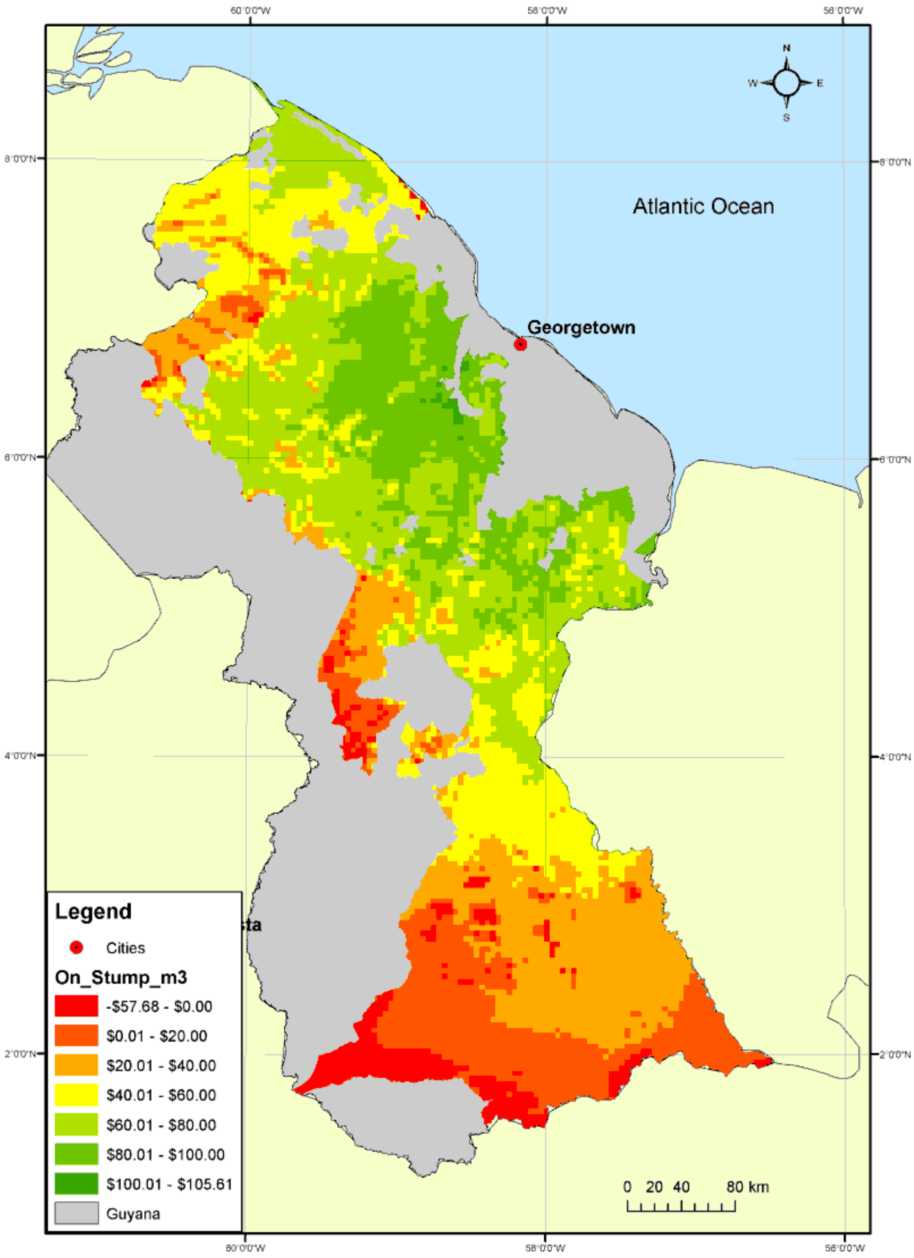
GUYANA FORESTRY COMMISSION

REDDES Monitoring
– Guyana's National Forest Estate Model



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PREFACE

This report is issued by Poyry Management Consulting (NZ) Limited (Pöyry) to Guyana Forestry Commission (GFC) for its own use.

We hope this report proves useful to you and we would be pleased to provide expert assistance to you on future assignments.

This Report forms part of an ITTO/GFC Project: *STRENGTHENING GUYANA'S CAPACITY TO MANAGE FOREST RESOURCES AND ENVIRONMENTAL SERVICES THROUGH RESOURCES ASSESSMENT AND MONITORING CHANGES IN DEFORESTATION AND DEGRADATION, RED-PD 005/09 Rev.2 (F,)* under the ITTO REDDES Thematic Programme.

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SUMMARY

The Guyana Forestry Commission being the State Agency to plan and manage the State Forest Estate has advanced efforts towards enhancing sustainable forest management and strengthening important areas such as legality, forestry industry training in harvesting practices, and considerations for environmental services. The model described in this report addresses Output 1 of Contract GFC-2-24/09/2010 between Pöyry and Guyana Forestry Commission.

The general objective of this project is to strengthen Guyana's capacity to manage forest resource and environmental services through resource assessment and monitoring changes in deforestation and degradation. Pöyry was contracted to develop a high level decision support model to allow for planning and management of these resources under the ITTO REDDES programme. The ITTO Reducing Deforestation and Forest Degradation and Enhancing Environmental Services in Tropical Forests (REDDES) Programme has a strategic focus on reducing deforestation and degradation through sustainable forest management of primary forests and the restoration and rehabilitation of secondary forests and degraded areas with the view of enhancing all the environmental services provided by tropical forests.

This report describes the approach adopted in preparing high level model for conducting, at a demonstration level, an assessment of forest resources and environmental services at the national level. This output will be part of strengthening the GFC’s ability to monitor and report on the rates of deforestation and degradation occurring within the State Forest, whilst strengthening Guyana’s capacity to manage forest resources and environmental services in general.

The model must be considered as a high level national planning tool which utilises a combination of assumptions, and ground data provided by Guyana Forestry Commission. The model enables the estimation of forest resource value across the Forest Estate on the basis of spatial, physical and financial inputs. The spatial inputs are described in the accompanying User Guide. The inclusion of a spatial integration component enables GFC to undertake spatial analysis and interrelationship between identified environment services, stakeholders, and geographic locations of each of these components. This approach allows for scalability and spatial modelling of physical, and financial aspects in implementing financing mechanisms for environmental services.

The key output from this model is the map and tabular data depicting the value range of “On Stump Revenue per Cubic Metre" across the eligible forest estate. It is important to state that these values are given as ranges as they represent a high level analysis at national level. All assumptions are described in an accompanying User Guide.

