ESTIMATION OF THE CARBON SEQUESTRATION POTENTIAL OF BELIZE

Potential areas for forest mitigation under the Clean Development Mechanism (CDM)

The first step to measure the potential of the national forest sector to mitigate climate change is to identify areas, which are eligible as potential project sites. Under the definition of forest given in the Kyoto Protocol, the areas must have been deforested before 1990. To determine these areas, maps of land use or forest cover up to 1990 are utilized to show the extent of the deforestation until that point.

In the Belizean context, none of the available maps covered exactly that period, with the closest being the Land Use Map of Fairweather and Gray that covered the period 1989-1992, therefore it was used.

Data extrapolated from the Land Use Map show that up to 1989 about 217,241 hectares or 10% of the national land area had been deforested for agriculture, which was far and away the main reason for deforestation in the country. Of the dedicated agricultural area most was being used for annual crops, sugar cane, shifting cultivation and pastures. It is important to note that many agricultural operations were mixed farming systems in which the objective is for the production of more than one agricultural commodity.

Some of the areas deforested prior to 1990, has been left to reforest naturally while other areas have been reforested through human interventions (e.g. plantation forest). The Kyoto Areas are all those regions deforested up to the end of 1989, minus any areas reforested in the intervening time period.

Table 12
LIC agricultural land use
(1989)

Description		Count	Hectares
Annual Crops	Agriculture	212	21608.631
Annual Crops + Pasture	Agriculture	19	24982.250
Annual Crops - Non Mechanized	Agriculture	98	19606.663
Banana	Agriculture	9	2457.370
Cashew	Agriculture	2	33.539
Citrus	Agriculture	121	12947.946
Clearing for Agriculture	Agriculture	93	2941.437
Cocoa	Agriculture	1	201.531
Mango	Agriculture	2	1654.088
Pasture (Improved & Un-improved)	Agriculture	13	805.696
Pasture (Improved & Un-improved)	Agriculture	320	28480.523
Shifting Cultivation (Milpa)	Agriculture	464	37162.236
Shrimp Farming	Agriculture	5	252.925
Sugar-cane	Agriculture	35	42196.670
Sugarcane + Thicket	Agriculture	31	21909.923
Total agricultural area Deforested up to 1989		1,425	217,241.410
Less Areas Reforested since 1989			34,763.000
Total Kyoto Areas			182,478.000

Kyoto Areas with real mitigation potential under the established criteria

Not all the Kyoto Areas will have real potential as sites for reforestation projects. The four largest agro-industries are sugar, citrus, banana and livestock production, however the annual crops plus sugar, citrus and banana cater to more or less stable markets. Although the prices for these commodities are mostly depressed, it is unlikely that areas occupied by these crops will be dedicated to any other land use for the time being, barring any unforeseen and sustained market turbulence.

This does not mean that some of the areas dedicated to these crops will not become fertile grounds for reforestation projects. Some farmers who are disillusioned with the current low market prices may decide to go into reforestation projects, providing there are suitable incentives to do so. There are also some areas occupied by agricultural enterprises, which lie on marginal grade IV and V land. In times of slim profits, it is easy to envision the owners of these parcels warming to reforestation projects under the CDM, given the high input of resources that these areas require to be productive under their existing production regime.

Pastureland may offer better opportunities for reforestation projects, especially where the production regime is under unimproved pastures. A good, but undetermined area of this grazing land, has been left to reforest naturally around the country. On the other hand, the improved pastures, given the high level of management investments, their tendency to be located on better soils and their relative profitability are not expected to become prime candidates for CDM projects.

Areas occupied by annual crops (usually mechanized such as for rice, corn and beans) should be regarded as dedicated long term usage. It is not expected that a sizeable portion of these areas will be available for reforestation projects. The trend to date is for annual crop producers to diversify their production into other agricultural cash crop production when the existing one experiences unfavorable market conditions.

