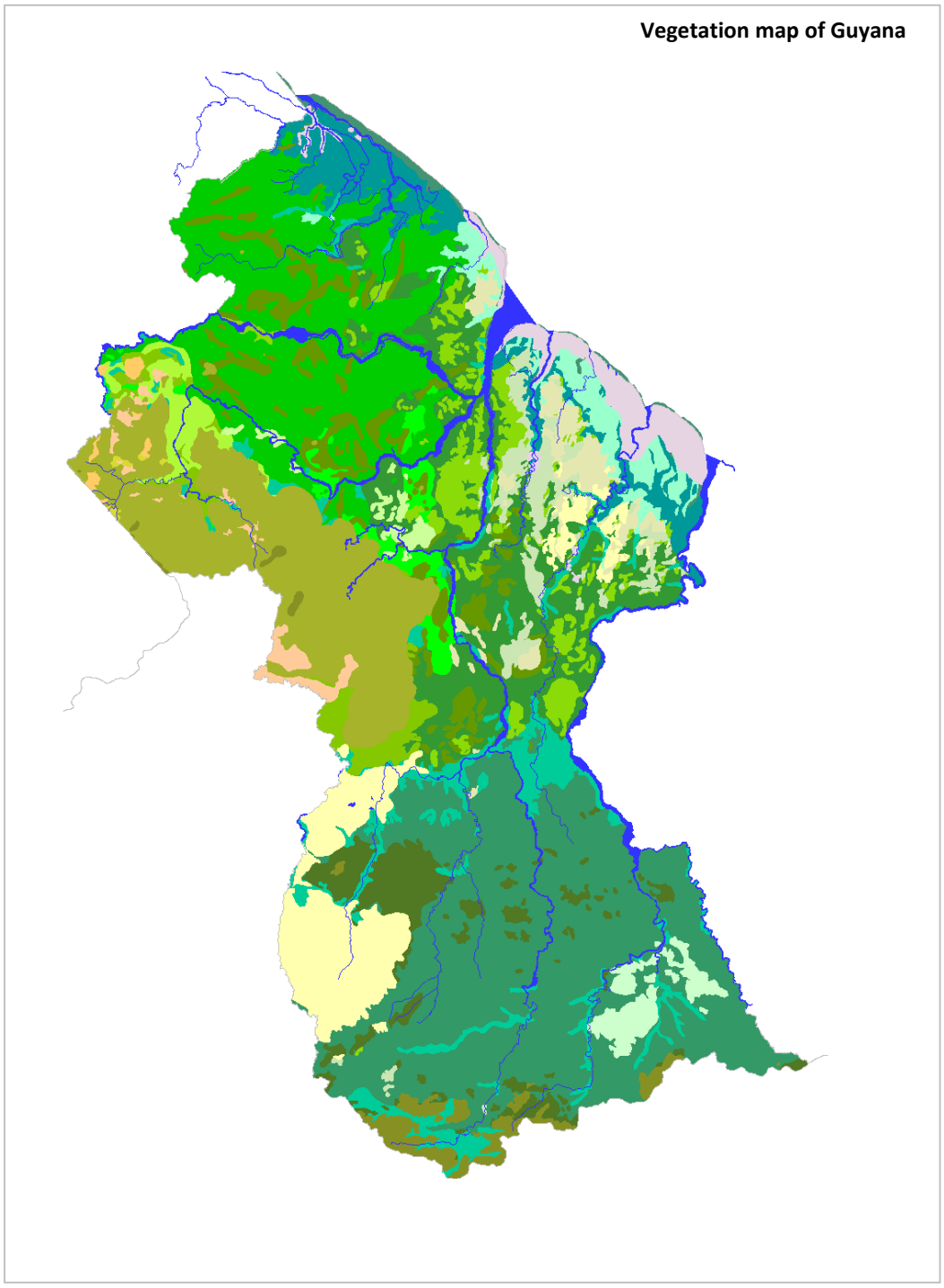
The above approach would calculate biomass in tonnes per hectare. For carbon accounting this needs to be converted to tonnes of carbon per hectare. A conversion factor of 0.5 for biomass to carbon is used following advise in IPCC (Penman *et al.* 2003). For CO_2-equivalent, tonnes of carbon are multiplied by the ratio 44/12, which is the ratio of their atomic weights.

Tier 1, 2 or 3

In terms of IPCC tiers (IPCC 2006), bole biomass are Tier 3, and the other components Tier 2.

Vegetation Classes and Forest Area

A vegetation map of Guyana (ter Steege, 2001) is shown in Map 2. Table 6 shows the related key to forest types and forest and other land use areas. These areas are calculated from the GIS shape file used in the map. The map itself is was developed by ter Steege from a variety of sources including satellite imagery, soil maps, research plots and forest inventory plots.



Map 2. Vegetation map of Guyana. Source: ter Steege (2001)

Table 5: Vegetation type areas and key to Map 2

Code	Vegetation Types	Map	Area (km^2)
1.1	Mixed forest Central/NE Guyana		20,858
1.2	Mixed forest NW Distict		28,393
1.3	Mixed Forest Pakaraimas		3,233
1.4	Mixed Forest South Guyana		47,789
1.5	Mixed Forest on steep hills		7,817
1.6	Mixed Forest on steep hills Pakaraimas		3,339
1.7	Mixed Forest on steep hills South Guyana		6,922
1.8	Mixed Forest/Swamp complex		2,513
2.1	Clump Wallaba Forest		1,016
2.2	Clump Wallaba/Wallaba Forest		2,522
2.3	Wallaba Forest		7,329
2.4	White Sand Forest South Guyana		136
2.5	Dakama Forest		4,234
2.6	Muri scrub/white sand savannah		3,810
3.1	Open Swamp		4,604
3.2	Marsh Forest		9,891
3.3	Coastal Swamp Forest		7,865
3.4	Forested Islands in Rivers		765
4.1	Mangrove Forest		1,262
5.1	Lowland grass/shrub savannah		11,287
6.1	Upland scleromorphic scrub		525
6.2	Upland grass/shrub savannah		1,940
6.3	Broadleaf upland meadow		196
7.1	Submontaine Forest Pakaraimas		23,549
7.2	Montaine Forest Pakaraimas		275
8.1	Submontaine Forest Southern Guyana		3,090
9.0	Clearings, cultivated land, large mines		4,687
	Rivers, lakes, streams		5,123
TOTAL			214,970

Source: ter Steege (2001)

Vegetation types in Table 5 were merged into broader vegetation classes. This is illustrated in Table 6. Table 6 also shows the distribution of plots after stratification.

Table 6. Creation of vegetation classes

Vegetation Class	Vegetation Type (codes from Table 6)	Area Km^2	FAO	CIDA	GFC
Cultivated /urban/cleared	9.0	4 687			
Lowland Mixed Forest	1.1 to 1.4 & 2.4	100 408	548	5 169	2294
Hill/Montane Forest	1.5 to 1.7 & 7.1 to 8.1	45 190	241		145
Wallaba Forest	2.1 to 2.3	10 867	12	1 506	233
Dakama Forest	2.5	4 234		576	154
Scrub or Savanah	2.6 & 5.1 to 6.3	17 562	5	40	13
Swamp/Marsh Forest	3.1 to 4.1	26 899	48	407	56
Total		**209 848**	**854**	**7698**	**2894**
Waterways, open water		5 122			
Guyana total area		**214 970**			
Sample area (hectares)			171	123	289

Source: Alder & Kuijk (2009)

Biomass and Carbon Stocks

Equations of Chave et al (2005) were used to calculate biomass on a tree by tree basis. Swamp and Marsh forests used the WET forest type equation, scrub and savannah used DRY type. Other types, i.e. most of the data used MOIST coefficients. Wood densities were found for the 134 most common species in Zanne et al (2009), for the remainder a weighted average of 0.71 was assumed.

Table 7 shows the biomass values calculated for all the inventories and vegetation classes by size class.

Table 7. Biomass estimates by size class for the FAO, CIDA and GFC inventories. Interpolated figures are shown in blue italic. Above ground biomass in tonnes per hectare by ten centimetre classes.

Inventory/Vegetation class	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109	110+	Total
FAO 1968-73													
Lowland Mixed Forest	*20.0*	*31.4*	*48.7*	57.4	50.3	51.5	46.3	25.0	10.4	7.4	5.8	6.7	360.9
Hill or Montane Forest	*21.2*	*33.3*	*51.7*	59.1	51.4	45.0	32.3	16.0	14.4	9.2	8.0	41.1	382.7
Wallaba Forest	*19.5*	*30.5*	*47.4*	78.5	67.9	70.9	26.1	10.2					350.9
Swamp/Marsh	*11.2*	*17.5*	*27.2*	25.1	25.2	27.5	28.4	11.9	11.1	3.8	9.1	3.6	201.5
Mean FAO	*19.7*	*30.9*	*48.0*	56.0	49.1	48.3	40.8	21.4	11.4	7.6	6.5	16.1	355.8
CIDA 1990-94													
Lowland Mixed Forest	*20.4*	31.0	50.5	58.7	54.2	41.2	36.8	26.8	22.4	14.5	9.3	20.1	385.9
Wallaba Forest	*24.0*	35.0	60.9	74.4	81.6	73.4	47.1	33.4	21.8	12.6	7.5	11.8	483.3
Swamp/Marsh	*10.6*	15.8	26.7	28.2	28.2	21.5	17.6	10.8	11.1	10.7	6.9	11.5	199.7
Dakama Forest	*28.5*	60.8	53.0	28.1	14.3	8.4	4.3	2.2	0.7	0.4	0.3	0.3	201.2
Scrub or Savannah	*10.8*	28.1	15.0	12.2	5.3	4.3	1.3		1.5				78.6
Mean CIDA	*21.0*	33.4	50.5	55.7	52.9	42.2	33.9	24.3	19.2	12.3	7.8	15.8	369.1
GFC 2002-2008													
Lowland Mixed Forest	*15.9*	23.4	40.2	48.5	40.3	36.5	30.3	20.9	16.8	12.5	7.0	11.2	303.6
Hill or Montane Forest	*13.3*	26.4	26.7	52.5	41.1	33.7	29.4	11.9	14.1	6.4	12.4	7.7	275.5
Wallaba Forest	*14.7*	24.5	34.3	59.3	55.1	47.2	36.6	17.9	10.0	5.7	4.8	1.1	311.3
Swamp/Marsh	*11.5*	19.9	26.1	29.6	17.6	12.0	7.9	2.0	1.2	1.3			129.1
Dakama Forest	*17.2*	32.4	36.3	22.1	5.3	3.4	0.8		0.2		0.5		118.2
Scrub or Savannah	*7.1*	13.7	14.7	20.2	8.6	1.5	3.0						68.8
Mean GFC	*15.6*	24.0	38.5	47.7	39.1	34.9	28.6	18.6	14.9	10.7	6.6	9.4	288.6
Mean, all inventories	*18.1*	28.7	43.8	53.7	49.3	40.8	33.1	22.7	17.6	11.6	7.4	14.3	341.1

Source: Alder & Kuijk (draft)

The overall mean figure of 341 tonnes per hectare above ground biomass is weighted by plot numbers. Table 8 shows the areas for each vegetation class, above and below ground biomass estimates. The table also includes carbon an CO2 equivalents.

Table 8. Total biomass and carbon content in Guyana (tonnes per hectare)

Vegetation Class	Area	Tonnes per hectare				Total, millions tonnes			
	km²	*Above ground biomass*	*Biomass incl. roots*	*Carbon*	*CO_2 equiv.*	*Above ground biomass*	*Biomass incl. roots*	*Carbon*	*CO_2 equiv.*
Lowland Mixed Forest	100,408	361	440	220	807	3,621	4,417	2,209	8,098
Hill/Montane Forest	45,190	342	418	209	766	1,547	1,888	944	3,461
Wallaba Forest	10,867	460	561	280	1,028	499	609	305	1,117
High forest subtotal	156,465	362	442	221	810	5,668	6,914	3,457	12,676
Dakama Forest	4,234	184	224	112	410	78	95	47	174
Scrub or Savannah	17,562	77	93	47	171	134	164	82	300
Swamp/Marsh Forest	26,899	192	235	117	431	518	632	316	1,158
Cultivated/urban/cleared	4,687					-	-	-	-
Total land area	209,847	305	372	186	682	6,397	7,805	3,902	14,309

Source: Alder & Kuijk (draft)

The average tree biomass per hectare arrived at (442 tonnes per hectare) is higher than ter Steege's (2001) estimate (304 tonnes per hectare). This is probably because ter Steege did not adjust for missing data below 30 cm dbh.

Table 10 has carbon estimates for soil and necromass, calculated using the factors detailed above. Figures must be regarded as uncertain, much too uncertain to permit separation of dead wood from necromass. The survey outlined in Alder & Kuijk (2009) will provide more reliable Tier 3 estimates for these figures. Figures in Table 9 are most likely conservative.