CONTENTS

1 INTRODUCTION/BACKGROUND

The total land area for Guyana as at 2009[1] is 21.1 million hectares, as determined from ground survey points and supported by mapping from medium resolution satellite imagery.

State Forests administered by the Guyana Forestry Commission (GFC) account for about 12.9 million ha (63% of the land area). Approximately, 52% of state forest has been allocated for timber harvesting. In addition to state forests, a portion of the national forests are titled Amerindian lands (approximately 14% or an estimated 3m million ha).

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The Government of Guyana has advanced its efforts to target a carbon financing mechanism that focuses on maintenance of forest carbon stock whilst allowing sustainable natural resources utilization to continue (including agriculture, mining and forestry). The Low Carbon Development Strategy sets out a development growth path of economically rational scenarios that have a low carbon characteristic and that support development of livelihoods and welfare.

The goal of the model presented in this report is to provide information required for decision-making at national level. This report provides a description of the approach adopted in preparing the model for conducting, at a demonstration level, an assessment of forest resource. This tool contributes to strengthening the GFC's ability to make informed decisions in the allocation of timber harvesting concessions and initial resource value estimation at a macro level.

The model takes into account the current status of resource type distribution (species), transportation networks (both roads and rivers) and identifies potential gaps in transportation network. Where the transportation network is estimated to be absent or inadequate, the costing factors derived from resource valuation data are applied to estimate stumpage values within each unit of assessment. This estimate value therefore considers the cost of developing any infrastructure necessary to extract the forest products from source to destination for each unit of assessment. In this instance each unit of assessment is 4km x 4km in size as outlined in the maps.

Some of the data utilised in the development of the model is derived from a suite of datasets. Additional information is derived from preliminary analysis of high resolution satellite imagery acquired specifically for this purpose. Pöyry has also

[1] The coastal boundary has been edited to account for coastal erosion between 1990 and 2009.

applied assumptions based on expert advice, knowledge, and experiences in similar exercises undertaken in neighbouring countries in the region. Pöyry also undertook field work in the form of over-flights as part of the verification process for both resource assessment and development of model assumptions.

As part of the capacity building, GFC staff are provided with user manuals and training in making adjustments to the model input parameters and input data.

Noting that Guyana's Monitoring Reporting and Verification System for carbon financing considers the identification of initiatives to be undertaken that focus on ecosystem services, demonstrating the range of values and economic benefits to local communities is one aspect considered in designing the model presented in this report. The model is therefore designed in such a manner as to be able to demonstrate spatial relationships between current and future biodiversity elements as defined from time to time including interrelationships with local communities.

This intrinsic interrelationship can therefore be presented in a spatial environment to evaluate the upstream or downstream beneficiaries or communities within, for instance, specific watershed or boundary. With the completion of the mapping of land use and identification of land use change drivers, relationships between these change drivers and corresponding communities can in fact be identified in developing forest carbon financing mechanism. It is however, important to note that the model does not at this stage undertake assessment or valuation of environmental services but is designed with the scalability to do so.

2 METHODOLOGY & DATABASE STRUCTURE

In order to develop a manageable model, Guyana was divided into small units. The number of units was determined based on Pöyry's experience in undertaking similar work as well as limitations associated with using Microsoft Excel. Noting that this model is a high level decision making tool rather than a planning tool, Guyana is subdivided into 10,000 grids of 4km x 4km (1,600ha). The grid size may be varied in future as more detailed information becomes available, for where considerations need to be made for defined environmental services in locations smaller 1,600ha.

An iterative approach was taken to determine the appropriate size for each grid in order that the total number of grids did not exceed the maximum specified above. This resulted in a total of 9,789 grids across the State Forest area.

One main database table has been constructed and is held in a Microsoft Excel worksheet. The fields within this database can de sub-divided into ‘Spatial’, ‘Physical’, and ‘Financial’ inputs. The Physical and Financial Inputs tables have links to other Excel worksheets via lookup functions. This structure could be readily modified to a MS Access or any relational database management system (RDMS) environment

Table 2-2 and Table 2-3 summarise the fields contained within each of the three database sections. Selected fields are discussed more fully in Sections 0,0, and 0.

In the worksheet ‘Input Summary’, users may enter their own values (in the blue font section of the worksheet), and then select ‘User’ from the adjacent drop down box. All calculated fields in the database will automatically update. Selection of ‘Default’ in the drop down box will restore the default variables.

Table 2-1:
Spatial Input Fields

Field Name	Unit	Field Description
Id	Number	Unique identification number for each grid
Hectares	ha	Total State forest area within each grid
TerrainClass	Number	Shows the predominant slope class for the grid
Veg1_Hectare	ha	Area of Mixed forest
Veg2_Hectare	ha	Area of Wallaba/Dakama/Muri Shrub Forest
Veg3_Hectare	ha	Area of Swamp/Marsh forest
Veg4_Hectare	ha	Area of Mangrove
Veg5_Hectare	ha	Area of Savannah >30% cover
Veg6_Hectare	ha	Area of Montane & steep forest
NonFor_Hectare	ha	Non-forested area
rds_Len	km	Centroid to closest Exit point: distance along existing roads
riv_Len	km	Centroid to closest Exit point: distance along rivers
oce_Len	km	Centroid to closest Exit point: distance along coast
prds_Len	km	Centroid to closest Exit point: distance along proposed roads
nrds_Len	km	Centroid to closest Exit point: distance along new roads
total_Len	km	Centroid to closest Exit point: total distance
FExitPt_ID	Number	Identifies closest Forest Exit point to each grid (6 Exits)
RoadDensity	m/ha	Existing road density
LConc_Hect	ha	Area of large concession within each grid
SConc_Hect	ha	Area of small concession within each grid
ConcType	text	Concession type - 'large' or 'small'

Table 2-2:
Physical Input Fields

Field Name	Unit	Field Description
FExittoMill_len	km	Average distance from Forest Exit point to Customers
Arterial density target	m/ha	Required arterial road density
Feeder density target	m/ha	Required feeder road density
Arterial density to const	m/ha	Difference between existing arterial road density and density target (i.e. density of arterial road to construct)
Exist Feeder density	m/ha	Existing feeder road density (considered a feeder road if existing density is greater than arterial road target)
Feeder density to const	m/ha	Difference between existing feeder road density and density target (i.e. density of feeder road to construct)
Arterial road dist	km	Length of arterial road to construct
Feeder road dist	km	Length of feeder road to construct
Skid trail dist	km	Length of skidder trails to construct
Bridges	Number	Number of minor bridges to construct
Transport Mode	Reference number	Combination of modes to move logs from felling site to customer (1: skidder-truck, 2: skidder-truck-barge)
TRV/ha	m^3/ha	Average recoverable volume per hectare