In the case of the tree crops (e.g. cashew, mango but not including citrus) it is not expected that any of these areas will be available for reforestation projects given that they already have a high content of sequestered carbon locked into their biomass. These areas should be discounted completely. The flow dynamics of anticipated land use changes is summarized in Table 16 (further).

Areas with biophysical potential for reforestation projects

The identification of deforested areas with biophysical potential was determined by overlaying the Map of Land Use prior to 1990 onto the Map of Soil Potential. In the case of Belize, the Map of Soil Potential divides land into five classes on the basis of their relative agricultural values. This is not in agreement with the soil potential maps used in most of the countries in the region, where the groupings are in eight classes. An effort was made in this study to reconcile the national soil potential maps with the FAO maps to facilitate the regional analysis.

In this study, grades I and II soils were included as potential areas for reforestation projects under the CDM on account of low population density and the fact that land pressures for agricultural expansion on the better soils is not severe enough to warrant their exclusion. This is definitely the case in the Belize River Valley area, which has a sizeable territory of unutilized grade I and II land. It is therefore reasonable to conclude that reforesting these areas would not necessarily lead to deforestation later on to liberate the land for agriculture. It is important to note that other significant factors will however come into play, which will reduce the biophysical potential.

Table 13
Biophysical potential of the national Kyoto Areas

FAO Classes	Class 1	Class 2	Class 3 &4	Class 5&6	Class 7&8
National hierarchical Structure	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
Annual Crops	11,197	29,726	11,410	10,424	2604
Banana	663	97	304	136	77
Citrus	6,927	1,970	911	1035	1832
Clearing for Agricultural Expansion	267	486	904	422	676
Pasture	5,131	8,304	8209	5037	2203
Shifting Agriculture	4,587	6,073	10,057	9414	4112
Aquaculture	-	-	4	-	249
Sugar Cane	-	50,172	2906	7288	3558
Other Tree Crops	199	-	-	-	1641
Total	28,972	96,830	34,708	33,760	16957

Key: purple = high potential; green = medium potential; light green = low potential

Areas with socioeconomic potential for reforestation projects

To determine the potential project areas for CDM activities, a third map was overlaid on the Land Use/Soil Potential Map. Unfortunately no recent maps showing socioeconomic parameters exist within the country and any attempt to produce such maps would have been time consuming and expensive. The socioeconomic map produced for this study uses data derived from the most recent housing and population census conducted in 2000 and released in 2001. The map has 3 layers namely population density, poverty levels and educational attainment levels for the national population. It was therefore decided to show the available data only at the district level, instead of as for discrete and overlapping locales (e.g. at the community level). Because of this, the map of population density should be viewed with caution. Although it correctly reflects population density at the district level, it does not accurately reflect population density on the ground. For example, the Toledo and Cayo districts have a large proportion of their vicinity under protected areas designation where there are no permanent human settlements. In the same vein the Belize district would be one of the most sparsely populated districts in the country since it has only small areas under protection and most of the population (72%) lives in Belize City. These were overlaid to get a single map of socioeconomic potential.

Assessing the socioeconomic potential at the district level is allowed under the methodology in the absence of available maps showing more discrete categories.

An analysis of the Socioeconomic Map shows that the Toledo district is the zone of highest socioeconomic potential in all three areas having the lowest population density and the least favorable human development indicators. The Stann Creek and Cayo districts also show favourable socioeconomic potential to host CDM projects.

In determining the potential project areas, a matrix was prepared showing land use and soil potential in all grades (I, II, III, IV and V). Land uses in the deforested areas were combined into seven broad groups and their biophysical potential as sites for CDM projects were evaluated. The basis for this assessment comes from the Land Use Maps for 1989 and 2001 Ministry of Agriculture's Annual Report for 2000-2001, and the Forest Department's Report contained in the Ministry of Natural Resources'

Annual Report spanning the period 2000–2001 along with relevant statistical data provided by these ministries and the Central Statistical Offices. Once the biophysical potential for the chosen categories was determined, the Biophysical Map was superimposed on the Socioeconomic Map. The resulting map was graded in three levels of high (15%), medium (10%) and low (5%) potential as is shown in the matrix given in Table 14.