Table 9. Ecosystem carbon including soil and necromass

Vegetation Class	Area	Carbon tonnes per hectare					Total carbon, millions tonnes					CO_2 equiv.
	km²	*Above ground biomass*	*Roots*	*Necro-mass*	*Soil carbon*	*Total*	*Above ground biomass*	*Roots*	*Necro-mass*	*Soil carbon*	*Total*	*Gigatonnes*
Lowland Mixed Forest	100,408	180	40	19	33	271	1,810	398	190	326	2,725	9.99
Hill/Montane Forest	45,190	171	38	18	33	259	774	170	81	147	1,172	4.30
Wallaba Forest	10,867	230	51	24	33	337	250	55	26	35	366	1.34
High forest subtotal	156,465	181	40	19	33	272	2,834	623	297	509	4,263	15.63
Dakama Forest	4,234	92	20	10	22	143	39	9	4	9	61	0.22
Scrub or Savannah	17,562	38	8	4	22	72	67	15	7	38	127	0.46
Swamp/Marsh Forest	26,899	96	21	10	84	211	259	57	27	225	568	2.08
Cultivated/urban/cleared	4,687		-	-		-	-	-	-	-	-	-
Total land area	209,847	152	34	16	37	239	3,199	704	336	780	5,018	18.40

Source Alder & Kuijk (2009)

High forest of Guyana according to the present model has an average of 272 tonnes per hectare. This is lower than the estimate by ter Steege (2001) of 351 tonnes per hectare. There are probably several explanations to this. ter Steege's estimate is for central Guyana, thus restricted to well stocked forests. The equations of Lescure (1983) that are used place greater weight on big trees than the equation used in the present study.

5.1 Changes in carbon through deforestation and degradation

Deforestation Rate

In the colonial era British Guiana Forestry Department reported a total forested area of 70 000 square miles (181 300 square kilometres). Rees (1963) includes a table of forest types, reproduced in Table 10.

Table 10 Guyana forest areas in 1962 (Rees 1963)

	Mile^2	km^2	
Coastal strip	2,200	5,698	
Swamp and Marsh Forest	2,050	5,310	
Rain Forest	29,300	75,887	
Seasonal Forest	5,900	15,281	181,430
Dry Evergreen Forest	16,500	42,735	
Montane Forest	18,350	47,527	
Savannah	8,700	22,533	
Guyana total	83,000	214,970	

Source: Rees (1963)

Current closed high forest estimates at 156 465 square kilometres based on mapping in 2001 suggest a loss of forest area of 24 965 square kilometres in 39 years. According to Earthtrends (2003) Guyana suffered a 3 per cent loss of forest cover between 1990 and 2001, corresponding to an annual loss of 0.3 per cent. This is in reasonable agreement with the comparison between 1963 and today. An allowance for errors in interpretation of satellite images has to be made.

It would thus appear that an average loss of 640 square kilometres has been going on since the late fifties, corresponding to a loss of 0.4 per cent on a current area basis.

The 640 square kilometres is a gross figure that needs to be studied more in detail. It may well incorporate degradation as well as deforestation. The reason this has not been studied in detail is probably the low rate of deforestation in the country. A special study of deforestation and degradation should of course include a major component of ground truthing.

Forest Degradation

Although forest degradation is easily recognized when seen it is difficult to define. The IPCC definition is "A long term reduction of tree crown cover towards but not exceeding the minimum accepted forest threshold. The UNFCCC definition is "A decline in carbon stock in forest land remaining as forest land".

Concern regarding overlogging, and repeated creaming operations , was raised already in 1961. Log production then was 270 000 cubic metres. Then followed a period of decreasing log production. By 1972 log production was 136 000 cubic metres. After that production began to rise and reached half a million cubic metres in the mid-nineties. This is a level that by and large has been maintained since then. This is well within the limits for sustainable forestry. It is thus unlikely that current logging practices lead to long term degradation. The stringent Code of Practice now enforced by the Guyana Forestry Commission further contributes to that. A field survey to evaluate implementation of management regulations would be justified.

Two comparative studies of the carbon emission effect of selective logging are summarised in Table 11. The studies have been conducted in Sabah, Malaysia and in Para, Brazil. The study in Malaysia was of extraction rates far higher than in Guyana, and the Brazilian study of rates at least double those of Guyana. Emissions to be expected in Guyana are thus lower, exactly how much lower is open to speculation, but it would seem that emissions to be expected are on the low side.

Table 11. Carbon stocks, losses, and retention over cutting cycles in unlogged and logged tropical rain forests in Malaysia and Brazil. Carbon consequences of conventional logging and reduced-impact logging are compared.

	Sabah Malaysia	**Para Brazil**
Total carbon in unlogged forest, tonnes per hectare	213	186
Logging intensity, cubic metres per hectare	125	30
Carbon loss and retention with a 30 year logging cycles		
- Loss from conventional logging, tonnes per hectare	108	19
- Loss from Reduced Impact Logging, tonnes per hectare	78	12
- Carbon retained due to Reduced Impact Logging, tonnes per hectare	30	7
Carbon loss and retention with 60 year logging cycles		
- Loss from conventional logging, tonnes per hectare	93	24
- Loss from Reduced Impact Logging, tonnes per hectare	57	14
- Carbon retained due to Reduced Impact Logging, tonnes per hectare	36	10

Source: Putz et al, 2009.

There is however evidence of ongoing forest degradation. This is mainly caused by mining, expansion of settlements, infrastructure development and some, limited, conversion to agriculture. Road construction often cause hydrological changes and increased fire frequency.

Ongoing climate change may well increase fire proneness of the Guyana forest.

There is reason to investigate whether there exists backlog of overlogged and degraded forests in Guyana. Management standards on smaller concession and on Amerindian and other private land should also be evaluated.

Carbon Emissions from Deforestation and Forest Degradation

Deforestation and degradation are estimated at around 640 square kilometres per year. Data to permit a separation of the two have not been obtained. The mean total forest carbon is 272 tonnes per hectare. The endpoint of deforestation/degradation is typically scrub/savannah with 72 tonnes of carbon per hectare. Total carbon loss is thus 200 tonnes per hectare, on a national level 12.8 million tonnes.

As mentioned above the figure of 640 square kilometres is a gross figure that needs to be scrutinised more in detail. It is probably a gross measure of deforestation and forest degradation. The figure above should thus be regarded as a "worst case scenario". This is an issue that needs to be studied more in detail, as it is an important part of a REDD mechanism.

It is quite possible that natural forest "recaptures" areas (e.g. abandoned plantations) thereby reducing deforestation and degradation. This is a factor that should also be studied in a special review of deforestation and degradation.

5.2 Extent of Deforested Area and Main New Land Cover Types

As mentioned above, Guyana could have lost some 24 965 square kilometres, or about 2 500 000 hectares of forest land between the late fifties and 2001. Much of this area would be land cleared for agriculture and settlements along the coastline. A striking example is the depletion of mangrove forest (Anonymous 2001). The nature of the "loss" of forest land should be separately studied. Data from sources other than the Forestry Commission will probably have to be consulted. The 250 000 would certainly seem to be a worst case scenario.

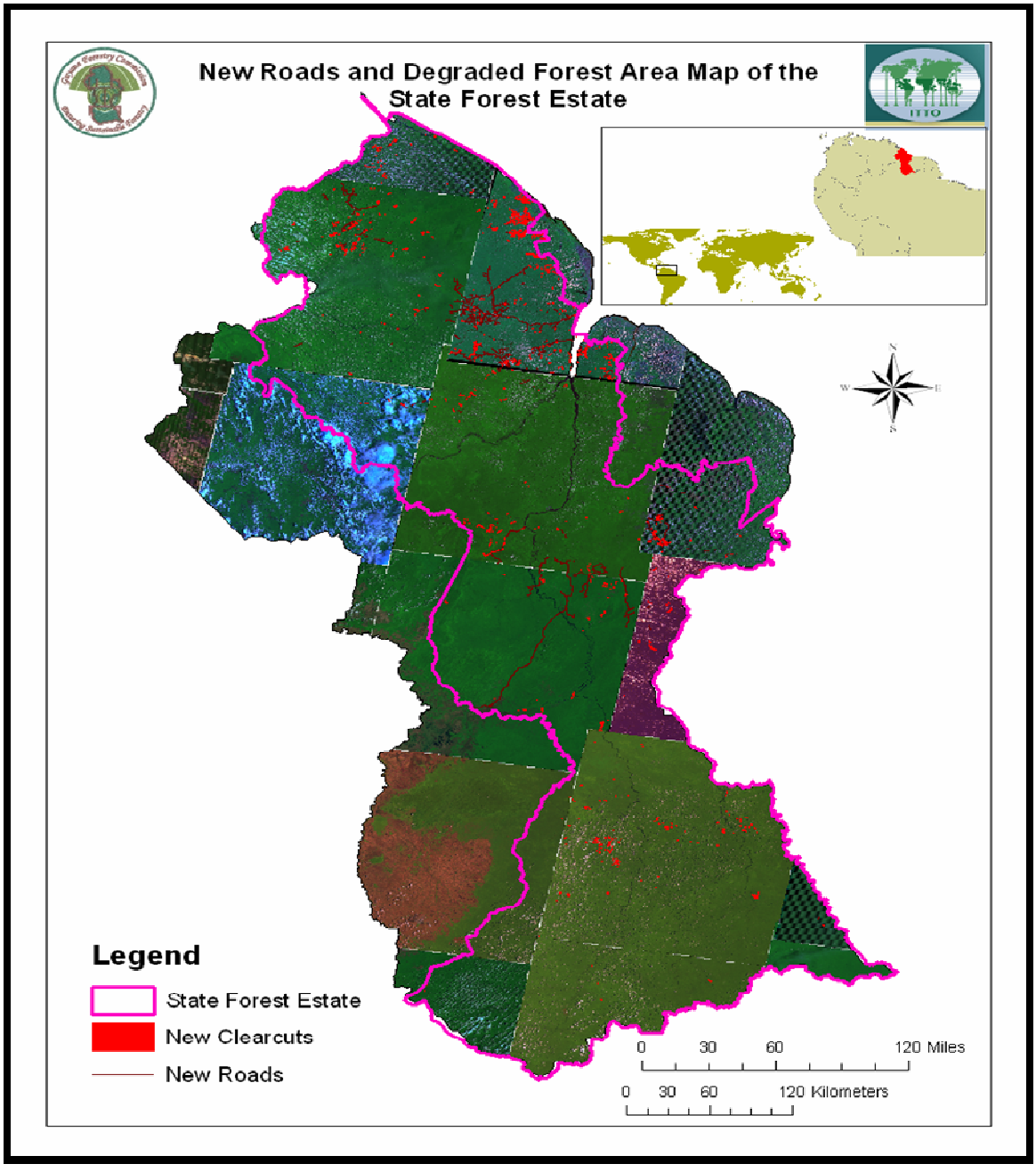
There is dynamics over time in areas lost/degraded and areas "recaptured by the jungle". Annual losses need not be additive. This needs special study.

It deserves to be mentioned the Environmental Protection Agency and the Sea and River Defence Administration now work with mangrove management (P. Bolanath 2009, correspondence).

The Guyana Forestry Commission has in place, a change detection system for recording and updating roads and forest disturbances from satellite data. Analyses of Landsat scenes combined with ground truthing have been made of all forest land in the country. Analyses by the Forestry Commission indicate a total of 54, 210 ha of degraded/deforested forest area and 2,626 km of forest roads (Anon 2009). Analyses were made 2007-2008. Mining seems to be the single most major cause of degradation within the SFE. Approximately 24, 428 ha of forests was cleared due to mining activities and another 21, 903 ha of forests was cleared for agriculture. Most degraded forests areas are found in the North-West region of the country, which is traditionally known to have the highest concentration of mining concessions. There were several rounds of ground truthing and aerial surveys together with hotspot monitoring using ALOS Radar images at high resolution to verify findings of Landsat images.

Analyses further show that in 2008 the country had a total of 2 626 kilometres of forest roads. The occurrence of roads is significant in of Guyana. About 80% of official forest roads are concentrated in the central and north-west regions of the country, particularly in the large concession lease areas. The extent of degraded/deforested land is shown in Map 3.

The Landsat analyses should be treated with care. Abandoned mining sites will be difficult to detect unless there is a water pan big enough for detection. Abandoned agricultural land could also be difficult to detect. The Landsat image analyses above, though certainly valuable, do not permit estimates of annual rates of disturbances.



Map 3. New roads and degraded forest area map of the State forest estate. Source: Guyana Forestry Commission (Anonymous 2009)

5.3 Drivers of Deforestation and Degradation

Industrial Forestry/Selective Logging

As mentioned above, selective logging in Guyana is currently done at a level well within the realms of sustainability. Selective logging in Guyana is further subject to a stringent Code of Practice (Anonymous 2002). Implementation of the code, although not perfect, is under steady improvement (Anonymous 2005).

Extraction rates are governed by length of cutting cycle. Cutting cycles are either 25, 40 or 60 years. It is very rare for logging intensity to exceed 15cubic metres per hectare. The minimum permissible felling diameter is 35 centimetres at breast height. Felling intensity is thus around ten trees per hectare (Anonymous 2004). Felling intensity must be regarded as low by international standards (Putz *el al*. 2009). There is also a rule that trees felled must be at least 10 metres apart.

Logging is done using chainsaws (normally Stihl 070 or 054) for felling, wheeled skidders (typically Clark Ranger F68 or Caterpillar 528) with integral arches, and occasionally crawler tractors (with Caterpillar D6 the most common) for yarding. Equipment used must be regarded as appropriate, and not unnecessarily powerful/heavy.

There are three kinds of concessions/logging permits.