Table 2-3:
Financial Input Fields

Field Name	Unit	Field Description
Road constn cost	USD	Road construction distances multiplied by construction costs
Bridge const cost	USD	Bridge number multiplied by construction costs
Logyard constn	USD	Logyard number multiplied by construction costs
Road+Bridge+Logyard constn	USD/m3	Combined road, bridge, and logyard construction cost expressed as a unit rate
Road maintenance	USD/m3	Production cost - road maintenance
Log and Load	USD/m3	Production cost - log and load
Road transport	USD/m3	Production cost – transport
Loading 1	USD/m3	Production cost - loading onto barge (if Mode 2)
Log Pond	USD/m3	Production cost - log pond (Mode 2)
Barge transport	USD/m3	Production cost - barging (Mode 2)
Loading 2	USD/m3	Production cost - unload barge (Mode 2)
Overheads	USD/m3	Production cost - harvest related overheads
At Market Revenue	USD/m3	Weighted average log price at mill door/at wharf gate
On Stump Revenue	USD/m3	Unit Stumpage revenue (i.e. Revenue less all costs)

3 MODEL ASSUMPTIONS

Spatial Inputs – Description of Selected Fields

A spatial data model (see Appendix 1) was developed to calculate transportation and vegetation type spatial variables for each 4000 metre grid unit and provided as input to the numerical forestry model. Key spatial layers used in the model include terrain data, vegetation, roads, rivers, location of state forests, sawmills and proposed roading infrastructure. Each of these layers are described in more detail below. The basic premise with the spatial modelling is to allow for creating locational relationships between land tenure, infrastructure, and physical components.

Selected fields from Table 2-1 are described below.

Terrain Classification (TerrainClass)

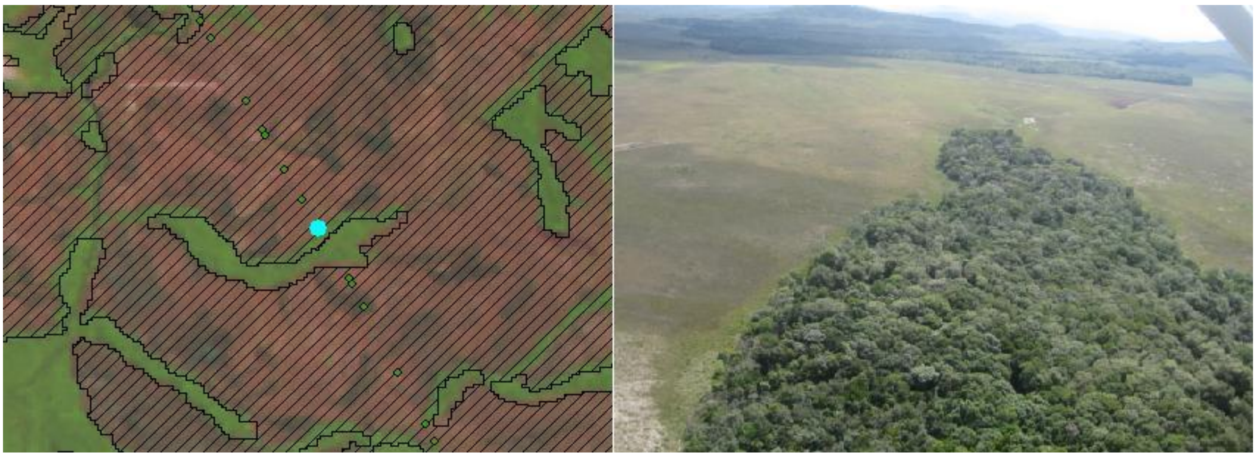
The mean slope in each grid is calculated, and each grid assigned a class between 1 and 4. Grids with a slope greater than 15 degrees (i.e. class 3 and 4) are excluded from the productive forest area.

Table 3-1:
Terrain Classes

Class	Description	Range (degrees)
1	Flat	<10
2	Rolling	10-15
3	Steep	15-20
4	Very steep	>20

Forest Type Classification (Veg1_Hectare etc)

The area by vegetation class is derived from the vegetation layer. Six vegetation classes are defined along with the non-forested area. Vegetation classes are derived from the classification of satellite imagery complimented by field verification as illustrated in the picture below showing a flight path (green dots overlaid on a satellite image) and on the right a geo-located photograph of the corresponding location along the flight path.



The vegetation maps used for the State Forest Area (SFA) was created from various existing vegetation maps and updated using interpretations of historical aerial photographs, satellite radar imagery from the Japanese Earth Remote Sensing satellite (JERS 1). The maps completeness was supported by analysis of field data collected during the Commission's forest inventories.

At the same time a national forest and land use classification map at a scale of 1:1 000 000 scale was produced based mainly on national soil survey data made available by the National Agricultural Research Institute (NARI).

Forest Exit Points (FExitPt_ID)

These represent logical 'exit points' for log volumes from groups of grids based on existing transportation network and saw mill locations. Six exit points have been defined at locations shown in Figure 1.