Table 14
Matrix to determine project potential of the Kyoto Areas
(all figures are in hectares)

Biophysical Potential / Socio-economic Potential	Annual Crops	Banana	Citrus	Clearing for Agric.	Pasture	Shifting Cult. (Milpa)	Sugar Cane	Other Tree Crops
Corozal	5% of 3,615 = 181	none	10% of 45 = 5	none	10% of 166 = 17	none	10% of 26,128 =2,613	none
Orange Walk	5% of 23,285 =1,165	none	10% of 42 = 4	10% of 989 = 99	15% of 8,603 = 1,290	5% of 531 = 27	10% of 37,783 = 3,778	none
Belize	10% of 2,549 = 255	none	0% of 1008 = 0	10% of 29 = 3	15% of 2,507 = 376	5% of 162 = 16	none	5% of 101 = 5
Cay o	10% of 22,737 = 2,274	10% of 12 = 1	5% of 1,225 = 62	10% of 586 = 59	15% of 13,726 = 2059	5% of 5,665 = 284	none	5% of 211 = 11
Stann Creek	5% of 1,541 = 77	5% of 808 = 41	5% of 9,986 = 499	10% of 372 = 37	15% of 771 = 116	10% of 3,871 = 387	none	none
Toledo	10% of 11,609 =1,161	15% of 457 = 69	15% of 333 = 50	15% of 777 = 117	15% of 3090 = 464	15% of 23,946 = 3,592	none	5% of 1,526 = 76
Total Potential by Land Use Category	5,113 ha	111 ha	620 ha	315 ha	4,322 ha	4,306 ha	6,391 ha	92 ha

Key: purple = high potential; light green = medium potential; green = low potential

Establishment of the baseline assessment

The establishment of a baseline assessment is important in trying to determine what would have happened in the absence of the proposed project activity. This will enable project proponents to roughly guesstimate the anticipated additionality that will accrue from their proposed intervention.

To determine the baseline value, an inventory of the existing land uses and the extent of these uses are necessary. It is also important an evaluation of the direction and the flow of land use changes for the remainder of the project period (up to 2012). This can only be determined from the historical and existing land use trends but are highly subjective in that attitudes and practices could change overnight for a variety of reasons. Because of this, baseline assessments should be revised periodically. Despite this obvious shortcoming, it is nevertheless the best tool available to assist in the assessment. The historical evidence shows that from 1989 to 1996 approximately 25,000 hectares were being lost to deforestation per annum, while an estimated 5,000 hectares reverted back to forestland yearly. During this period about 2,135 hectares were being dedicated to forest plantations.

This represented an annual change of –1.4% and +0.27% of the total forest area respectively. The historical changes for the other main land use category in the deforested areas is summarized in Table 15 and the projected flows are summarized in the matrix given in Table 16.

Table 15
Historical trends in land use changes

	1989	2001	Change per annum (%)
Pasture land	29,286	86,064	16
Subsistence Agriculture	37,162	57,465	4.5
Annual Crops	66,198	79,481	1.7
Perennial crops	42,525	55,080	2.5

Table 16
Forecast of the direction of land use changes up to 2012
(based on historical use tendencies)

Land Use Type	Present Area (ha)	Anticipated Net Change until 2012 (ha)	Flow Dynamics of the Land Use Sector (expressed as change into hectare per annum)					
			Primary Forest	Secondary Forest	Pasture	Subsistence Agriculture	Annual Crops under mechanized production (corn, rice, beans etc.)	Perennial Export Crops (sugar,citrus and banana)
Primary Forest	1,728,923	- 242,049		4841 (20%)	8,472 (35%)	6,051 (25%)	3,631 (15%)	1,210 (5%)
Secondary Forest	34,763	+ 46,680	467 (10%)		233 (5%)	467 (10%)	233 (5%)	233 (5%)
Pasture	86,064	+ 47,315		710 (15%)			473 (10%)	
Subsistence Agriculture	57,465	+ 16,919		761 (45%)	338 (20%)		85 (5%)	338 (20%)
Annual Crops	79,481	+ 11,069		55 (5%)	166 (15%)			55 (5%)
Perennial Export Crops	55,080	+ 10,463		52 (5%)	157 (15%)		105 (10%)	