Timber Sales Agreements are for large scale operations. There of at least 24 000 hectares and there is no upper limit for size. Agreements are usually for 25 years and subject to renewal. Management plans of 5 years and annual plans must be set up, and be approved by the Forestry Commission. Plans have to follow a set of guidelines to ensure sustainability.

Wood Cutting Leases are for medium operations. Leases are for 10 to 15 years and subject to renewal. Areas range from 8 000 to 24 000 hectares. Management plans of 5 years and annual plans must be set up, and be approved by the Forestry Commission. Plans have to follow a set of guidelines to ensure sustainability.

State Forest Permits are available for small scale operators. They are issued for areas no bigger than 8 000 hectares. Permits are valid for 2 years, but can be renewed. State Forest Permits are the typical source of raw material for chainsaw lumberers and non-Amerindian community forestry. The main management prescription valid is an annual quota assuming a 60 year cutting cycle. The activities in State Forest Permits are also subject to the environmental monitoring and legality assessments by the Guyana Forestry Commission. The national log tracking systems, removals permitting process as well as others are implemented at this level. There have been several advances in improving the practice of reduced impact logging at this level. The Forestry Training Centre Inc, an Agency that has been set up to provide training in Reduced Impact Logging has conducted a number of courses with small operators including community level operators. The Forestry Commission offers advice on forest management to holder of these permits.

State Forest Exploratory Permit is a three year permit to prepare an application for area to log. Thus, it does not give the holder a permit to cut any trees.

State Forest Permit Conversion Areas are areas set aside for conversion to other land uses, mainly permanent agriculture. Very little conversion has actually taken place on these areas (Khan 2009, Personal Communication).

Forests on **Amerindian Titled Land** is regarded as private property. The Forestry Commission has no authority over these territories as long as wood is cut for local consumption. Normal rules start to apply as soon as timber is traded outside the titled the area. Titled villages are free to seek the advice of the Forestry Commission on forest management.

Areas under the different permit are presented in Table 12 and mapped in Map 4 (excluding State Forest Permits).

Illegal logging occurs but at a relatively modest rate (Clarke 2006). A stringent log tracking system is in place (Singh 2007).

To conclude. Large and medium scale selective logging in Guyana is done at low intensity using adequate equipment and following stringent regulations. Management and operational plans to ensure sustainability must be approved before any trees can be cut (Anonymous 1999).

It is difficult to see that selective logging would cause deforestation. Repeated re-entries could cause forest degradation. With few truly commercial species and a market known for its fluctuations, re-entries are, understandably, tempting. With re-entries the forest is subjected to a new round of logging before it has recovered from the previous. Felling damage is added and skid trails extended, roads may also have to be extended.

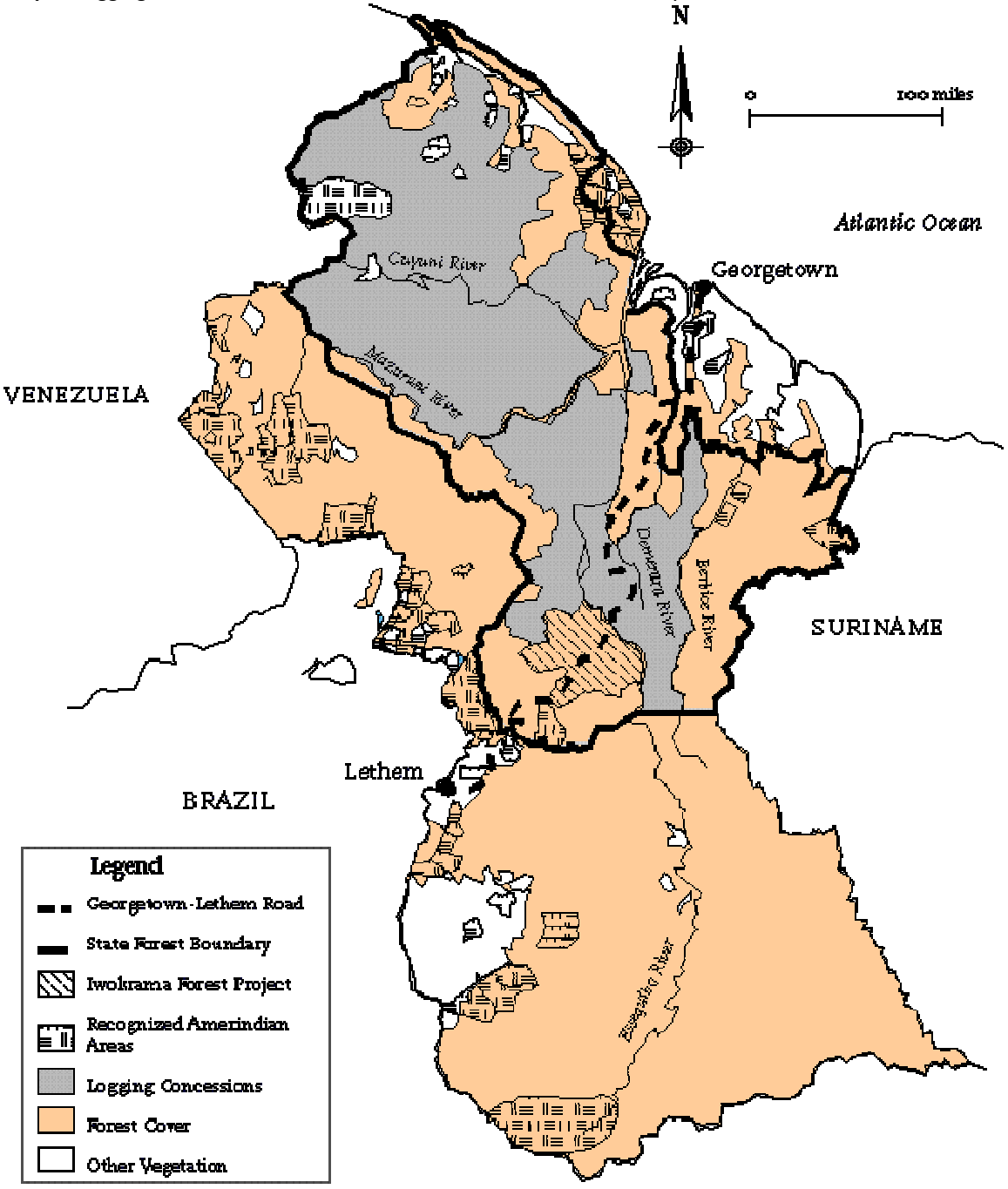
Nevertheless, if a REDD mechanism is to be launched field implementation of laws and practices need to be evaluated on all land where forestry is practiced. Implementation further needs to be independently assessed at regular intervals.

Table 12. Forest Allocation as Recorded by the Guyana Forestry Commission (December 2007) Guyana Forestry Commission is responsible for management of all state forests.

Classification	Count	Area (hectares)	Area Type (per cent)	Total Allocation (%)	State Forest (%)
Production Area Allocations					
State Forest Permissions	299	863,750	12.5%	10.3%	6.3%
Wood Cutting Lease	3	295,610	4.3%	3.5%	2.2%
Timber Sales Agreement	27	4,492,366	64.8%	53.4%	32.8%
SFP Conversion Areas	27	540,481	7.8%	6.4%	4.0%
State Forest Exploratory Permit	4	737,264	10.6%	8.8%	5.4%
Total Production Area Allocations	**360**	**6,929,471**	**100.0%**	**82.3%**	**50.7%**
Other Land Areas	15	1,485,694	**100.0%**	**17.7%**	**10.9%**
Total Forests Allocated	**375**	**8,415,165**		**100.0%**	**61.5%**
Unallocated Forests		5,263,451	**38.5%**		38.5%
Total State Forests		**13,678,616**			**100.0%**
Forests on private land					
Gazetted Amerindian land		1,300,000			
Ungazetted merindian land, leases etc.		3,500,000			

Carbon and commercial forestry. A worst case scenario is described in Section X.X. Provided that pre-mature entries are not permitted this is a highly unlikely development. Table X with comparative data from Malaysia and Brazil indicate that carbon emission from one entry are very moderate. Research is needed in this area.

Map 4. Logging Concessions, Forest Cover, and Amerindian areas in Guyana



Source: Organization of American States, 1996 (WRI 1996). Note: Logging concessions refer to Timber Sales Agreements and Woodcutting Leases. State Forest Permissions are not included here.

Shifting Cultivation

On most meetings held it was agreed that shifting cultivation as done today in Guyana is on a small scale, and can be regarded as a balanced system (sensu Appendix 2). This opinion is supported in (Anonymous 2009). It is doubtful whether the shifting cultivation of today qualifies as forest degradation. It is highly unlikely that it causes deforestation.

This environmentally benign situation could change quickly. If small scale mining increases, a new market for cultivated crops will develop. Miners are unlikely to raise crops. It does not seem unlikely that a new cadre of shifting cultivators could take up the practice. Should that happen, shifting cultivation could become a very major driving force of forest degradation. This development could happen fast. Tendencies have been observed in Suriname (K. Tjon, Personal Communication, 2009).

What a development of unsustainable shifting cultivation would mean in terms of carbon is next to impossible to predict. It depends on the extent of the practice

Mining

An investigation by the Guyana Forestry Commission (Anonymous 2009b) using remote sensing techniques discovered a total of 54, 210 ha of degraded forest area and 2,626 km of forest roads in 2007-2008, as shown in Map 3. It was found that 24 428 hectares had been cleared by mining. The most degraded forests areas are found in the North-West region of the country, which is traditionally known to have the highest concentration of mining concessions. This area coincides with timber concessions, meaning that forestry will have provided infrastructure for mining, free of charge.

The investigation gives a static picture of the pace of degradation caused by mining, it is thus not possible to estimate at what rate disturbances caused by mining occur. Abrams (2008) estimates deforestation caused by mining at 2 387 square miles in 2007 (about 6 000 hectares). Suffice it to say that the rate at which mining causes deforestation and forest degradation should be carefully studied.

Small and medium scale open pit mining can cause serious environmental and social problems (Anonymous 2007, Cotula & Mayers 2009). Site rehabilitation, although probably possible, is difficult and requires substantial effort (Bollers 2007). Mercury free techniques exist and seem to have been adopted in French Guyana (Vieira 2005, 2006, 2008). Regional rather than national efforts may be needed to control the use of mercury (Hilson & Vieira 2007).

The effects of uncontrolled mining on carbon stocks are probably be like those of degradation of primary high forest to scrub/savannah, i.e. a loss of some 200 tonnes of carbon per hectare. The subject warrants further study, should a REDD mechanism be launched.

Permanent Agriculture, Plantations and Expansion of Forest Area

Guyana Forestry Commission (Anonymous 2009b) estimated that there was 21 903 hectares of forest land deforested or degraded in 2007-2008. As for mining, the estimate is static, and does not permit any estimates of the area deforested or degraded per year. The figure might also contain a fair amount of shifting cultivation. Comparing Map 3 and 4 gives an indication that agricultural land is established where there is infratrsucture available, i,e, mainly, though not exclusively, in the state forest areas.

About 90 % of the population lives along the coastline, and this is also where permanent agriculture is practiced.

From time to time there is talk in media about Brazilian interests in establishing plantations of e.g. rice and soy in south Guyana. That is a development that has yet to take place. Guyana has land suitable for agriculture that remains to be utilised (Anonymous 2008a), so this is a scenario that may well materialise.

Forest plantations cover some 12 000 hectares (Anonymous 2005a). There are no plans to expand forest plantations. Sugar plantations have partly been converted to townships.

Expansion of the natural forest at the expense of agricultural land has not been studied. It cannot be ruled out that there are plantations that have been abandoned and "recaptured" by natural forest.

Climate Change

On many of the meetings held as part of the present mission it was mentioned that Guyana has experienced climate change during the last decade (sensu Appendix 2). Weather has become drier, rains fewer but heavier and flooding has increased. No scientific data confirming this has been encountered, but it cannot be ruled out that this is indeed true.

A drier climate may increase forest degradation due to fire and expansion of savannah areas, of which Guyana already has plenty. Savannah fires can spread into islets of forest on the savannah or into adjacent forests. There is evidence of this already happening (Anonymous 2008b).

On a meeting with representatives of the Amerindian community it was stated that flooding had now become so serious that they feel forced to look at new areas for agriculture and settlements.

Infrastructure Development

The road going from Georgetown to Lethem in South Guyana cuts through much of the forests of the country. The road is in poor shape, and a major upgrade has long been considered. A system to monitor forest carbon in a corridor along the road, should it be upgraded, has been developed by Conservation International (Alexander, E.,*et al*. 2009, Killeen, T., *et al.*, 2009 & Schoch, D., *et al*. 2009). An account of the work is given at the start of the present report.

Infrastructure development makes areas available for development. Connecting Guyana with Brazil and making a large part of the interior available for various activities will of course have consequences for e.g. forestry, mining and agriculture. Settlements along the road are of likely. This is indeed true for road construction in general.

5.4 Selective Logging and Biodiversity

As mentioned, logging in Guyana is done at a low intensity, using appropriate equipment and adheres top a stringent Code of Practice (Anonymous 2002). From a timber standpoint, effects of logging in Guyana are hardly alarming. There is concern about regeneration of greenheart (Chlorocardium rodiei) after logging (Ek et al, 1997 & ter Steege 2003). That however is a silvicultural problem that deserves further study. The Guyana Forestry Commission has indicated that it considers species based harvesting limits governed by growth and yield assessments and referenced to forest inventory data (P. Bolanath 2009, correspondence).