Figure 1:
Forest Exit Points and Sawmill Locations

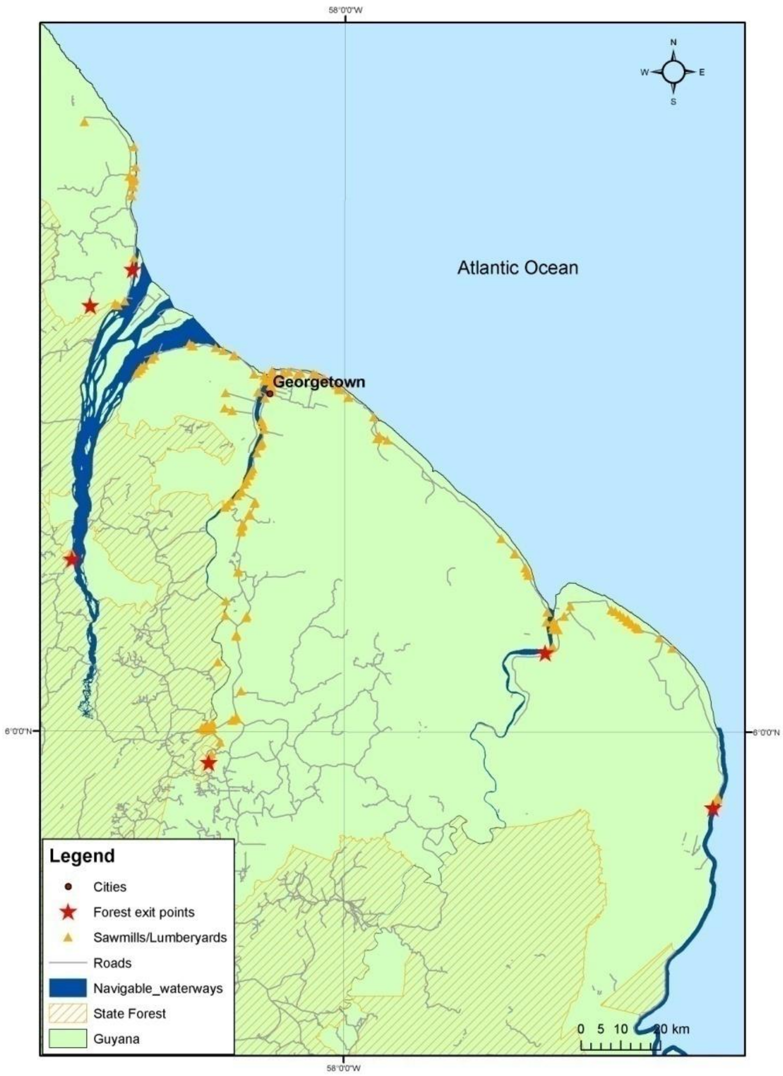
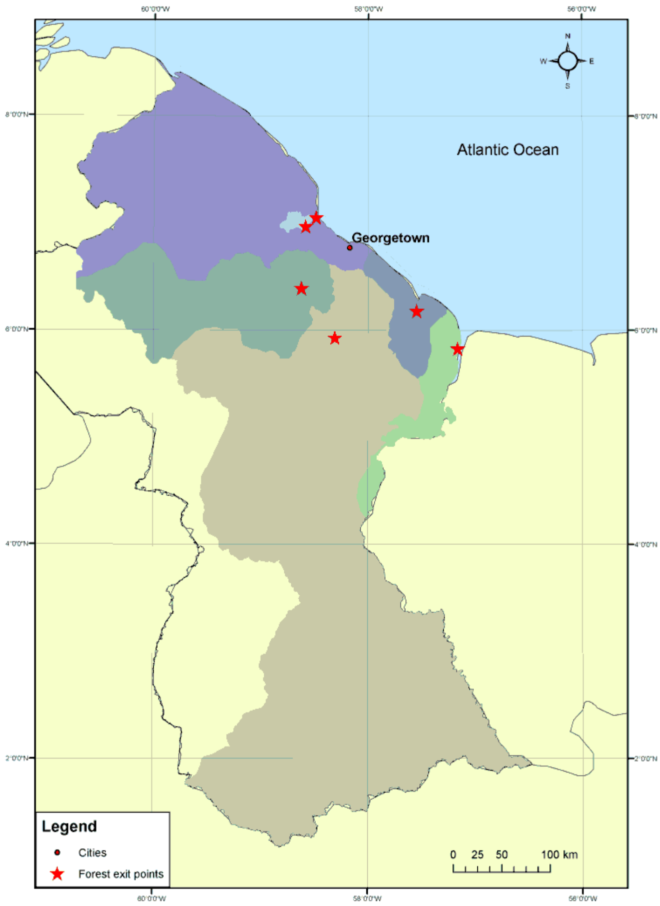


Figure 2 shows the "closest", in term of cost to transport, forest exit location for any point in the state forest boundary.

Figure 2:
Areas Suppling Each Forest Exit Location



Road Transport Distance - Grid to Exit Points (rds_Len, prds_Len, nrds_Len)

These fields represent the distance from the centroid of each grid to the nearest forest exit point along existing, proposed (as per GFC's dataset), and new roads. The path is identified using a least-cost path analysis as described in Appendix 1.

River Transport Distance – Grid to Exit Points (riv_Len, Oce_Len)

These fields represent the distance from the centroid of each grid to the nearest forest exit point along rivers, and coastal shipping routes if applicable.

Road Transport Distance - Exit Point to Mills (FExit-Mill_len)

The distances from each forest exit point to existing processing facilities have been calculated. The distance held in this field is assumed to be the average of the individual distances. This therefore represents a refinement that could be made, for example a weighted average distance could be calculated based of the log product/species mix purchased by each mill.

Physical Inputs - Description of Selected Fields

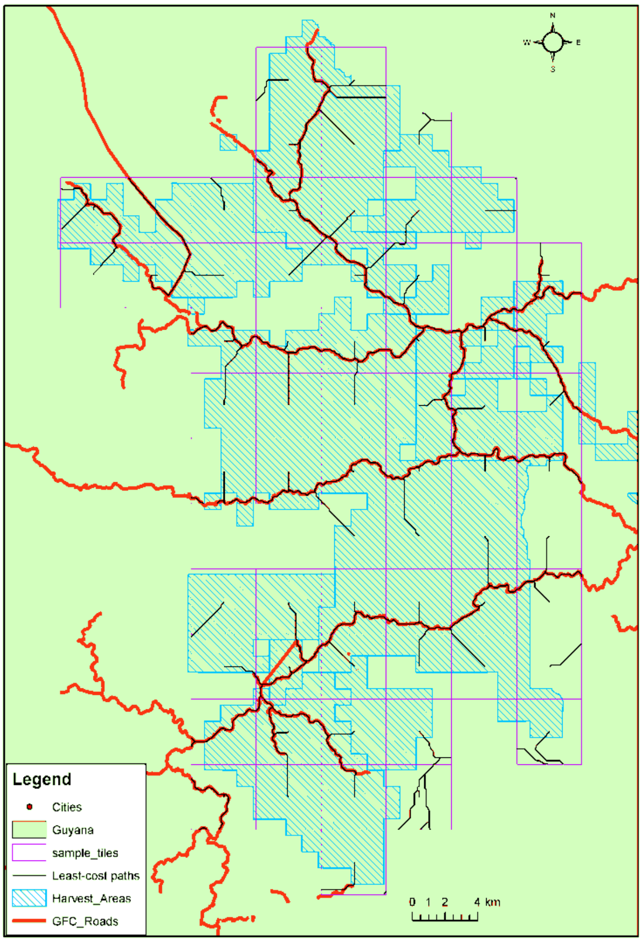
Table 2-2 sets out the fields in the Physical Inputs table. Selected fields are described below.