In terms of future projection the matrix given in Table 16 must be interpreted with caution since incipient market conditions could drive the production of agricultural commodities in unpredictable directions. On present trends, it is anticipated that the rate of deforestation will continue at existing levels as the population increases and the country continues to rely on a few main agricultural exports. This deforestation however, will not be evenly distributed across the country, but rather will be concentrated in those areas of highest rural population density. The recruitment of abandoned areas into secondary forest is also expected to continue at present levels, but may increase if population dislocation occurs due to accelerated urbanization or if the economic base is transformed due to worker preferences (e.g. people from rural areas commuting into towns for employment opportunities).

Present market conditions dictate a stable market for livestock producers as new export opportunities are found abroad, however there is a high rate of abandonment of unimproved pastures in the country, especially of those occurring on lower value soils. Subsistence agriculture, though being increasingly abandoned by native-born Belizeans, continues to be the mainstay for Central American immigrants who settle in rural areas. With renewed efforts on the part of the government to curb illegal immigration there is a strong possibility for a reduction in the areas dedicated to subsistence agriculture, however the production trends for annual crops will probably stay at present levels or even increase over the next 10 years. Finally deforestation cannot continue indefinitely; eventually after all the forest on the better lands has been removed, the only remaining areas would be locked away in protected areas and presumably beyond the reach of the agents of deforestation.

The situation with the perennial export crops presents the most unstable and unpredictable situation. Market conditions are currently depressed for all three of the big commodities, namely sugar, citrus, and bananas. It is possible that there will be contraction in the area devoted to sugar, if the Bagasse Co-generation Plant does not come to fruition. Bananas, on the other hand, will probably consolidate into larger more efficient operations as the protected trade arrangements, which shielded Belizean banana exports in the past, are removed. Citrus is expected to hold its own over the next 10 years, but neither citrus nor bananas is expected to expand much beyond their existing land coverage, if at all given the un-encouraging market outlook. The real possibility remains that one or two of these major industries will collapse over the next 10 years if their market outlook does not improve significantly.

Quantification of the baseline for the potential project areas

The calculation of the baseline value is based on the identification of areas on the map polygons as potential project areas and the assumption that a certain percentage of these areas will actually be used as sites for CDM projects. The credibility of any proposed CDM project rest on the assumption that the baseline removal of carbon will be lower than for the project activity.

In this study the static approach is used to measure the baseline. This approach assigns static or fix rate for carbon uptake at the start of the project and uses the same rate for the lifetime of the project. The main advantage of this approach from an investor's point of view is that the amount of carbon credits can be estimated before the onset of project activity. The chief deficiency in using the static approach is that long-term projections may not accurately reflect carbon uptake hence the need to periodically update the baseline assessment.

The area for the baseline is obtained from the values assigned in the matrix of socioeconomic potential, land use and soil potential given in Table 17. The values given in the matrix are based on the historical use tendencies of the area and on the current market conditions for the existing land uses, which is expected to have a major bearing in determining future land uses.