Logging damage has been the subject of few studies in Guyana. Data from the Barama concession (Anonymous 1995 & Harrison et al 1993), the biggest concession in Guyana, give little cause for alarm. An assessment in 2008 (Anonymous 2008c) of the same concession seems to confirm this. Reduced Impact Logging has been studied and developed in Guyana (van der Hout 1999). Avoidance of gaps and conscientious selection of trees to be felled art part of the logging system developed for Guyana.

The effects of selective logging on biodiversity, soil and water was given much in the set of Tropenbos studies done in Guyana, e.g. Brouwer (1996), Jetten (1994), Rose (2000), ter Steege (1996), ter Steege et al (2003), van Ulft (2004) and Thomas (2001). These studies conclude that the physical environment as well as biodiversity can cope with logging as long as operational standards are high.

6. Capacity for measurement reporting and verification, knowledge gaps and institutional and legal aspects

6.1 Setting a Reference Level

Guyana is a country with a high forest cover and a low deforestation. REDD reference levels must thus take assumptions on future development into account. Detailed knowledge of national development plans, and as yet unaddressed needs, is necessary. Natural resources must be declared to the degree possible. Anonymous (2008a) represents an attempt to do part of this, however assumptions, facts and figures need to be better substantiated.

An essential part of a system for measurement, reporting and verification is a defined reference level of carbon stocks and pools that can be monitored. Forest types relevant to carbon measurement need to be defined and studied. Forest types as defined for Guyana by Fanshawe (1952) are ecologically relevant (indeed a classical work in its field) but are difficult to use as a base for carbon assessments.

A reference level should contain a transparent statement of carbon stocks, and a reliable method to monitor their change over time. Change patterns in land use and their rates, and what implications ongoing land use processes have on greenhouse gas emissions. A mechanism to regularly report and verify ongoing development is also needed.

The present study includes carbon assessments. The assessments will be improved upon as results from the Guyana Forestry Commission study under way (Alder & Kuijk 2009) become available.

IPCC (2003) states that only managed forest should be reported. Forest management is practiced only on parts of the Guyana forest, see map 4. Forest management however is not the only human induced activity management applicable for forest land. Mining has convincingly shown that in Guyana. Development potential of land in Guyana, shown in Anonymous (2008a) and reports of future prospecting for oil, indicates a need to take future development into account when setting a reference level. Large parts of the interior have barely been inventoried in the past. It is therefore important that data collected is collected on the ground, and not through remote sensing.

Information, collected on the ground, on carbon stocks is thus needed from all parts of the country. The information needed concerns carbon stocks and their change. An option is to use data from the biomass study Information on carbon stocks that will be provided by the activities outlined in Alder & Kuijk (2009a). The activities outlined will surely also serve as very useful ground truth in future remote sensing.

From a Measurement, Reporting and Verification standpoint it is important that forest types that differ in terms of carbon stocks can be distinguished. It is equally important that ways to monitor changes in these forest types are defined.

6.2 Future Scenarios

Conservation International has defined four different scenarios in a most thought provoking publication (Killeen et al. 2009). The scenarios in short are:

Nostalgic past. Nothing of any significance happens. Small changes in land use and in development. A scenario deemed unlikely since an upgrading of the Georgetown – Lethem has been decided upon.

Business as usual. A development typical of the region, after infrastructure projects. Connecting to the economic powerhouse Brazil means change. Land along the road will become agricultural land. Mining will increase, roads open up frontiers. South Guyana will become open to timber harvesting. This scenario could increase employment, at the expense of biodiversity and greenhouse gas emissions.

Insufficient REDD. Because of Guyana's low deforestation, REDD revenues are low, insufficient to counter negative effects of infrastructure development. Since REDD revenues are so low, Guyana will face problems honouring agreements, and will thus be disqualified from REDD funds. Development after that will follow the second scenario.

Effective REDD. A reference level based on future development has been set. There will still be an increase in the rate of land clearing, but much less than in the other scenarios. REDD revenues can be used to reform the forestry sector. Proven sustainable forest management methods can be applied. The concession system is reformed, with better state control of operations.

The scenarios should be regarded as models. Models are approximations of reality and thus never quite true. Nevertheless they serve an important purpose in that they structure thought and are useful as a basis of discussion.

It is particularly important that both parties in a negotiation on REDD funds have discussed scenarios thoroughly. Disappointments with results can be avoided that way.

6.3 Knowledge Gaps

To set reference levels and to define realistic scenarios, areas with a potential for permanent agriculture need to be defined. With improved infrastructure profitability of agriculture will improve, so there is reason to expect a period of expansion for permanent agriculture in Guyana. Moreover, demand from mining communities will also contribute to this development.

From a REDD perspective it is very important to agree on a total forest area for Guyana. At the time of writing, there is a disturbing discrepancy between areas reported to different agencies. The area reported to FRA (Anonymous 2005b) is 15.205 million hectares, the present report assumes 15.6 million hectares from the vegetation map of 2001, ITTO reports an area of 16.9 million hectares. There is also reports of more than 18 million hectares. This is a matter that must be resolved if a REDD mechanism is to be launched. Without an agreed total volume, it will be hard to set a reference level. Much of the discrepancies are probably attributable to definitions, but the matter needs to be resolved.

Only one national forest inventory that covers the whole country has been made, and that was more than thirty years ago. Much of the southern parts of the country have never been properly

inventoried. To make vegetation maps reliable there must be data, collected on the ground, available for all parts of the country. Use of the permanent plot network outlined in Alder & Kuijk (2009a) is an option, as it has been designed to give a good cover of forest types.

There has been no study of biomass in Guyana. There is a study under way (Alder & Kuijk 2009a), but Tier 3 data are not yet available. Once the biomass study is complete, an impressive set of permanent plots will be available for use e.g. as ground truth in remote sensing.

The pace of deforestation and degradation is not known with any certainty. Educated guesses can be made, and deforestation is for sure not alarming at present. Better knowledge of this is required to set a reference level. Investigations of deforestation and degradation should also encompass changes in land use, i.e. what happen to forest land lost, and whether there is land that changes into forest land in the country, and if so what type of land.

It is likely that there exists a backlog of overlogged and degraded areas in Guyana. The early nineties saw a boom in illegal logging (Lewis, Personal Communication 2009), the present Code of Practice has not been in force for a decade yet, there are areas where the Forestry Commission has limited authority and community forests that may have been over-utilised. These are issues that need to be addressed when setting a reference level.

It is appreciated that Guyana Forestry Commission has gone to great lengths in ensuring that operational standards are kept high. To set reference levels for a REDD mechanism it would however appear justified to do a separate study of present efficiency in implementation of forest management standards, including recommendations on how to improve implementation and on how to ascertain continuous improvement. Independent reviews of logging operations will be necessary at regular intervals.

Areas degraded in the past by e.g. mining and poor forestry practices are areas that could be rehabilitated, increasing carbon stocks. The extent of these areas should be assessed.

The economics of small and medium scale mining need to be better understood, and separated from large scale mining. The money they bring to the national treasury must be balanced against the costs of site rehabilitation and mercury pollution.

The reported use of excavators by small scale miners needs special attention. Excavators equipped with back hoes are capable of inflicting stunning levels of damage to the forest they operate in. The author of the present report has a long personal “hands on” experience of working with excavators in forest environment. Using excavators in the forest in a manner that causes only acceptable damage requires professional training and supervised practice. It must be demoralising, not to say demotivating, for a logger to see an area carefully logged wrecked by excavators.

A map depicting e.g. mineral resources, promising areas for oil prospecting, areas suitable for hydropower projects, areas with soils suitable for permanent agriculture and plantation agriculture needs to be made. Such a map is necessary for setting a future reference level.

6.4 Institutional and Legal Aspects

A problem for REDD is that there is at the moment no comprehensive land use plan for Guyana. This means that the legal status of forest land is undefined. Several rights may apply to the same piece of land. This has manifested itself in practice by mining taking place on forest concessions. Degradation avoided in harvesting may be caused by mining. This must be resolved if a REDD

mechanism is to be launched. Work with such a plan will involve a number of agencies and comprise a delicate stakeholder interaction.

Zoning of land use is useful as a tool to avoid unsound environmental development in connection to e.g. infrastructure projects. Zoning is a complex procedure that requires co-operation between agencies. A REDD mechanism will make zoning even more complex as it will have to take agreements regarding REDD into account.

The increase of permanent agriculture and mining that will probably follow improvements of infrastructure must thus not be allowed to catch agencies concerned with surprise of a REDD mechanism is to be launched. Institutional preparedness is required. Inter agency co-operation will prove necessary.

A special agency with fairly far-reaching authority, and well defined responsibilities, to work with REDD needs to be established. Such an agency should consist of staff from all agencies concerned by REDD. Mining would for example play an important part in such an agency. Work should resemble project work, e.g. consist of plans with set deadlines for deliveries.

A council of representatives from the main groups of stakeholders to advice the "REDD Agency" would be helpful as well as a steering committee made up of representatives for agencies involved. Steering committee and stakeholder councils are important in handling and modifying expectations from parties concerned, and in making sure that all concerned are given opportunity to voice concerns, even after the launch of a REDD mechanism. It is important that the party paying the REDD revenues is made part of steering committee and stakeholder council, to make sure that the product paid for is obtained and to have a clear understanding of problems and obstacles.

Before work to launch REDD is started it is essential that expectations from parties paying and receiving revenues have been clearly communicated and agreed upon.

It is most important that agencies concerned in by the REDD mechanism are involved in the process and held responsible and accountable for their parts.

Forest laws and codes of practice are adequate for sound forest management. There is a log tracking system in place that must be regarded as efficient and under continuous improvement (Anonymous 2006a & b). It is beyond the scope of the present mission to evaluate laws in detail. Implementation of laws and regulations need to be monitored as parts of a REDD mechanism.

Forest operations are not only carried out on larger concessions in Guyana. Smaller concessions, Amerindian land (gazetted as well as ungazetted) and other community held forests exist, see Table 12. Management prescriptions and advice tailored to their needs is needed. An effort in this respect is the Chainsaw lumbering project described in Appendix 2. As is evident from Table 12, small scale forestry is reasonably common in Guyana, and needs to be separately assessed if it is to be part of a REDD mechanism. Forests on private lands need special attention/negotiations if they are to be included in a REDD mechanism. Information to stakeholders concerned followed by negotiations will be necessary and demanding.

Mining will be an important issue. The mining commission will play an important role in a REDD mechanism. Approaches and methods to control mining need to be developed. Regulations need to be enforced. The Mining Commission has an obvious part to play in the work to make small scale mining an environmentally responsible activity.

REDD must be considered in planning of land use, infrastructure development and energy projects. Comprehensive land use planning is a necessary part of this. Land use planning must, if necessary,

be accompanied by enforcement. Zoning of land use forms will help make infrastructure development be in compliance with a REDD mechanism. Field adherence to the zoning will be a critical part of a REDD mechanism.

Agencies working with remote sensing and GIS will need to co-operate closer. This includes e.g. forestry, land surveying, agricultural agencies and mining.

Climate change was often mentioned in the meetings held. This needs to be verified by meteorological stations. Should there be changes going on, measures to combat wild fires may be needed. The country has large areas of savannahs and dry forests that are prone to fire. Fire control is a matter that has to be dealt with by agencies together. The same holds true for flooding.

The involvement of Amerindians in REDD must be carefully negotiated with those concerned. The consultant is confident that this issue has been adequately addressed in a separate consultancy.

Fund dispersal after the Launch of a REDD mechanism has been highlighted at a number of meetings held (sensu Appendix 2). Although the matter seems distant at present, it needs to be addressed at an early stage. Properly and transparently handled it could increase commitment to REDD among the general public.

6.5 Capacity Building

REDD will, if launched, influence training of students to work in sectors affected by REDD. Training will have to communicate an understanding of sectors other than that studied. Surveyors e.g. need a basic understanding of forestry and agriculture. Below follows a brief account of some areas with obvious need of capacity building.

Plans for REDD must take capacity building into account. At present it is not possible to make detailed proposals. Suffice it to say that it is not unlikely that reinforcements will be necessary as duties expand because of REDD. Below follows examples of areas where reinforcements seem likely.

Remote sensing and GIS

Guyana Forestry Commission has access to Landsat Images with a resolution 30 and 15 metres. The software used is Arc View 3.2/3.3 and Arc Map 9.2. There is uncertainty on the how well vegetation types can be distinguished using these resources. It has also proven difficult to distinguish logged forest from unlogged. Mining activities can be discovered. Spot images would be great, but comes at a price.

Clouds are a great problem in a rain forest country like Guyana. Radar would solve this, but there is uncertainty whether vegetation types can be distinguished using radar. Field staff is equipped with GPS. GPS is used for the road database.

Staff numbers is adequate for present needs. A REDD mechanism may necessitate better images and more staff. New techniques and, more important, new issues to work with will probably require training of staff, including officers. It is not unlikely that new officers will have to be recruited, at present there is two GIS officers at the Guyana Forestry Commission headquarters.