Road Network Density

These fields are required for estimates of road construction costs. ‘RoadDensity’ (note that this field is held within the Spatial inputs table) is the distance of existing roads in each grid. Road density varies based on the size of the concession with larger concession holders developing more road infrastructure relative to smaller concession holders. Therefore, two separate generic roads density values were calculated based on the actual road density in large and small concessions within areas of recent harvest activity. The field ‘Arterial density target’ is applied to all grids and its value is based on the size of the concession representing the majority of the grid, 1.7m/ha for small concessions and 4.2 m/ha for large concessions. Figure 3 shows a sample region within a large concession with recent harvest activity. The existing road network and least-cost paths used to calculate an average road density are shown within each grid units.

If the actual density in a particular grid is less than the target then the difference must be constructed (as shown in field ‘Arterial density to const’). If the actual density is greater than the target then the difference contributes to the feeder road density (as shown in field ‘Exist feeder density’).

Figure 3:
Sample Area Used to Calculate Average Road Density



The target feeder road density has been calculated based on an average skidding distance of 400m (large concessions) and 600m (small concessions), with an allowance for the terrain class. This results in a target density for large concessions of 6.3 m/ha and 12.5m/ha for flat and rolling areas respectively. The equivalent figures for small concessions are 4.2 m/ha and 8.3 m/ha. The difference between the actual and target feeder road density is therefore the density requiring construction (field 'Feeder density to const'). A summary of road density assumptions is provided in Table 3-4.

Road Construction Distances

Fields 'Arterial road dist' and 'Feeder road dist' are simply the density to construct fields as discussed above but represented in km per grid (i.e. they equal to the m/ha multiplied by the area of the grid).

Field 'Skid trail dist' is the km of skid trails required per grid, assuming a required density of 40 m/ha and 50 m/ha for flat and rolling areas respectively (and assuming no skid trails yet exist).

Bridges

Bridge density has been based on generic figures derived from other work undertaken by Pöyry in Guyana and Suriname. A bridge density on flat terrain of 0.02 per km and 0.04 per km is assumed for arterial and feeder roads respectively. For rolling terrain, the density is assumed to be 50% higher for both terrain classes.

A detailed analysis of the existing and proposed road network together with the waterways layer would allow a more refined estimate to be made for each grid, and represents a further refinement that could be made to the model.

Transport Mode

This field refers to the mode of transporting logs from the felling face to the end customer. '1'assumes a skidder-truck sequence, and '2' a skidder-truck-barge sequence. Under transport mode 2, barges are assumed to be able to unload logs directly into customer log-yards (i.e. there is no secondary road transport component).

Log Volume

Pöyry has utilised concession inventory information provided by GFC, together with in-house experience in estimating the likely log volume outturn for each grid. The following steps have been taken:

- The seven inventory datasets provided by GFC have been combined into a single database table to allow efficient analysis. This has involved the standardisation of field headings (mainly with regard to diameter classes), and ensuring consistency with species naming.
- The forest type classifications used in the inventories have been translated into the vegetation classes (1-6) used in the national forest estate model database, as per Table 3-2 below.
- Crop trees for each plot were calculated by extracting the number of non-defect trees above 35cm dbh (diameter at breast height), and expressing on a per ha basis.
- The average volume per tree was calculated using the Conoid formula and inputting the average diameter per plot, an assumed form factor of 70%, and an assumed merchantable length of 13m. Volume per tree was then converted to total recoverable volume per ha (TRV/ha) by multiplying this figure by the crop trees per ha. This figure represents the potential volume that may be recovered, before allowable cuts regulations are imposed.
- The average TRV/ha by vegetation class and species group was calculated weighted by the area covered by each concession inventory. The species groups are shown in Table 3-6. Table 3-3 shows the results of these calculations. A maximum allowable harvest of 20m^3/ha has been assumed, and Table 3-3 shows the volumes of each species class that can be extracted up to this volume limit (and this is termed 'Extractable Volume', i.e. the available commercial volume once allowable cut regulations have been imposed). Inventory information was not available for vegetation classes 4 (Mangrove) and 6 (Montane/Steep). Mangrove is assumed to yield 50% of class 3 (Swamp and Marsh), and Montane/Steep is assumed to yield 50% of

class 5 (Savannah). The average yield for each vegetation class is then applied in the main database. The species group yields within each vegetation class determine the average log price applied to that average yield (see Section 0).

Table 3-2:
Translation from Concession Inventory Forest Types to Database Vegetation Classes

Forest Type as per Concession Inventory	Assumed Vegetation Class	Vegetation Class Description
1	1	Mixed forest
1b	1	Mixed forest
1c	1	Mixed forest
1h	1	Mixed forest
3b	3	Swamp/Marsh forest
MFB	1	Mixed forest
MFH	1	Mixed forest
MFW	1	Mixed forest
SF	3	Swamp/Marsh forest
LF	5	Savannah >30% cover
WF	2	Wallaba/Dakama/Muri Shrub Forest
MMC	1	Mixed forest
MGB	1	Mixed forest
MGK	1	Mixed forest
MF	1	Mixed forest
WAL	2	Wallaba/Dakama/Muri Shrub Forest
MAR	3	Swamp/Marsh forest
MUR	2	Wallaba/Dakama/Muri Shrub Forest

Table 3-3:
Extractable Volume by Forest Class and Species Group Calculations (Note – no inventory data available for vegetation classes 4 and 6).

Vegetation Class	Species Group	TRV (m3/ha)	Extractable Volume (m3/ha)
1	0	10.2	10.2
	1	26.0	9.8
	2	11.6	
	3	11.7	
	4	21.6	
	9	7.8	
	10	1.3	
1 Total		**90.0**	**20.0**
2	0	4.0	4.0
	1	3.9	3.9
	2	11.3	11.3
	3	2.1	0.7
	4	9.2	
	9	7.0	
	10	0.0	
2 Total		**37.6**	**20.0**
3	0	11.5	11.5
	1	57.7	8.5
	2	12.8	
	3	11.3	
	4	29.8	
	9	9.1	
	10	1.1	
3 Total		**133.2**	**20.0**
5	0	0.0	0.0
	1	3.3	3.3
	2	2.0	2.0
	3	6.1	6.1
	9	5.4	5.4
	10	0.5	0.5
5 Total		**17.2**	**17.2**

Financial Inputs – Description of Selected Fields

Table 2-3 sets out the fields in the Financial Inputs table. Selected fields are described below.

Infrastructure Costs

Assumed infrastructure costs (along with density figures described in the previous section) are shown in Table 3-4 below. Costs are averages based on Pöyry's experience in the region. Bridges on feeder roads are assumed to be basic log bridges across small streams and of a temporary nature. Log-yards and log-ponds are assumed to be constructed wherever a transition occurs between road and water transport. The log-yard/pond construction cost is assumed to be covered in the log pond handling rate. The infrastructure fields in Table 2-3 show the cost per grid, and also the cost per m^3.