Table 17
Matrix to determine the baseline of potential project areas

Areas Differentiated by Socioeconomic Potential	Soil Potential and Equivalence				
FAO Classes	Class 1	Class 2	Class 3 &4	Class 5&6	Class 7&8
National Hierarchical Structure	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
Corozal – large sugar cane plantations characterize this area, although there is now some diversification into export crops such as papaya. Negligible evidence of reforestation			5%	10%	15%
Orange Walk – This area is also dominated by large sugar cane plantations but to a lesser extent. Large farms with annual crops and pastures also occupy a significant area, some reforestation but on small scale		5%	10%	10%	15%
Belize – Deforestation for agriculture is very small in this area, most of the farms are small and are geared to subsistence farming or pastures, negligible reforestation so far	5%	10%	10%	5%	5%
Cayo – This area contains large pastures, as well as sizeable areas of annual crops and some citrus, some reforestation, farmers are receptive for environmental and economic reasons	5%	5%	15%	15%	5%
Stann Creek – This area is dominated by large citrus and banana farms and to a lesser extent shifting cultivation, very little reforestation	5%	5%	10%	15%	5%
Toledo – This area has some banana farms but is best known for subsistence agriculture based on shifting cultivation, substantial interest in agro-forestry and reforestation.	10%	15%	15%	15%	10%

There is no data on carbon sequestered in the various types of agricultural operations in the country, and therefore in the analysis of the baseline values a generic rate of 10 tons of carbon per hectare of pastureland is used, while a higher figure of 20 tons of carbon per hectare is assigned to cultivated fields such as those producing annual crops like rice and corn. In higher yielding citrus plantations is assigned a value of 25 tons of carbon per hectare. In areas where the necessary field data for carbon values exist the formula used in this project is:

Baseline Carbon Value = Area * Incremental growth (Annual Average) * density (0.6) * 50%

In the formula above the annual increment given at the start of the project is the same for each of the remaining years of the project (static approach).

In Table 18 an area was assigned to each of the major land use categories that were deforested prior to 1990. Based on historical use tendencies a percentage of each of the areas was assigned a value according to the probability that a portion would be used for reforestation projects. It should be mentioned that historical use tendencies alone is not a good gauge to measure the acceptability of landowners in Belize to reforest since previous to now there has been little or no economic incentive to do so; a situation that will change with the introduction of CDM projects. Although the analysis varies a pattern is clear: the densely populated heavily farmed, northern region has the least potential in terms of dedicating its better soils to reforestation. Since good land is at a premium it is easy to imagine that most of the land given over to reforestation in the northern region will be the most marginal and unproductive type. The southern region is the antithesis to this, with many smallholders, and an agricultural base that is mostly subsistence, but with a strong tradition for reforestation, especially in Toledo. The central districts present an intermediate value between the northern and southern potential.

In the analysis to determine the baseline value in Table 18, only the deforested areas for land uses of more than 750 ha. is utilized with the reasoning that smaller areas for any reforestation project would be uneconomical and would complicate the analysis without producing tangible benefits for the outlook of CDM projects. It should be borne in mind however, that no area that qualifies under the CDM criteria can be disqualified by this report, and the information given here is geared solely at giving the regional body a credible analysis of the potential of the national forest sector to mitigate climate change.

Table 18
Baseline assessment for the potential project areas

Map Polygon (as production regime)	Area Under Production	Estimated Percentage Area Available for Reforestation Projects	Carbon per Hectare (Tons)	Total Carbon Sequestered per Baseline Category
1. Corozal				
Sugar Cane	26,128	10%	20	52,256
Annual Crops	3,615	5%	20	3,615
2. Orange Walk				
Sugar Cane	37,783	10%	20	75,566
Annual Crops	23,285	5%	20	23,285
Pasture	8,603	15%	10	12,906
3. Belize				
Annual Crops	2,549	10%	20	5,098
Pasture	2,507	15%	10	7,521
Citrus	1,008	0%	25	
4. Cayo				
Annual Crops	22,737	10%	20	45,474
Pasture	13,726	15%	10	20,589
Shifting Cultivation	5,665	5%	20	5,665
Citrus	1,255	5%	25	1531
5. Stann Creek				
Citrus	9,986	5%	25	12,483
Shifting Cultivation	3,871	10%	20	7,742
Annual crops	1,541	5%	20	1,541
Banana	808	5%	20	808
Pasture	771	15%	10	1157