Inventory and Forest Management

A senior staff with research competence will be needed to conclude work with biomass models. After work has been concluded plots will have to be maintained as permanent plots. The plots will

be essential in the continued work with REDD, and indeed in strategic planning of the forest sector. Staff working with the plots will of course need to co-operate extensively with remote sensing and GIS staff.

Field staff will also have to be trained in working with scientific demands. It is quite possible that field staff will have to be specifically recruited for work with the permanent plots and REDD.

Guyana forestry has an adequate legislation, a stringent code of practice for harvesting and detailed management prescriptions. For the continuous implementation and evaluation/improvement of methods, a cadre of fairly well trained staff need to be present at the concessions. Such staff would have an advisory as well as enforcing role. At present 15 employees of the Forestry Commission are present at the concessions.

To improve on, and continuously critically evaluate, present forest management routines, staff with research background in forest management will be needed.

Mining

The mining commission must, if it hasn't already done so, acquire expertise in environmental aspects of mining including rehabilitation. Field staff may have to be strengthened to enforce environmentally responsible mining.

Staff to do prospecting work in areas made accessible by improved infrastructure need to be recruited and trained. The objective of his is to avoid excessive digging.

6.6 Reference Sites and Models

Sites under Establishment

Guyana Forestry Commission is about to launch a biomass monitoring system (Alder & Kuijk 2009). A total of 900 permanent sample plots will be established as part of this effort. The plots will be grouped as 180 clusters in 60 transects and cover in all major forest types.

In addition to this detailed measurement of felled trees and tree roots to establish a data set of 300 plus sample trees for crown, bole and root biomass will be made. These data will allow the elaboration of local and current Tier 3 allometric functions for Guyana. Work requires the establishment of a simple biomass laboratory at Forestry Commission headquarters. The lab will comprise 2 drying ovens of 400 lt capacity each, electronic balances, and adequate space to store and process field samples.

Existing Permanent Experimental/Research Sites

Information of existing sites has been kindly provided by Dr. Denis Alder (Alder, correspondence 2009)

Mabura Hill Forest Reserve (former Tropenbos-Guyana Programme). The site consists of 2000 hectares of pristine forest. There is 2 intact buildings. The site was established in 1990. The site is four hours of driving from Georgetown.

A lot of ecological work was carried out in this reserve by researchers associated with the Tropenbos Guyana programme between 1989-2001. Work post 2001 includes visits from academic institutions in Guyana, tree identification training, and visits of foreign researchers.

Pibiri Research Site (former Tropenbos-Guyana Programme). The site consists of 1126 hectares of logged (experimental) forest. The site was established in 1994, it is five hours drive from Georgetown. Three intact buildings are found on the site.

Under the Tropenbos-Guyana Programme, fifteen permanent plots were set up in the Pibiri Research Area to monitor Reduced Impact Logging.

After the Tropenbos Programme Pibiri has been visited by students from Academic institutions in Guyana. Commission staff has been trained in tree identification there. site is considered for a study on primates.

Yarokabraw Training Centre. The centre manages 18 hectares of forest. It was founded in 1970. There is a building for training and accommodation for camping. The centre can be reached by car in 45 minutes from Georgetown.

The centre is mainly used for training of commission staff and university students.

Chickabaru. The site is of 1424 hectares of logged over forest. The site was founded in the late eighties. A trip by car from Georgetown takes about 2.5 hours.

Chickabaru is a suitable site for practical training in harvesting and inventory work. Even strong interventions can be permitted.

24 Mile reserve (Bartica). The reserve is made up of 260 hectares of unlogged forest. It was founded in the sixties. There are no buildings in the reserve. the centre can be reached in 3 to four hours from Georgetown.

Use is restricted to Guyana Forestry Commission staff. Only observations and measurements are generally permitted. Installations of permanent sample plots can be permitted.

Moraballi Reserve. A reserve of some 800 hectares of logged forest. The reserve was established in the fifties. No buildings are found. Moraballi can be reached in 2.5 hours from Georgetown.

The reserve has been logged legally as well as illegally. It is the site of several silvicultural trials, some of which can still be monitored. The reserve is most valuable from a silvicultural point of view

The Guyana Forestry Commission, through assistance from **Kreditanstalt für Wiederaufbau** (KfW) is currently engaged in a project to establish a monitoring station in the Reserve to strengthen forest monitoring in the Reserve and in surrounding areas.

Iwokrama (Trevin 2009). Nine sample plots and four experimental plots have been established. The nine sample plots include two plots on every major forest type, one in an area to be logged and one in an area that will not be logged. A ninth sample plot was established on a Dakama Forest (DF), not scheduled for logging. The four experimental plots are established in adjacent blocks that will be subjected to different logging intensities on the most common commercial forest type, MGK. Logging intensities recommended for trial are 17, 20, 23 and 26 cubic meters per ha.

Berama Concession. Permanent plots were established in the mid nineties in the Berama Concession (Khan, personal communication 2009). These plots could probably be relocated, should that be deemed necessary.

Finally there still exists some plots in the plantations established from the fifties to the seventies. The plots were set up to monitor growth and treatment response of *Pinus caribaea*. The plots are summarised in Table 13. Data on locations are uncertain.

Table 13. A summary of plots established in plantations of *Pinus caribaea.* Note that size is given in acres, not hectares. Data are too uncertain to make a conversion to SI units worthwhile.

Location	Size (acres)	Date established	Comments
$1^{1/2}$ miles Bartica/Potaro Rd (Arboretum)	2.5	1955	Existing, some parts burnt by fire, managed by GFC
5-6 miles Bartica/Potaro Rd-	325	1955-1965	Existing, road passing through,
Ebini – Still existence, managed as a reserve by GFC	80	1964-1968	Existing, still managed by GFC, thought to be the best pine stand of the study sties
Haima	100	1966	Burnt out
Kuru Kuru	21	1968	Burnt out
	28	1971	
Yarokabraw Forest Nursery	5	1970	Existing, managed by GFC
Long Creek	23	1970	Existing, recently experienced burning, managed by GFC
Kairuni I	24	1971	Existing, in good shape and managed by GFC
Kairuni II	28	1972	Existing, in good shape and managed by GFC
Hauraruni	1000	1974-1975	?
White Creek	30	1976	?

Source: Alder, correspondence 2009.

7. Synergies

A comprehensive land use plan is of obvious benefit to national development with or without a REDD mechanism. The need is particularly great in a time when a large part of the country is about to become accessible.

Climate change and carbon sequestration are not the only environmental problems facing Guyana, and indeed the rest of the world. REDD requires environmental thinking that will be beneficial to the Guyanese environment in general.

Sound forest management need not be in conflict with REDD. There are obvious benefits beyond carbon sequestration of sustainable forest management, e.g. conservation of biodiversity, improved water quality and reduced erosion and higher future production of timber.

Forest data with national coverage is a valuable tool for forest sector planning and environmental monitoring.

The cooperation between agencies that will prove necessary will be useful in conflict resolution in areas other than REDD.

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Appendix 1. Terms of Reference

UN-REDD PROGRAMME
Preliminary assessment of forest carbon, Guyana and Surinam
6 April 2009

Background

The United Nations Framework Convention on Climate Change (UNFCC) agenda item on "Reducing emissions from deforestation in developing countries and approaches to stimulate action" was first introduced at the Conference of the Parties (COP11) in December 2005 by the governments of Papua New Guinea and Costa Rica, supported by eight other parties. The challenge was to establish a functioning international REDD finance mechanism that can be included in an agreed post-2012 global climate change framework. Progress has been made and the need to meet the challenge is now reflected in the Bali Action Plan and the COP13 decision 2/CP.13. A functioning international REDD finance mechanism needs to be able to provide the appropriate revenue streams to the right people at the right time to make it worthwhile for them to change their forest resource use behaviour.

The United Nations Collaborative programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN-REDD Programme, www.un-redd.net) is a collaboration between FAO, UNDP and UNEP. A multi-donor trust fund was established in July 2008 that allows donors to pool resources and provides funding to activities towards this programme.

Based on request from Governments of Norway, Guyana and Surinam, FAO, as partner of UN-REDD, will field a consultant to work with institutions and experts in Guyana and Surinam to make preliminary national assessments of forest carbon stock and changes, evaluate the institutional capacities for Measuring, Assessing, Reporting and Verifying (MARV) for REDD and make recommendations on next steps to prepare for a REDD mechanism.

Country projects are currently initiated in Guyana and Surinam. The consultancy will perform a preliminary study on MARV in these countries.

Tasks

Under the direct supervision of the Director, Environment, Climate Change and Bioenergy Division, the consultant will:

(i) Travel to Guyana and Surinam and work with national institutions and experts to gather information and analyse findings;
(ii) Prepare a report for each country of maximum 20 pages (see scope in Annex 1)

(iii) Carry out other duties as required

Duration: 25 April – 1 July 2009, CST contract
Duty Station: Home based with international travel
Language: English

The conclusions of the independent assessment of logging practises should encompass the following elements:

1. Carbon storage and emissions in Guyana's forest ecosystem. Status and trends, including the carbon impact of current logging practise.

Core issues to be covered are:

- State of knowledge on carbon pools (as defined by IPCC) in Guyana's forest ecosystems
- Assessment of standing stock biomass and change rates (deforestation, forest degradation and stock enhancement)
- Extent of deforested area and main new land cover types
- The nature and extent of carbon degradation – drivers and impacts (in particular impact on carbon emissions)
- The impact of logging on biodiversity and ecosystem services should be briefly assessed

This work should be based on:

- A critical analysis of existing literature on the state of Guyana's forests, using a broad variety of the best available knowledge sources and approaches (FAO, IPCC, Tropenbos, DFID, GFC etc.)
- Additional information should be sought in co-operation with
    - Relevant authorities in countries
    - Relevant stakeholders
    - External experts

The validity/robustness of the assessment should be evaluated, and gaps in information should be explicitly identified.

2. Evaluate institutional capacities for Measurement, Assessment, Reporting and Verification for REDD, including:
    - Scientific and technical knowledge/needs for the design and implementation of national MARV systems, taking into account:
        a. Carbon data
        b. Data beyond carbon required for policy processes
    - Status of reference sites and models for biomass and carbon assessment, including options to use foreign references/models
    - Potential synergies with forest monitoring needs beyond REDD

Appendix 2. Account of meetings held.

An important part of the mission in Guyana has been to meet with representatives of agencies involved or concerned by REDD. Valuable information, documents and comments have been obtained through these meetings. Below follows accounts of the meetings. Please note that opinions expressed are those of the individual(s) and agencies with whom meetings were held, not those of the consultant or FAO.

May 11

Introductory meeting at Forestry Commission headquarters

Participants: *James Singh, Tasreef Khan, Pradeepa Bholanath (PB) & Sonya Reece (SR)*

Participants introduced themselves. The concession system was briefly presented together with normal forest management prescriptions. The log tracking system was mentioned. Key figures on forestry were given.

May 12

Forest Product Development and Marketing Council Incorporated

Participants: Derrick Cummings (Director)

Activities of the council were explained. Responsibility is towards stakeholder groups. Concern has been noted among stakeholders. It is however difficult to see major restrictions coming up for the stakeholders attached to the council, given present logging intensities.

Forestry Training Centre

Participants: Godfrey Marshall (Director)

The centre has been formed with the help of ITTO and Tropenbos. Work is done in two projects. One addressing large scale operators and one small scale operators. The institute employs 15 people, out of which nine are instructors. Instructors are capable of giving training in more or less all practical aspects of logging. The typical student/client is a regular forest worker. Guyana has in the range of 3 000 forest workers.

Courses are given in field camps and demonstration areas. Large scale operators are reluctant to send workers for training. Many workers change to mining which pays better. On the other hand, large scale loggers start feeling that the eyes are on them. They are now required to adhere to high operational standard.

The institute could easily expand its operations, should that be required by a REDD mechanism.

Chainsaw milling project (associated with Forestry Training Centre)

Participants: Maria Kerret (Project Manager)

The project assists three "forest communities" in forest management. These communities are in great need of training in sustainable forest management, current methods are sometimes destructive. There are many smaller scale operations in Guyana, and timber is an important part of the rural economy. Three people are employed by the project.

Climate related work has started on a modest scale with distribution of brochures. That alone is however not enough. Personal contacts are required. Focus must be on communicating advantages of REDD. As it is many are worried that REDD will reduce incomes by logging restrictions.

May 13

Department of Amerindian Affairs

Participants: Ovid Williams (Principal Regional Development Officer), Nigel Dharamlall (Permanent Secretary)

Guyana has 97 titled Amerindian communities. These cover some 14 % of the country. Land is owned by the community, in a way private ownership. Amerindian communities with that have had at least 125 inhabitants for at least 25 years can apply for status as Titled Village. All land use conflicts must be resolved for an application to be granted.

The Forestry Commission has no authority on this land, but does advisory work. Should timber from the titled villages be traded outside the village, normal regulations start to apply. Forestry is practiced in much the same way as smaller scale operations elsewhere in the country.

Around 10 %C of Guyana's people are Amerindians. The majority live in titled villages. Forestry provides much needed incomes for those living in the villages. The Forestry Commission intends t o work with all these communities, but has yet to reach this goal.

There is also mining on land owned by the communities.