Table 3-4:
Infrastructure Requirements and Capital Costs

Road Type	Road Density (m/ha)		Road Cost (USD/km)		Bridge Density (#/km)		Bridge Cost (USD/km)	
	Flat	Rolling	Flat	Rolling	Flat	Rolling	Flat	Rolling
Access roads	4.2	4.2	8 000	9 600	0.02	0.03	50 000	50 000
Feeder roads	2.1	8.3	4 000	4 800	0.04	0.06	10 000	10 000
Skid trails	40	50	800	960			included in road cost	

Production Costs

The harvesting method involves the use of chainsaws for directional felling along and bucking of trees in the forest. Logs are then extracted using a combination of rubber-tired skidders and tracked bulldozers to the log landing. At the log landing the logs are loaded onto trucks for transport to either the end customer (transport mode 1) or to a log-yard/pond (transport mode 2). Under mode 2, the logs are then barged to the end customer and unloaded directly into the customer yard.

Pöyry has assumed in this exercise that all harvesting and transport will be contracted to a third party. The contractor will be responsible for felling, skidding, loading, and road and water transport for a fixed USD/m^3 amount and provide all equipment required to perform these functions. Hence there is no allowance in the provided costs for the capital purchase of harvesting and transport equipment.

Production costs and their definitions are defined as follows:

Logging: includes felling, cross-cutting, and skidding of logs to the road edge.

Road Maintenance: the on-going maintenance of the road network to ensure the ready uplift of logs. Will include maintenance of culverts, drains, road edge weeds, and re-surfacing as required.

Loading - Primary: loading of logs on to trucks at the road edge (applies to transport modes 1 and 2).

Loading – Secondary: loading of logs on to barges at log ponds (applies to transport mode 2 only).

Road Transport: the cost to move the logs from the road edge to the end customer (transport mode 1) or to a log-pond (transport mode 2). Trucks are assumed to have a capacity of 25-30m^3. Includes the cost of unloading vehicles to either the log-yard/pond or end customer.

Barge Transport: the cost of moving logs from the log-pond to the end customer. Barges are assumed to have a capacity of around 1000m^3. Includes the cost of unloading the barge at the end customer.

Log-Yard/Pond: includes the cost of construction and maintenance of log-yards/ponds, along with handling of the logs in the yard/pond.

Overheads: covers the cost of forestry planning and surveys, inventory, administration, camps, general transportation, workshops, and head office (corporate) costs.

Table 3-5 sets out the assumed productions costs. Costs are averages based on Pöyry's experience in the region, along with actual large and small concession production costs as provided by GFC. Benchmarking of production costs is provided in Appendix 1.

Table 3-5:
Production Costs

Cost Item	Unit	Flat	Rolling
Logging	USD/m^3	7.00	8.40
Road Maintenance	USD/m^3	4.00	4.80
Loading (Primary)	USD/m^3	1.30	1.30
Loading (Secondary)	USD/m^3	1.30	1.30
Road Transport	USD/m^3/km	0.15	0.15
Barge Transport	USD/m^3/km	0.10	0.10
Log-Yard/Pond Handling	USD/m^3	5.00	5.00
Overheads	USD/m^3	23.50	23.50

At Market Log Revenue

The average unit revenue per m^3 has been derived for each of the six vegetation classes as per the following process:

- GFC provided a set of mill gate/wharf gate log prices by species and grade, as well as a summary of log exports by grade from January to October 2010.
- Pöyry applied the grade mix from the log export data to all species in order to derive a weighted average price per species. The 59 species were then sorted into their applicable species groups, and an average price per species group derived (Table 3-6).
- The average unit price per m^3 for each of the six vegetation classes is determined by the mix of each species group within that vegetation class (as shown previously in Table 3-3). The final prices by vegetation class are shown in Table 3-7.

Table 3-6:
At Market Log Price and Grade Mix Assumptions by Species

Species Group	Species	Log Quality Class						Price	Royalty	Price less royalty
		Low	Small Sawmill	Fair Sawmill	Standard	Superior	First Peeler	(USD/m3)		
0	Letterwood / Leopardwood / Snakewood / Tibokushi	140	140	170	200	200	200	171.81	0.52	171.29
	Marblewood	140	140	170	200	200	200	171.81	0.52	171.29
	Purpleheart	140	150	170	200	215	220	174.78	2.43	172.35
	Red Cedar	140	140	170	200	200	200	171.81	2.43	169.38
	Washiba	130	150	170	200	200	200	173.51	1.39	172.12
	Grade Mix	**9%**	**26%**	**23%**	**39%**	**2%**	**0%**	**172.74**	**1.46**	**171.29**
1	Greenheart	120	120	130	140	150	160	130.84	2.43	128.41
	Tonka Bean	120	120	130	140	150	150	130.84	0.52	130.32
	Wamara	120	120	125	140	140	140	129.45	1.39	128.06
	Cow Wood	110	120	130	140	140	140	129.68	0.52	129.16
	Kabukalli	110	120	130	140	140	140	129.68	1.39	128.29
	Pakuri	110	120	130	140	140	140	129.68	0.87	128.81
	Tauroniro	110	120	130	140	140	140	129.68	1.39	128.29
	Grade Mix	**9%**	**26%**	**23%**	**39%**	**2%**	**0%**	**129.98**	**1.22**	**128.76**
2	Kereti	110	120	130	135	140	140	127.73	0.52	127.21
	Brown Silverballi	110	110	120	130	140	140	120.84	2.43	118.41
	Bulletwood	110	110	120	130	130	140	120.60	2.43	118.17
	Darina	110	110	120	130	130	140	120.60	0.52	120.08
	Fukadi/Coffee Mortar	110	110	120	130	130	130	120.60	0.52	120.08
	Hububalli	110	110	120	130	130	130	120.60	1.39	119.21
	Iteballi	110	110	120	130	130	130	120.60	0.52	120.08
	Kakaralli	110	110	120	130	130	130	120.60	0.52	120.08
	Monkey Pot	110	120	125	130	130	130	124.38	0.87	123.51
	Shibadan	110	115	120	130	140	140	122.15	1.39	120.76
	Tatabu	110	120	125	130	135	135	124.50	1.39	123.11
	Waramadang	110	115	120	130	140	140	122.15	0.52	121.63
	Cabbage	100	110	115	130	130	130	118.52	0.52	118.00
	Itikiboroballi	100	110	120	130	130	130	119.68	1.39	118.29
	Kurokai	100	110	120	130	130	130	119.68	0.52	119.16
	Limonaballi	100	110	120	130	130	130	119.68	0.52	119.16
	Manni	100	110	120	130	130	130	119.68	0.87	118.81
	Maporokon	100	110	120	130	130	130	119.68	0.87	118.81
	Wallaba	100	110	120	130	130	130	119.68	0.87	118.81
	Grade Mix	**9%**	**26%**	**23%**	**39%**	**2%**	**0%**	**121.16**	**0.98**	**120.18**
3	Simarupa	110	115	120	125	125	125	119.84	1.39	118.45
	White Silverballi	110	120	125	125	130	130	122.42	0.52	121.90
	Kurahara	100	110	115	125	130	130	116.57	0.52	116.05
	Sawariskin Silverballi	100	110	120	125	125	125	117.61	0.52	117.09
	Grade Mix	**9%**	**26%**	**23%**	**39%**	**2%**	**0%**	**119.11**	**0.74**	**118.37**
4,9,10	Mora	110	110	115	120	130	130	115.54	1.39	114.15