Potential project activities feasible under national circumstances

The practice of reforestation is not common in Belize, given the relatively low deforestation levels within the country and the low priority accorded to this activity by the national institutions. To date, most reforestation work has taken place in response to natural disasters such as after hurricanes or diseases, which have decimated forest stands, as is currently the case with the pine forest of the Mountain Pine Ridge Forest Reserve. In the few instances where forest plantations have been established in the past they have been plagued with diseases and insect pest. The practice of establishing agroforestry plots is slowly catching on now. There is currently a major initiative in the south under the CARD project, which is targeting the small farmers. Besides this, the Ministry of Agriculture, the Programme for Belize and Trees Belize are spearheading other notable initiatives in the northern and western regions of the country. Whereas no human induced reforestation plots were recorded on the 1989 Land Use Map, the Ecosystems Map of 2001 recorded 2,135 ha. of plantation forest.

There is currently no government incentive for private landowners to reforest their land with timber or any other trees. Most plantation forest are private initiatives, formed with the objective of serving the environmental ethic or as a business move to anticipate future shortages of the high value timber species or as shade for crops such as cocoa and to a lesser extent coffee. This situation will be at least partly addressed within the National Biological Corridors Project, where a big emphasis will be placed on payment for environmental services, and other incentives to promote reforestation, particularly in the context of strengthening corridor linkages. The large open areas in the north of the country have the best layout for large-scale forest plantations; unfortunately, these areas also show the least favorable socioeconomic and biophysical indictors for the establishment of plantations. The areas in the central region of the country including the Stann Creek and Cayo district but excluding the Belize district shows moderate potential for forest plantations having a mix of large farms (mainly pastures, citrus and bananas) and smallholder operations. In the southern region (Toledo) the farms are mainly smallholder and subsistence, however this area has the most credible historical pattern of reforestation and this initial tendency is being nurtured by the numerous conservation NGOs that are active in this area.

The evidence to date suggests that farmers have traditionally been more comfortable with the native, high value species such as Mahogany *(Swietenia macrophylla)* and Cedar *(Cedrela odorata)*, although some exotic species such as Teak *(Tectona grandis)* are gaining in popularity. Market preference is high for Mahogany and Cedar and there is currently a shortfall in production for both woods, which will only get worse in the future. Pine is not being contemplated for reforestation efforts within this project because a tiny portion of the Kyoto eligible areas within Belize were traditionally planted to pine, nor are the soil conditions suitable.

Table 19
Timber tree inventory and sales up to 2001
(Adopted from MAF annual report)

Timber Specie	In Stock Inventory	Seedlings Sold
Teak	7,000	9,333
Mahogany	50	5,721
Cedar	2,225	2,310
Salm Wood	100	228
Mayflower	75	100
Cabbage Bark	200	25

In selecting suitable growing stocks for reforestation projects under the CDM, it is important to look at relevant factors such as soil potential of the areas involved, cultural preferences and market conditions. Even areas with soils of a good grade might not provide all the growth requirements for certain species and therefore it is useful to investigate what species have been grown in the various regions of the country and the results of such efforts. In the interest of maintaining high biodiversity values (a national sustainable development priority) and to ensure good returns from carbon investments in reforestation projects, it is recommended that the system adopted for plantation systems use multiple high value species interspersed between each other to minimize incidences of pest and disease.