No TSA:s (or concessions) are granted on communal land. The community can however decide to let others harvest timber on their land. Once again, as soon as the timber leaves the community, normal legislation applies.

The communities need to diversify their livelihood beyond forestry. It is hoped that a REDD mechanism will be helpful in this.

Iwokrama

Participants: Dane Goblin (CEO), Raquel Thomas (Director of Resource Management and Training)

Manages an area of about 350 000 ha in Southern Guyana. A vegetation map is under way. Forestry in the area is certified by FSC. Mapping and ground truthing is a major concern, and will prove expensive adaptations to REDD. Iwokrama co-operates with NASA on remote sensing. As it is now, it is difficult to distinguish logged forest from unlogged. To properly monitor mining a resolution of three meters is necessary.

Iwokrama fully supports the REDD mechanism. REDD will require more stringent stakeholder processes. It is essential that REDD is taken to the heart by rural population.

Permanent sample plots have been established by Iwokrama.

Mining is by far the most serious forest degrader in the country. There is also high pressure to get permits to log. Reduced impact logging is under introduction in the country as a whole, but will continue to face opposition from the loggers.

Guyana Geology and Mines Commission

Participants: William Woolford (Commissioner), Wycliffe Abrams (Economist), Derek Babb (Mines Manager), Karen Livar (Environment)

A mine is an example of disturbance, not degradation. Illegal mines, although illegal, may also be examples of land disturbance rather than degradation. A problem with licensing is that people may have a license for one area, but do the mining in another.

Illegal mining is not a problem, as licences are cheap and not too hard to obtain. There is a policy of mutual co-existence between forestry and mining.

REDD mechanisms are welcome as long as they do not reduce people's income. The commission is also strongly against deforestation. Mining should be done in a responsible way. EIA:s are accepted. Little work has been done regarding forest restoration after mining. Use of heavier machinery e.g. excavators is on the increase, and they cause more damage. Some 250 excavators are thought to be active in mining.

Legalities dictate that restoration of sites degraded up to 1970 should be restored by the state.

Three kinds of mining can be distinguished:

Bauxite	Large companies (120 000 acres)
Diamonds	Medium to small size companies (12 000 acres)
Gold	Medium to small size companies (30 000 acres)

Only parts of a claim are actually mined. Mercury is used to a lower degree than in other locations. Mercury is not seen as a problem.

Mining can take place on forest concession. Multiple land use that is not seen as a problem.

Guiana Shields Project/UNDP.

Patrick Chesney, Project Manager.

A pilot project at Iwokrama under way. As is a study of carbons stock assessments using vegetation maps set up by remote sensing. Results are not ready for public use, but they indicate that ter Steege (2001) is an underestimate, not by much though. Guyana suffers from lack of baseline data. Another thing that is lacking is a legal status for forest land. A comprehensive land use plan is also lacking.

There is more or less no data at all from large parts of the country, the reason being that they have never been studied.

Lots of work is done by the Guyana Forestry Commission to raise operational standards. Verification of progress in these efforts is greatly needed. Policy workers need to be trained.

Multiple land use is seen as a mixed blessing. Small scale mining causes deforestation and degradation. The extent and the seriousness remain to be studied.

Hydropower projects are under discussion in the south. Savannah land could be concerted to agricultural plantations. Brazilian companies have shown interest in land for soya and rice cultivation. Oil could also be found in South Guyana. Livestock has more or less disappeared since an outbreak of foot and mouth disease. A road from Georgetown to Lethem could have an impact on land use and carbon emissions.

May 14

Guyana Manufacturing and Services Association Limited

Ramesh Dokhoo, President

There are many reasons to impose strict regulations on export of roundwood. If an industry is to develop, logs have to be used inside the country.

In principle support to a REDD mechanism. But things are happening so fast that it is difficult to keep track, and formulate opinions. It is hope that a REDD mechanism will not reduce log production, which must be considered low. Stakeholder consultations need to be carried out. There is a risk that rules and regulations may change too fast. The current financial crisis makes adaptations harder.

The association has 15 to 20 member companies. International companies are not without problems. Investments promised have failed to materialise. It is felt that international companies have been given privileges not granted to local companies.

The poorest practices have been checked by a stringent log tracking system, and regulations against land lording.

REDD will mean a change in the sense that rules imposed will have to be implemented with great stringency. Distribution of money from REDD is going to be difficult. It is essential to get that right, from the very start.

Guyana Forestry Commission

Pradeepa Bholanath, Head of Division

Organisation of Guyana Forestry Commission was described. A semi-autonomous body with an advisory but influential board. A new forestry act is under way. The ministry responsible is the Ministry of Agriculture. Associated agencies are Forestry Training Centre and Forest Products Development and Marketing Board. A REDD secretariat has been set up.

Office of the President

Shyam Nokta and Andrew Bishop, Presidential Advisors.

Market expectations are important. Markets should recognise future projected deforestation. Carbon from the forest should be viewed as any other carbon, and thus competitively priced. Refer to the "Avoided Deforestation" paper.

There is uncertainty about what rules will ultimately apply for REDD. It is impossible to make any statement on what changes will be necessary before the rules are known. December will be a watershed. The mechanism still needs to develop. No working model exists. It will be up to Guyana to pave the way. "REDD-like" actions will be important with or without the mechanism. Guyana is feeling climate change.

WWF

Patrick Williams, Country Manager, Janice Bollers , Forest Officer and Rickford Vieira, Mining Specialist

WWF supports the government policy on REDD. WWF helped the government write its position paper for the Posnan meeting. WWF also helps finance two international consultants working with biomass assessments. Capacity building is a priority. Indeed REDD must have capacity as one of its components.

Mining is the main agent of deforestation. Mining practices are also detrimental to human health, mainly due to mercury pollution. New technology for small scale mining has made practices even more destructive. Illegal and legal mining are equally destructive. Miners should be helped by prospecting to reduce unnecessary digging. Small scale mining could be environmentally improved. There are interesting examples from French Guyana. At present there is a gold rush. Larger companies are taking their responsibility to the environment reasonably well.

Prospecting for oil is set to commence next year.

Agriculture cannot at the moment be said to be a competitor to forestry. Shifting cultivation is to some extent. Ecotourism might become a competitor.

May 15

Conservation International

David Singh, Executive Director and Eustace Alexander, Biodiversity Analyst

Conservation International has a long history of co-operation with the Forestry Commission on biodiversity and climate issues. Impact studies of a future improved road from Georgetown to Lethem is an example of this.

Extent of savannahs in Guyana are an important indicator of climate change. Shifting cultivation on the savannah represents a danger to the forest cover. The present extent of savannahs could be the result of climate change.

There is a pressure for land from Brazilian interests. Should REDD fail, there will be major implications for the forest of Guyana. How money is spent will also have implications. A top – down approach means that people may feel alienated. Reserving the money in funds, much like Norway, is worth considering.

A major effort in awareness and information regarding REDD will be required for it to have any chance of success. REDD could instigate good governance. REDD will also force Guyana to review its natural resource management and land use planning.

REDD money must be enough to constitute an incentive. Should REDD prove to provide major funds, the money could help make conservation profitable, and to assist forest dependent people. The ecosystem could become an income earner in its own right. Making people take this to their hearts is a big undertaking. Much remains to be done. The general public, not only the top need to embrace REDD.

Ecosystem services is a concept that must be developed e.g. among university students.

Drivers of deforestation and forest degradation in Guyana are:

The Georgetown – Lethem road, the driver of drivers

Unregulated mining

Intensive and unregulated logging

Ongoing efforts to shorten cutting cycles are a cause for concern.

Forest Products Association

S.K. Chan (CEO Demerara Timbers), Hubertus Cort (Consultant, China Timber resources Group), David Persaud (Vice chairman, Toolsie Persaud)

The stricter implementation of Code of Practice has made many in the business with an uneasy feeling. Despite repeated consultations, they feel that their sentiments are poorly understood. Guyana should make up its mind on the future of commercial forestry.

They feel that it is unfair that they should have to comply with high technical standards when a miner can come and clear fell forest much as he pleases. They also feel that small scale loggers get away from the stringent standards prescribed by Code of Practice. An example of a regulation felt unfair is the 10 metre rule, stating that trees felled must be at least 10 metres apart.

It is estimated that there are some 2500 skidder operators and timber fellers working in the large scale concessions. Another 2500 people with other jobs are also found in the concessions. Stihl chain saws dominate (070 & 054), the most common wheeled skidders are Clark Ranger F68 and Caterpillar 528. The crawler tractor mainly used is Caterpillar D6. Crawler are normally not used for yarding.

PFC has 45 members, and they are the 45 biggest actors in concession forestry in Guyana. Members represent every aspect of production forestry from timber felling to ready made products. The members provide employment for 25 000n people. In addition to that some 5 000 people work with small scale enterprises.

There are many small companies in forestry. Harvesting technology used by the does not differ from that of the bigger companies, but they tend to be less regulated.

REDD has to be better understood before they are willing to take a firm stand on it. They do not know how much money REDD might give, and that is something that matters. A land use policy is also lacking. Even PFC is a bit concerned about concequences of an upgraded road between Georgetown and Lethem.

On a long term there is concern that profitability may become so poor that it is questionable whether the "show should go on". Forestry Commission staff in the concession should function more as advisers than police.

May 18

Lawrence Anselmo & Tony James (Amerindian Peoples Association), Ashton Simon (National Amerindian Development Foundation), Pamela Mendosa (the Amerindian Action Movement of Guyana) Ovid Williams (Ministry of Amerindian Affairs)and James Singh (Guyana Forestry Commission)

There is great concern about mining among Amerindians. Even more so now that small scale mining is done with the help of bulldozers. Damage to the forest is massive and water is polluted by mercury. Shifting cultivation as presently done by Amerindians is rather benign in comparison to mining. There is an impression that there is little control of mining at present. There are areas where mining has been ordered to stop and yet it continues. Even mining outside titled land is a problem to Amerindians, as water is polluted.

Small scale mining need to be monitored and controlled. These are two effects of REDD that are hoped for. Guyana Forestry Commission is busy with an effort on monitoring.

The REDD process is little understood by the Amerindian community. There is the impression of a complex process that goes without the involvement of Amerindians. They would appreciate being consulted. James Singh of the Forestry Commission replied that no decisions have been taken. The process has yet to start. A national consultation is about to be launched.

Communication with Amerindians requires professionalism. Amerindians often have no access to internet. Technical expressions are difficult to understand. Interpreters needed in consultations not only to have translation, but rather to have it translated into words that make sense to Amerindians.

It seems that droughts and floods have increased. This has been particularly pronounced since 2004. New crops may have to be considered, and new land may have to be tilled.

Forests provide Amerindians with a number of products needed for their traditional life. Non-wood forest products are of the greatest importance. Amerindians have a special relation to their land. Outsiders have a problem understanding that. Land rights to them go beyond their titled villages.

They need more information and time to comment on REDD. There is concern that REDD may mean restrictions on their land use.

May 19

University of Guyana

Lawrence Lewis, Head of Forestry Department

REDD has started to get attention at the university. There is a study in progress on the effect of Reduced Impact Logging and regeneration. There is also a study under way on above ground biomass. If REDD is launched, that will affect teaching in e.g. inventory and ecology. New courses will also have to be tailored to REDD..

The co-operation with the Forestry Training Institute has helped Guyana introduce Reduced Impact Logging. Smaller concessions typically have no trained foresters employed.

A REDD mechanism will necessitate a closer co-operation between the University and the v Forestry Commission. Contacts have yet to be taken. REDD will require highly qualified staff.

National forest data have not been collected since the fifties. Since then use has been made of management inventories in concessions. REDD will need a national forest inventory. Training is given in remote sensing. The department has four permanent lecturers and eight teaching part time. Teaching accounts for almost all working hours. Shortage of funds is crippling the department.

Mining, shifting cultivation, expansion of communities and roads are what causes deforestation and forest degradation in Guyana. Illegal logging was at its peak 1992 to 1994.

Environmental Protection Agency

Indarjitt Ramdass (Executive Director), Geeta Devi Singh (Director, Environmental Management Division), Shariffa Ratzak (Diresctor, Education, Information and Training), Teij Persaud (Environmental Officer, Miing and Forestry Unit) and Frederica Chiappe (Environmental Economist)

There is a climate committee in which are part. REDD has not been discussed in any detail. Less employment in forestry and mining will have implications for traditional life. REDD cannot be permitted to stop people from earning a living. Setting a baseline will be critical, as critical as the follow up after launch. There is too much that is unknown at the moment for any meaningful discussion.

The role of EPA is unclear. Another thing that is unclear is how to distribute the money earned through REDD. It is important that money is well spent. The McKinsey study is interesting.

Inter agency co-operation will be required in REDD. Agencies will have to assume responsibility for their areas to a larger extent.

May 20

Guyana Forestry Commission

James Singh, Pradeepa Bholanath, Khan, Sonya Reece

A three year plan starting now has been made. A World Bank grant of 3.2 million US dollars has been applied for.

Forestry will continue on areas already allocated as concessions even after the launch of REDD. This goes even for forests outside the State Forest. REDD will probably require Guyana to improve resource utilisation and to invest in forest industry. Alternatives land uses to logging must be found.

Training and research will be required. The commission will probably have to expand, e.g. to enable a National Forest Inventory.