Species Group	Species	Log Quality Class						Price	Royalty	Price less royalty
		Low	Small Sawmill	Fair Sawmill	Standard	Superior	First Peeler	(USD/m3)		
	Sand Mora/Clump Wallaba	110	110	115	120	130	130	115.54	0.52	115.02
	Arisauro	100	110	115	120	120	120	114.38	0.52	113.86
	Aromata	100	110	115	120	120	120	114.38	1.39	112.99
	Baradan	100	110	115	120	120	120	114.38	0.87	113.51
	Black Kakaralli	100	110	115	120	120	120	114.38	0.52	113.86
	Burada	100	110	115	120	120	120	114.38	0.52	113.86
	Determa	100	100	110	120	120	120	110.60	1.39	109.21
	Devildoer/Devildoor	100	110	115	120	120	120	114.38	0.52	113.86
	Dukali	100	110	115	120	120	120	114.38	0.87	113.51
	Dukaliballi	100	100	115	120	120	120	111.76	0.52	111.24
	Hishirudan	100	110	115	120	120	120	114.38	0.52	113.86
	Huruasa	100	110	115	120	130	130	114.62	0.52	114.09
	Kanakudiballi	100	110	115	120	120	120	114.38	0.52	113.86
	Morabukea	100	110	115	120	120	120	114.38	1.39	112.99
	Muniridan	100	110	115	120	120	120	114.38	0.87	113.51
	Sada	100	110	115	120	120	120	114.38	0.52	113.86
	Suradan	100	110	115	120	120	120	114.38	0.52	113.86
	Suya/Durban Pine	100	100	110	120	120	120	110.60	0.52	110.08
	Wana	100	110	115	120	120	120	114.38	0.52	113.86
	Wina	100	110	115	120	120	120	114.38	0.52	113.86
	Others	100	110	115	120	120	120	114.38	0.52	113.86
	Grade Mix	**9%**	**26%**	**23%**	**39%**	**2%**	**0%**	**114.03**	**0.73**	**113.31**

Table 3-7:
At Market Log Price by Vegetation Class

Vegetation Class	Species Group	Extractable Volume (m3/ha)	Log Price less Royalty (USD/m3)
1	0	10.2	171.29
	1	9.8	128.76
1 Total		**20.0**	**150.37**
2	0	4.0	171.29
	1	3.9	128.76
	2	11.3	120.18
	3	0.7	118.37
2 Total		**20.0**	**132.07**
3	0	11.5	171.29
	1	8.5	128.76
3 Total		**20.0**	**153.15**
5	0	0.0	171.29
	1	3.3	128.76
	2	2.0	120.18
	3	6.1	118.37
	9	5.4	113.86
	10	0.5	113.86
5 Total		**17.2**	**119.04**

On-Stump Log Revenue

The on-stump revenue represents the standing value of the tree crop, i.e. it is the at-market revenue (as discussed above) less all costs:

	At Market Revenue (refer Table 3-7)
less	Royalties (refer Table 3-7)
less	Road and Bridge Construction (refer Table 3-4)
less	**Road Maintenance (refer**

Table 3-5)

less	**Log and Load (refer**

Table 3-5)

less	**Road Transport (refer**

Table 3-5)

less	**Loading - primary (refer**

Table 3-5)

less	**Barge Transport (refer**

Table 3-5)

less	**Loading - secondary (refer**

Table 3-5)

less	**Overhead (refer**

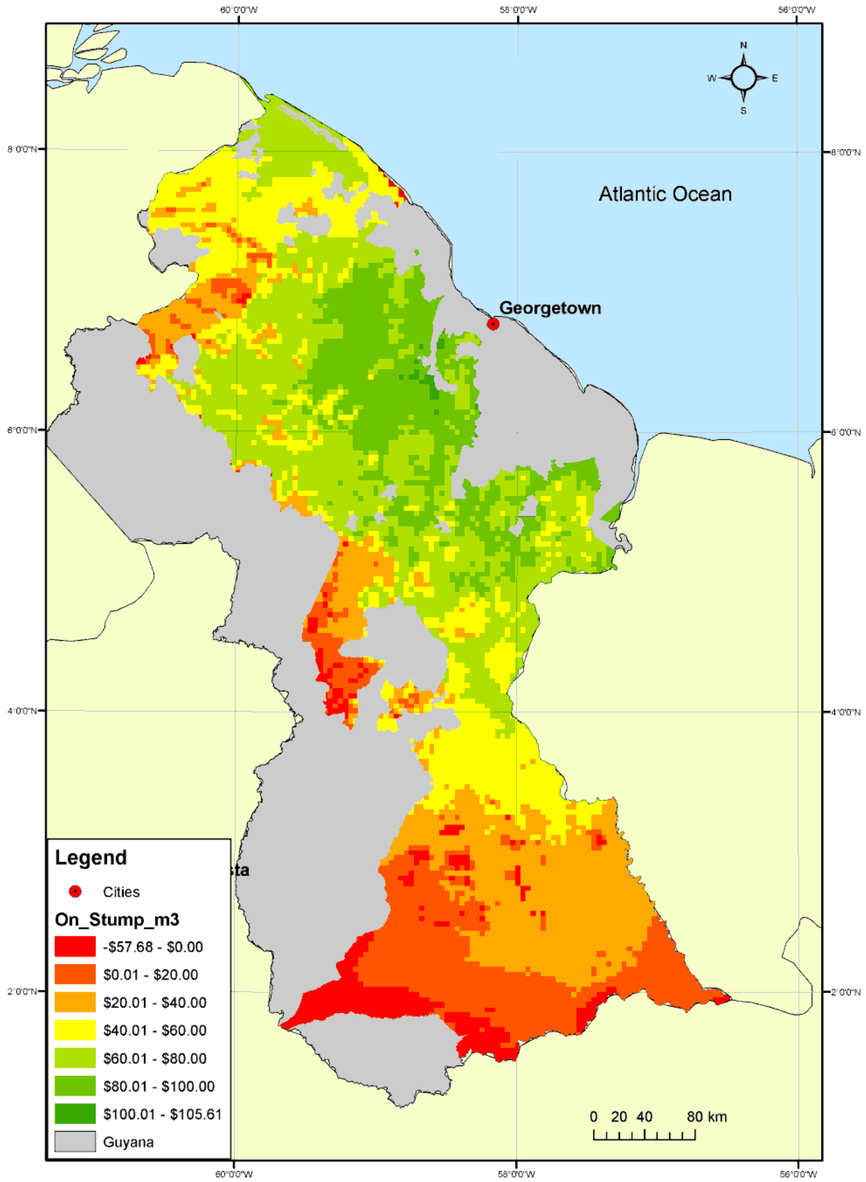
Table 3-5)