Table 20
Plant species with good potential for reforestation projects

Common Name	Scientific Name	Family	Map Identification Polygon	Suggested Production Regime
1. Timber Species				
Mahogany	Swietenia macrophylla	MELIACEAE	Sugarcane, citrus, banana, pasture	Mixed forest Plantations
Cedar	Cedrela odorata	MELIACEAE	Sugarcane, citrus banana, pasture	Mixed forest Plantations
Salmwood	Cordia alliodora	BORAGINACEAE		Mixed forest Plantations
Teak	Tectona grandis	VERBENACEAE	Sugarcane, citrus, banana, pasture	Plantation
Gmelina	Gmelina arborea	VERBENACEAE	Sugarcane, citrus, banana, pasture	Mixed Forest Plantation
Pine	Pinus caribea	PINACEAE	Grade 4 & 5 land only	Plantation
Black Cabbage Bark	Lonchocarpus castilloi	FABACEAE	Sugarcane, pasture	Mixed forest Plantations
Cortez	Tabebuia chrysantha	BIGNONIACEAE	Shifting cultivation	Mixed forest Plantations and Agroforestry and
Sapodilla	Manilkara zapota	SAPOTACEAE	Shifting cultivation	Mixed forest and sustainable forest products systems
Santa Maria	Calophyllum brasiliense	CLUSIASEAE	Shifting cultivation	Mixed forest Plantations
Nargusta	Terminalia amazonia	COMBRETACEAE	Sugarcane, pasture	Mixed forest Plantations and Agroforestry
Yemeri	Vochysia hondurensis	VOCHYSIACEAE	Sugarcane, pasture	Agroforestry
Guam Wood	Schizolobium parahyba	FABACEAE: Caesalpinioideae	Shifting cultivation	Agroforestry
Tubroos	Enterolobium cyclocarpon	FABACEAE: Mimosoideae	Sugarcane, citrus, banana, pasture	Agroforestry
Mylady	Aspidosperma cruentum	APOCYNACEAE	Shifting cultivation	Agroforestry

Estimation of total carbon sequestered under each project activity

The amount of carbon sequestered under each project activity in excess of what would have been sequestered in the baseline, will constitute the additionality of carbon benefits that will be credited to the project. Finding the carbon sequestered per hectare of project activity and multiplying it by the number of hectares in each polygon of the map of potential project sites will determine the total carbon sequestered in these areas.

For Belize there is data available on a single carbon sequestration project conducted in the northwest of the country. However, the measurements are for carbon sequestered in natural forest stands and the carbon credits accrued from emissions avoided (the project prevented the deforestation of an area) and enhancement of carbon uptake due to management interventions, e.g. suppression of wildfires, low impact logging, and so forth.

Based on data initially collected by the project it was estimated that the total carbon stocks sequestered in live and dead vegetation, excluding dead wood, was 153 t C/ha. When soil carbon is added to this value the mean total carbon content raises to 285 t C/ha with a 95% confidence interval and a calculated precision mean of ± 9.6%.

In the 2001 operational period, the system for the inventory of the carbon stocks was revised and instead of using a series of 6m plots, the project proponents decided on a series of nested plots measuring 6m, 14m, and 20m radiuses. The use of these plots over the areas previously covered with the 6m plots produced different results and showed that the total carbon stocks sequestered in live and dead vegetation was 101 t C/ha with a 95% confidence interval and a calculated precision mean of ± 6.1%. When soil carbon is factored into the total the figure rises to 233 t C/ha.

None of the data available from this project has straightforward application to the CDM, since it is assumed that national sustainable development priority will dictate that projects invest in plantations which not only use species that maximize carbon uptake but also add to the national timber stock. Thereby helping to alleviate timber shortages and generate employment and foreign exchange earnings. It is recommended that this "no-regrets" approach be taken, although this should not rule out completely the possibility that certain project proponents might want to reforest naturally creating an indigenous climax forest. Research has shown that such forest, if properly managed can demonstrate high carbon offset values (Univ. Helsinki Tropic. Forest Report, 2000).

Since these results are from the driest life zone of the country (north) it is very difficult to extrapolate them unto the southern forest where it is assumed that the growth rates will be higher due to increased availability of soil moisture due to a much higher rainfall, although this alone cannot account for higher carbon content.