Annotated Bibliography

Abrams, W., 2008. Value of Land Available for Mining in Guyana (Preliminary Report September 2008). Guyana Geology and Mines Commission.

A presentation of land available for mining and value created by mining. An estimate of deforestation caused by mining is made.

Alder, D., 2000. Development of Growth Models for Application in Guyana. A technical report prepared for the Guyana Forestry Commission Support Project with the assistance of the UK Department for International Development, October 2000.

This consultancy has produced the tables of mortality and increment rates by species, a summarisation and grouping system for increment and mortality, with mean group statistics, and a list of volume trees with gross and net volumes, dbh, bole length and stump diameter that can be used for further volume studies.

Alder, D. and van Kuijk, M., 2009. Proposals for a National Forest Biomass Monitoring System in Guyana. Guyana Forestry Commission.

The report proposes establishment of an extensive network of plots, and also detailed measurements of single trees. Establishment of a simple biomass lab is proposed, as is capacity building. A ground truthing routine for Landsat analyses is finally proposed. Proposals are made with a REDD mechanism in mind.

Alexander, E.,*et al*. 2009. Assessment of Forest Carbon Stock and Historical GHG emissions from Land Use and Forest Degradation. Biodoversity Mainstreaming through Avoided Deforeststion, Guyana Case Study (BMAD-GCS) Project (GY-T1058). Technical Paper A.

Tier 3 carbon assessments of carbon pools. A preliminary biomass function for Guyana has been devised. Carbon stocks for national vegetation types have been calculated. Historical data, sample plot data and data from Iwokrama are used.

Anonymous, 1995. 2nd Annual Report by Edinburgh Centre for Tropical Forests on its Programme of Monitoring and Research for the Barama Ltd. North West Guyana Sustainable Timber Production Programme Covering the Period 1.1.94 – 31.12.94.

An evaluation of the work of the concessionaire. Logging was found to be of “remarkably” high standards. Data on damage support this. The document is rich in basic forestry data. Basal area of the permanent plots established averaged 23 and stems numbered 215 (<20cm dbh)

Anonymous, 1997. Guyana. National Forest Policy Statement. Government of Guyana.

The first national forest policy document since 1953. A document addressing legal issues e.g. land use and ownership. A forest industry strategy is included.

Anonymous, 1999. Forest Management Plan Guidelines. Guyana Forestry Commission.

Specifications of what forestry planning is required from concessionaires. Adherence to the guidelines would seem to ensure forest management of high standard.

Anonymous, 2000. Environmental Impact Assessment Guidelines. Volume 3 – Mining. Environmental Protection Agency/Environmental Assessment Board

This manual is a result of the joint effort of the Environmental Protection Agency (EPA) and the Environmental Assessment Board (EAB). The intention is to provide to the EPA, EAB, sector agencies, private sector, NGOs, members of the public and consultants a set of approved guidelines for the conduct of Environmental Impact Assessments (EIA) for Mining Projects in Guyana.

Anonymous, 2001a. Environmental Impact Assessment Guidelines. Volume 5 – Forestry. Environmental Protection Agency/Environmental Assessment Board.

This manual is a result of the joint effort of the Environmental Protection Agency (EPA) and the Environmental Assessment Board (EAB). The intention is to provide to the EPA, EAB, sector agencies, private sector, NGOs, members of the public and consultants a set of approved guidelines for the conduct and review of Environmental Impact Assessments (EIA) for Forestry projects in Guyana.

Anonymous, 2001b. National Forest Plan. Draft. Guyana Forestry Commission.

A document setting a framework for National planning and coordination, resource management, forest industry, research and information and social development.

Anonymous, 2001c. Lesser Utilised Timber Species of Guyana. Guyana Forestry Commission.

An informative presentation of species with commercial potential.

Anonymous, 2001d. Guyana Climate Chang Action Plan. Actions for Addressing Climate Change. Government of Guyana.

The Plan seeks to develop, apply and diffuse technologies (and technology transfer), practices and processes that control, reduce or prevent human emissions of greenhouse gases in relevant sectors, including energy, transport, industry, agriculture, forestry, waste management and health sectors. Climate change scenarios arte further discussed.

Anonymous, 2001e. The Forestry Sector in Guyana. Guyana Forestry Commission, DFID "Support to the Guyana Forestry Commission" Project.

A comprehensive and most informative review of the sector. Most sectors are covered, with an emphasis on the forest industry and its role in the conomy of Guyana.

Anonymous, 2002a. Code of Practice for Timber Harvesting, Second Edition. Guyana Forestry Commission.

A comprehensive set of guidelines for selective logging that cover, planning, operational inventory work, areas to exclude from harvesting, construction works, logging, post-harvest activities, operational- and camp hygiene, health and safety as well as social issues. The code stipulates operations of high standards.

Anonymous, 2002b. Guyana Timber Grading Rules for Hardwood. Guyana Forestry Commission.

Guidelines and instructions on grading logs. A useful document that presents commercial timber trees of Guyana and their properties.

Anonymous, 2002c. Guyana Initial National Communication in Response to Its Committments to the UNFCCC. Government of Guyana.

Guyana has signed the United Nations Framework Convention on Climate Change (UNFCCC). This document is its first national communication. The base year for this communication is 1994

The Holdridge classification system was used together with the climate scenarios to determine thepossibility of change in the sector. With a doubling CO2 concentration, indications are that the forests in southern Guyana may be affected with the shrub savannah spreading southward to replace tall evergreen forest. With a tripling CO2 concentration, the same areas can be affected. However, the northwest may also be affected by a change to shrub savannah types. Again, the sensitivity analysis must be guided by further studies.

Anonymous, 2002d. Analysis of the Forest Industry in Guyana. Forest products Association of Guyana. Vijay Rambrich and Associates.

A publication where concern is raised about the regulations that have started to be enforced by the Guyana Forestry Commission. It is pointed out that concessions are too short to allow a concessionaire to benefit from investments in sustainable forestry.

Anonymous, 2003. Achieving the ITTO Objective 2000 and Sustainable Forest Management in Guyana – Report of the Diagnostic Mission. ITTO 34:th Session, Panama City, Panama.

In broad terms, the forest resource of Guyana is under fair control and a good framework has been created within which sustainable management of the resource is possible. If this is to be achieved, then revenue must be generated through equitable and profitable commercialisation. This has yet to be achieved.

Anonymous, 2004. Legal and institutional framework for SFM. Guyana Forestry Commission.

The objectives of a national forest policy and related legislation are presented. Legal framework and institutions connected to forestry are reviewed. Management and silviculture are briefly presented.

Anonymous, 2005. Status of Tropical Forest Management 2005. ITTO.

A position paper addressing the global quest for sustainable management of tropical forest. The publication has a chapter on Guyana.

It is concluded that Guyana has introduced and implemented a well-designed forest management and control system in its timber production forests. However, there is a gap between the well-functioning core

staff of the GFC and the industry that has to implement forest management in the field. Political and social uncertainty, lack of secure tenure, lack of understanding and awareness, lack of skilled labour.

Anonymous, 2007a. Forestry in Guyana 2007. Leaflet issued by the Guyana Forestry Commission.

A useful and well written compilation of essential forestry data and development trends from Guyana.

Anonymous, 2007b. All that Glitters: Gold Mining in Guyana. The Failure of Government Oversight and the Human Rights of the Amerindian Communities. International Human Rights Clinic, Human Rights Program, Harvard Law School.

A critical review of gold mining in the interior of Guyana. Special attention is given to the Amerindian population. The report focuses more on social than on environmental issues.

Anonymous, 2008a. The Chainsaw Milling Project. Project Update No. 1. Chainsaw Milling Project Guyana.

A brief description of an project to assist selected forest dependent communities.

Anonymous, 2008b. Creating Incentives to Avoid Deforestation. Office of the President, Republic of Guyana.

An analysis of what will be needed to align the economic interests of tropical forest countries with those of the broader world community. This analysis starts with the premise that mechanisms can be designed to make participation economically rational for rainforest countries. It offers four contributions to a deeper understanding of how to make REDD effective and fair:

The 'economically rational' deforestation baseline
Economic Value to the Nation
Boundary conditions for a long-term deal
Future outlook

Anonymous, 2009a. Forest Products Development and Marketing Council of Guyana Inc (FPDMC).

A presentation of the organisation, its background and its main objectives.

Anonymous, 2009b. Deforestation and Forest Degradation in Guyana. Quick Assessment Paper. Guyana Forestry Commission.

No national approach to assess forest carbon stock has been developed or implemented in Guyana. There needs to be a methodological assessment model developed to assess forest carbon stock at the national level drawing in some way, on the resources and results of already initiated.

Mining seems to be the single most major cause of degradation within the SFE. Approximately 24, 428 ha of forests was cleared due to mining activities and another 21, 903 ha of forests was cleared for agriculture. The most degraded forests areas are found in the North-West region of the country, which is traditional known to have the highest concentration of mining concessions.

Anonymous, 2009c. WWF Guianas Position paper on the status Greenheart. WWF Guyana.

WWF of Guyana is concerned that greenheart is not sustainably harvested. Data is shown to support this. WWF wishes to see strict enforcement of the Code of Practice for harvesting. Moreover greenheart needs to be protected in special areas inside the concessions.

Anonymous, 2009d. WWF'S Position Paper on Carbon. WWF Guyana.

WWF pledges support for the current efforts by the government of Guyana to launch a REDD mechanism.

Having recognized that the Kyoto Protocol does not take into consideration compensation for developing countries with large areas of standing forests with respect to climate change and that the REDD proposal has no relevance to its current situation, Guyana advanced its proposal founded on: (a) Opportunity Cost Consideration, (b) Environmental Services Consideration, and (c) Scientific Data Consideration.

Anonymous, 2009e. Consultations Summary – Guyana. Climate Change, REDD and the FCPF Programme. Guyana Forestry Commission.

A document including a presentation made to the communities. Responses and comments by communities and stakeholders are also found in the document.

Anonymous, 2009f. Forest Carbon Stock Assessment. WWF Guianas, Guyana Forestry Commission (GFC) (Agreement No: KR-43) Interim Technical Report. Period February 1, 2009 – March 31, 2009.

A document outlining a co-operation between the Guyuana Forestry Commission and World Wildlife Fund to national measurement and monitoring of forest carbon stock in Guyana.

Bholanath, P., 2009. Area Converted. Internal Communication, Guyana Forestry Commission.

Based on wall to wall coverage of satellite images at 30m resolution (Landsat) the areas converted by drivers are as follows. 54, 210 ha of degraded forest area and 2626 km of forest roads exist. Mapping was done to determine this over the period 2007 and 2008. 34, 044 ha of degraded forests are found within the State Forest Estate. 24, 428 ha of forests was cleared due to mining activities and another 21, 903 ha of forests was cleared for agriculture. The most degraded forests areas are found in the North-West region of the country, The occurrence of roads is significant in the central and north-west regions of Guyana. About 80% of official forest roads are concentrated in these areas, particularly in the large concession lease areas.

Bollers, J., 2007. An Assessment of the Self Recovery Potential of Mined Sites. M.Sc. Thesis, University of Bangor.

Primary succession was studied to assess the potential for self-recovery and site native species establishment in areas degraded by mining in Guyana. Twenty mined sites abandoned for periods ranging from 2 to 60 months old were selected.

Natural regeneration can be for site restoration. If the objective is to restore vegetative cover, natural regeneration without assistance is possible. On the other hand, if the objective is to restore sites to conditions prior to mining with native species regeneration, natural regeneration coupled with other site restoration methods, is needed.

Bollers, J., Plouvier, D., Schanzenbaecher, M., Viera, R., Williams, A. And Williams P, 2008. Environmental conservation in Guyana: Selected Publications. World Wildlife Fund.

A number of studies on human health aspects of water quality, mining, forest management and the potential of carbon credits.

Brouwer, L.C., 1996.Nutrient Cycling in Pristine and Logged Tropical Rain Forest. A Study in Guyana. Tropenbos – Guyana Series 1.

A research report that concludes that sustainable timber extraction from rain forest can be sustainable in Guyana. Logging should be carried out so that large gaps (200 to 500 square metres) are avoided and that skidder movement is held at a minimum.

Clarke, G., 2006. Law Compliance and Prevention and Control of Illegal Activities in the Forest Sector in Guyana. Preliminary Report Prepared for the World Bank. World Bank, Washington DC.

This rapid assessment suggest that illegal logging and noncompliance does occur in Guyana though probably at a far lower rate in comparison with other countries. The legislative, policy, governance and regulatory framework is considered to be generally well developed and largely effective in encouraging legality and best practices in the forestry sector. The issue of land and resource access is one that should be on the table for discussion at appropriate fora

Cotula, L. and Mayers, J., 2009. Tenure in REDD. Start point or afterthought. Natural Resource Issues No. 15. International Institute for Environment and Development. London, UK.

A document on tenure issues. Guyana's legal framework is considered comprehensive. Implementation is however lacking. This applies to tenure issues as well and forestry practices. Future major increases in mining is a concern. Amerindian issues are paid much attention in the report.

Ek, R.C. (Editor), 1997. Botanical Diversity in Tropical Rain Forest of Guyana. Tropenbos – Guyana Series 4.

A set of studies mainly addressing management of *Chlorocardium rodiei* (greenheart) rich forests. Logging intensity is found to be a most important part of Reduced Impact Logging. Gap creation should also be held at a minimum, greenheart is a shade tolerant species. Some post-logging treatment may be called for to control vine infestation.