Given that there are no existing reforestation plantation or agroforestry plot in the country where carbon measurements have been taken, a generic value is used for reforestation under both activities. The available data for carbon sequestered for the same species under plantation conditions vary widely throughout the region and therefore any attempt to use such information here would be conjectural. The point is made that as soon as possible; indigenous data should be obtained for forest plantations under Belizean conditions. It was decided instead to use the average of as many different sites as possible to get a representative sampling that could give a useful average for that particular land use type. It is generally believed that forest plantations are lest adept at sequestering carbon than natural forest stands since their overall biomass is reduced by the virtual elimination of the under story and the spacing of trees. For this reason it has been found that plantations at their highest carbon values will only store about 70% of the carbon stocks of the natural forest (Butcher et. al, 2001). Based on this figure if plantations were planted at the project site in north-western Belize, the projected output would be about 65.8 t C/ha, which closely agrees with the median given in Table 21 for reforestation projects.

Table 21 shows the result of an extensive database combined from the literature for five major forestry practices. The table shows the median and interquartile values for the mean storage for the five practices under tropical conditions. The values represent the mean carbon storage (MCS), which is calculated by adding the standing biomass from each year and dividing by the rotation length.

For those practices where the number of studies is equal to or less than five the individual data points are given rather than the median and interquartile scores. The methodology for the calculation of carbon values for this study requires that the highest score (maximum volume) is used which will be 100 t C/ha for planted degraded tropical forest (plantations) and 50 t C/ha for agroforestry plots.

Based on these estimates the proposed carbon sequestered due to project activities are given in Table 22.

Table 21
Average estimated carbon benefits per hectare under different land uses

Practices	Number of Studies	Tropical Forest Carbon (t Cha^{-1})		
	n	median	Q25	Q75
Tropical evergreen (0-1000m)				
Reforestation (plantation)	136	63	30	100
Afforestation	3*	29	46	128
Natural Reforestation	3*	119	195	195
Silviculture	12	34	14	70
Agroforestry	16	30	10	50

Source: WGBU (1998), Winjum and Schroeder (1995), Brown and Gillespie (1989), Spetich and Parker (1992), Goulden *et al.* (1996), Singh *et. al* .(1994), Rutkowski and Stottlemeyer (1993).

Table 22
Projected carbon uptake per project activity

Map Polygon (as production regime)	Area Coverage	Estimated % Area Available for Reforestation Projects	Proposed Project Activity	Estimated Carbon per Hectare (Tons)	Total Carbon Sequestered per Project Activity
1. Corozal					
Sugar Cane	26,128	10%	Mixed Forest Plantation	100	261,280
Annual Crops	3,615	5%	Mixed Forest Plantation	100	18,075
2. Orange Walk					
Sugar Cane	37,783	10%	Mixed Forest Plantation	100	377,830
Annual Crops	23,285	5%	Mixed Forest Plantation	100	116,425
Pasture	8,603	15%	Mixed Forest Plantation	100	129,045
3. Belize					
Annual Crops	2,549	10%	Mixed Forest Plantation	100	25,490
Pasture	2,507	15%	Mixed Forest Plantation	100	37,605
Citrus	1,008	0%		-	
4. Cayo					
Annual Crops	22,737	10%	Mixed Forest Plantation	100	227,370
Pasture	13,726	15%	Mixed Forest Plantation	100	205,890
Shifting Cultivation	5,665	5%	Agroforestry	50	14,163
Citrus	1,255	5%	Mixed Forest Plantation	100	6,275
5. Stann Creek					
Citrus	9,986	5%	Mixed Forest Plantation	100	49,930
Shifting Cultivation	3,871	10%	Agroforestry	50	19,355
Annual crops	1,541	5%	Mixed Forest Plantation	100	7,705
Banana	808	5%	Mixed Forest Plantation	100	4,040
Pasture	771	15%	Mixed Forest Plantation	100	11,565
6. Toledo					
Shifting Cultiv ation	23,946	15%	Agroforestry	50	179,595
Annual Crop	11,609	10%	Mixed Forest Plantation	100	116,090
Pasture	3,090	15%	Mixed Forest Plantation	100	46,350
Grand Total					1,854,078 t/carbon