Fanshawe, D.B., 1952. The Vegetation of British Guiana – A Preliminary review. Imperial Forestry Institute, University of Oxford.

A classical account of the vegetation of Guyana. Forest types (six of them) are defined; rain forest, seasonal forest, dry evergreen forest, montane forest, marsh forest and swamp forest. Numerous subtypes are also defined.

Hagner, M. & Maluenda, J. (Editors), 1997. Workshop on Sustainable Forest Management in Tropical Forests. Orgut Consulting AB.

A course programme including lecture notes. Volume estimates for two forest types are included.

Harrisson, M.J.S., Allen, E. & Sutton, G., 1993. Barama Company Limited. Northwest Guyana Sustainable Forest Programme. Environmental and Social Impact Assessment. Edinburgh Centre for Tropical Forests.

A document where the Barama concession is scrutinised for resources, demography, land uses and local economy. Social and environmental impact assessments are made. Government and Barama responsibilities are defined.

Hays, P. And Vieira, R., 2004. Mercury Contamination, a Legacy to Handicap a Generation. Technical Paper Series 2. WWF Guianas Regional Program Office.

Documentation of detrimental effects of mercury are reviewed. The mining sector is described. The importance of awareness and implementation of improved mining technology is stressed.

Hilson, G. And Viera, R., 2007. Challenges with minimising mercury pollution in the small-scale gold mining sector: Experiences from the Guianas. Journal of Environmental Health Research 17(6): 429-441.

A study that concludes that a harmonised mercury policy in the region is an important tool to control mitigation of the substance. This needs to be combined with education campaigns among miners. Outlets providing equipment for mercury free mining are also needed.

van der Hout, P., 1999. Reduced Impact Logging in the Tropical Rain Forest of Guyana. Ecological, economic and silvicultural consequences. Tropenbos – Guyana series 6.

A reduced impact logging system that also includes tree selection is proposed and tested. Gap avoidance is stressed. Economy of the system proposed is assumed to be at least equal to traditional logging.

Jetten, V.G., 1994. Modelling the Effects on the Water Balance of a Tropical Rain Forest. A study in Guyana. Tropenbos Series 6.

Given low extraction rates logging seems not to affect given low extraction rates logging seems not to affect the hydrology of an area studied. Albic arenosols are more affected than other soils.

Killeen, T., *et al.*, 2009. The Use of GIS in Estimating Deforestation, Forest Degradation and Estimation of GHG Emissions from Reference Scenarios in Guyana. Biodiversity Mainstreaming through Avoided Deforestation. Guyana Case Study (BMAD-GCS) Project (GY 1058) Technical Paper B. Conservation International.

Four REDD scenarios are analysed. The scenarios indicate that even relatively small changes in deforestation rates can lead to large differences in emission of greenhouse gases. Models used are critically reviewed.

Lowe, S. And Viera, R., 2008. Situation Analysis of Small Scale Gold Mining in Guyana. World Wildlife Fund – Guianas Program.

Analyses on a broad scale of environmental and human concequences of small scale mining, particularly for gold. Methods for environmental improvement are proposed.

Nokta, S. Clarke, G., 2005. Forestry Sector Environmental Assessment. Guyana Forestry Commission.

The document is part of an effort to streamline planning and management in the forestry sector. Mechanisms for planning and management of operations, legal and institutional framework and the system for environmental permits are in special focus.

Tracey O., T. & Clyde, K., 2005. Carbon offsets as an economic alternative to large-scale logging: a case study in Guyana.

The results of this case study illustrate the cost effectiveness of alternative land-use options that reduce deforestation and associated greenhouse gas (GHG) emissions. This analysis demonstrates that using Guyana's rainforests for climate change mitigation can generate equivalent revenue to that of conventional large-scale logging without detrimental environmental impacts.

Outboter, P., Landburg, G., White, C., Mol, J., van der Lugt, F., Quik, J. and Viera, R., 2007. Mercury Pollution in the Greenstone Belt. World Wildlife Fund. Guianas Regional Program.

An overview of the mercury pollution in the Greenstone belt, where most of the gold mining occurs. Control site outside the study area were used. Human consumption of predatory fish is cautioned against.

Pennington, T., 1993. The Commonwealth and Governnment of Guyana Iwokrama Rain Forest Programme. Botanical Studies. Chatham, UK. Natural resources Institute.

A botanical survey of the Iwokrama area is presented. Forest types and land systems are also described and mapped.

Price, S., 2004. Investigating logged Wallaba Forests in Guyana. Guyana Forestry Commission/World Wildlife Fund for Nature.

A short descriptive study of Wallaba forest. Seedlings were abundant after logging. Low growth rates of wallaba however will make rotations long.

Rose, S.A., 2000. Seeds, Seedlings and Gaps - Size matters. A Study in the Tropical Rain Forest of Guyana. Tropenbos – Guyana Series 9.

A comparative investigation indicates that shade tolerant species are greatly favoured by Reduced Impact Logging. This is somewhat surprising in view of the minor differences ingap creation. A possible explanation could be reduced cruising in the forest by skidders and crawler tractors, i.e. less soil compaction.

van der Sanden, J.J., 1997. Radar Remote Sensing to Support Forest Management. Tropenbos – Guyana Series 5.

It proved difficult to distinguish logged over forests from unlogged forests in Guyana using radar remote sensing. Roads are the most easily observable indicators of selective logging. Remote sensing is only as good as its ground truthing.

Schoch, D., *et al*. 2009. Monitoring Forest Carbon in the Georgetown – Lethem Road Impact Corridor. Biodiversity Mainstreaming through Avoided Deforestation Guyana Case Study (BMAD-GCS) Project (GY-T1058). Technical Paper C. Conservation International.

An evaluation of environmental concequences of the project to greatly improve the road between Georgetown and Lethem. The report outlines a forest carbon measurement and monitoring framework that gives estimates with known precision.

Singh, J., 2007. Keeping Track of Guyana's Logs. ITTO Tropical Forest Update 17/2, 2007

An audit of Guyana's log tracking system is presented. It was found that the mechanisms necessary for a robust chain of custody are in place, but must be strengthened in order to ensure legal trade in all forest products.

Singh, J., 2008. *Et al*. The Forest Carbon Partnership Facility (FCPF).Readiness Plan Idea Note (R-PIN). Government of Guyana.

A state of knowledge and readiness assessment before starting work to launch a REDD mechanism. An informative and well written document.

Singh, J. *et al*. 2009. Readiness Plan. Guyana Forestry Commission

The document is a detailed plan on how to make Guyana ready for REDD. Deforestation rate in Guyana is 0.1% to 0.3% an average above-ground stock of 340 t CO_2e per hectare, and an additional 20% of biomass below ground, Deforestation and degradation occur mainly in the State Forest Estate where logging, mining and agricultural activity co-exist, as well as in the forests on Amerindian and other private lands.

The plan is designed to allow national evaluation and quantification of carbon stocks as well as develop a framework of monitoring for these carbon stocks.

Sizer, N., 1996. Profit without Plunder. Reaping Revenue from Guyana's Tropical Forests without Destroying Them. World Resources Institute.

Identifies key steps Guyana can take for sustainable forestry management, providing both concrete proposals for immediate and long-term action and a comprehensive analysis of the country's forestry programs to date.

Ways to enhance income from the traditional timber industry and from such alternative forest-based development as tourism, genetic resource harvesting, and non-timber forest products are explored

ter Steege, H., *et al*., 1996. Ecology and Logging in a Tropical Rain Forest in Guyana. With recommendations for forest management. Tropenbos Series 14

Four years of study in Mabura Hill. Contains practical recommendations to minimise damage to residual trees and soil. Non-supervised selective logging causes large amount of damage, mostly through skidding. Careful and supervised operations cause only acceptable damage.

ter Steege, H., 2001. Biomass Estimates for Forests in Guyana and Their Use in Carbon Offsets. Research Report 2001-01. Iwokrama. International Centre for Rain Forest Conservation and Development.

The report assesses carbon stocks in the rain forests of Guyana and their potential for carbon offsets. Estimates are made for different forest types. Reduced Impact Logging is found to reduce carbon emissions substantially.

ter Steege, H., *et al*., 2003. Long-term Changes in Tropical Tree Diversity. Studies from the Guiana Shield, Africa and Melanesia. Tropenbos Series 22.

Studies of tree diversity in Suriname indicate that the tree community is resilient against logging. Species diversity was found to be more affected by silvicultural treatment.

Tree communities in Guyana are generally shade tolerant. Logging changes that, as pioneer species benefit from the disturbance. Long-term effects warrant further study. Pioneer invasion seem positively correlated to harvesting intensity.

Chlorocardium rodiei (greenheart) abundance was studied in an area of 800 square kilometres. The species had after almost 80 years not recovered. Other species were less affected by selective logging.

van Ulft, L.H., 2004. Regeneration in Natural and Logged Tropical Rain Forest. Tropenbos Guyana Series 12.

A set of studies on seed dispersal and regeneration in tropical rain forest in Guyana. A conclusion is that although logging can make stimulate seed production of single trees, the limited dispersal of seeds from non-pioneer species suggests major concequences for regeneration of these species. To offset these effects it is proposed that seed trees are retained. Gap creation should be held at a minimum in the interest of *Chlorocardium rodiei* (greenheart) regeneration.

Thomas, R., 2001. Forest Productivity and Resource Availability in Lowland Tropical Forests in Guyana. Tropenbos – Guyana Series 7.

A comparative study of forest stand dynamics encompassing four forest types. With the relatively low extraction rates in selective logging in Guyana (rarely more than 50 m^3), it is spatial distribution of trees felled that matters more than volume cut. The species most sought for *Chlorocardium rodiei* (greenheart) often occurs in clusters. Greenheart logging can thus cause large local disturbance. The seemingly modest canopy openings caused by logging can have great effects on the understorey vegetation. No significant changes in leaf, woody and reproductive litter were found after selective logging (15 m^3 removed per hectare on a Brown Sand plot).

Trevin, R., 2007. Procedures for Establishing Permanent Sample Plots for Forest Monitoring in the Iwokrama Forest. Iwokrama International Centre for Rainforest Conservation and Development.

A report that gives an account of methodologies used in establishing a network of permanent sample plots in Iwokrama conservation area. A section is dedicated to measurement of carbon.

Trevin, R., 2009. Establishment of Permanent Sample Plots (PSP) in the Iwokrama Forest. Final Report. Iwokrama International Centre for Rainforest Conservation and Development.

Presentation of the permanent sample plots at the Iwokrama concession. Plots are 100 m x 100 m square plots, divided into twenty five 20 m x 20 m subplots. All trees larger than 20 cm dbh are measured. Smaller trees of the pole (5 cm to 19.9 cm dbh), sapling (2 cm to 4.9 cm dbh) and seedling (+ 30 cm height) categories are measured in special subplots of the main plot. Plots are located in areas to be logged in a near future and in reserve areas where no logging is planned. Plot location takes into account forest type. 13 plots have been established.

Vieira, R., 2006. Mercury-free gold mining technologies: possibilities for adoption in the Guianas. Journal of Cleaner Production 14(2006): 448-454.

The rudimentary mining techniques used in the Guianas involve large amounts of water and the use of mercury. Mercury free techniques are considered imperative. Such techniques are reviewed in the study.

Vieira, R., 2008. The Banning of Mercury Exports from the European Union and the USA: - Implications for Small and Medium and Medium Scale Mining in Guyana. Leaflet from WWF Guianas.

The leaflet describes how mercury is used in mining in the Guianas. The effects of this use are summarised. An international review of work done on mercury is also provided. It is hoped that restrictions will help reduce the use of mercury in Guyana mining.

Vieira, V.S., 1980. Logging in Guyana and Considerations for Improvements. Guyana National Printers.

A production oriented short textbook on logging in tropical forest. Highly informative and excellent reading for newcomers to the subject.

Williams, P.E., Parry, J.T. & Eden, M.J. (editors), 1997. Land Use, Land Degradation and Land Management in Guyana. Commonwealth Geographical Bureau.

A textbook with essays on the history of, and current patterns, land use and land degradation in Guyana. Monitoring techniques are also given attention.

Wright, H.L., 1999. Consultancy Report on Forest Inventory. Guyana Forestry Commission Support Project.

A review of past inventories of Guyana. Current procedures presented as well as the use of results. Recommendations regarding analysis and reporting results are found. Recommendations for future work are made.

MRV Working Papers series

WP Nr.	Title	Date
01	*Role of satellite remote sensing in REDD by Peter Holmgren*	13 October 2008
02	*REDD-Workshop Monitoring, Assessment and Verification (report of the Washington meeting)*	16-17 September 2008
03	*Review of literature on monitoring to support REDD by Claudia Hiepe, Hideki Kanamaru*	16-17 September 2008
04	*Carbon Stock Assessment and Modelling in Zambia. A UN-REDD programme study by Kewin Bach Friis Kamelarczyk*	September 2009
05	*Measurement and Reporting of Forest Carbon in Suriname: Preparing for REDD Implementation by Jonas Cedergren*	2009
06	*Measurement and Reporting of Forest Carbon in Guyana: Preparing for REDD Implementation by Jonas Cedergren*	10 July 2009