equals	On-Stump Revenue

4 MODEL OUTPUT

The map in Figure 4 shows the on-stump revenue per cubic metre (as defined previously in Section 0) for each grid unit in the State Forest. Red regions indicate negative revenues and orange to green regions indicate positive revenues with green indicating the greatest revenue per cubic meter. Other maps are readily generated showing for example required infrastructure costs, or total production cost. The on-stump figures shown in Figure 4 are consistent with the figures in column BB of the GFC REDDES Database, grouped into USD20/m^3 ranges.

Figure 4:
On Stump Revenue per cubic metre



An assumption has been taken that all wood is sold within Guyana. On the basis of this assumption, timber extracted far from market points tend to have a higher transport costs.

APPENDIX 1

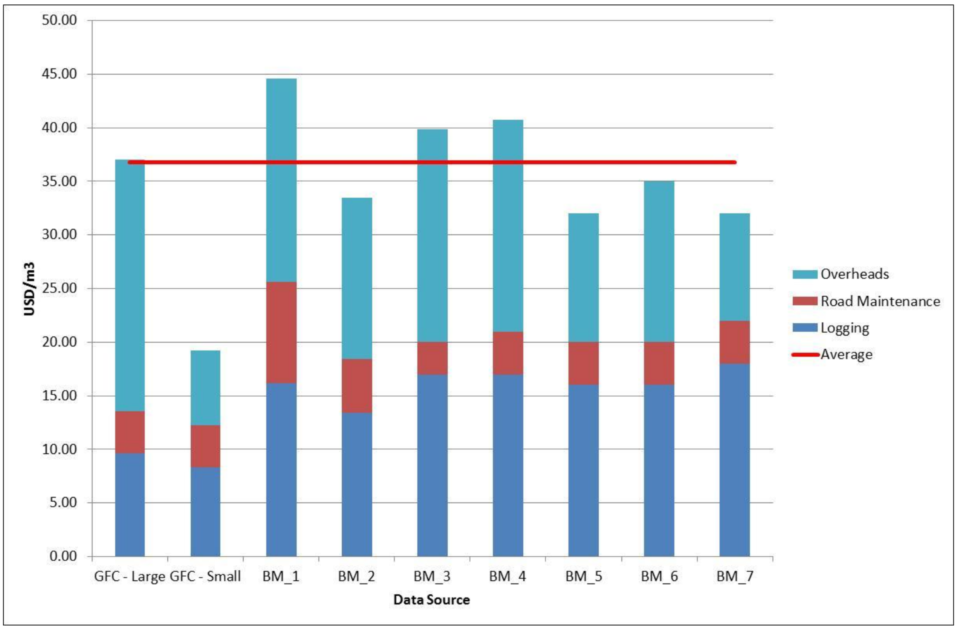
Production Cost Benchmarking

PRODUCTION COST BENCHMARKING

Logging, Overheads and Road Maintenance

Table 3-5 (Section 0) set-out the assumed production costs. Figure 5 compares non-transportation related costs (see next section) to benchmark data held by Poyry for Guyana and other South American countries. This highlights that the large concession costs provided by GFC are similar to the average of the benchmark data. In contrast the small concession costs for GFC are significantly lower. While Poyry has recognised in the model the less intensive roading networks associated with the small concessions, the large concession production costs have been applied to all concessions sizes (although these can be changed in the User Inputs section of the model).

Figure 5:
GFC Selected Production Costs Compared to Poyry Benchmark



Log Transport Costs

Log transport costs cannot be readily compared on a USD/m^3 basis as this as this figure will vary depending on the transport distance. The selected unit rates of USD rates of USD0.15/m^3/km and USD0.10/m^3/km for road and barge transport respectively are considered realistic averages for the Guyana operations.

APPENDIX 2

Spatial Data Model Description

SPATIAL DATA MODEL DESCRIPTION

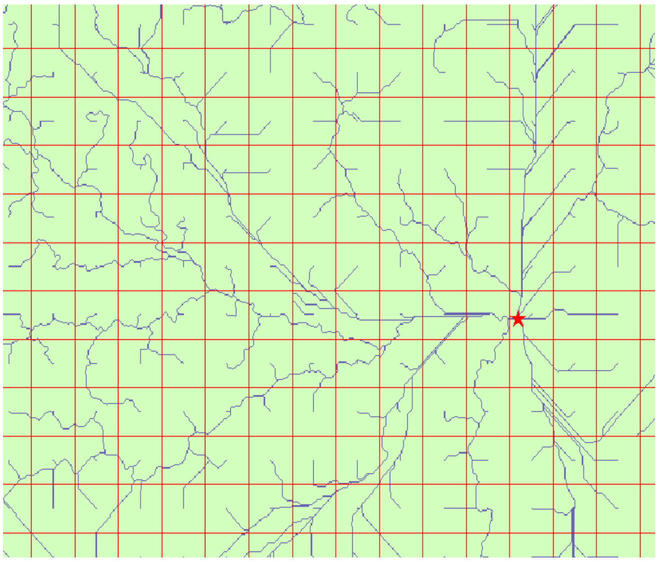
The spatial data model was developed in ArcMap to calculate spatial data variables required by the numerical forestry model.

Transportation distance calculations

Transportation distance calculations were performed using ArcMap Spatial Analyst cost distance tools. Cost distance tools require raster (i.e. grid) inputs. For purposes of the analysis at a national scale, a 90m cell size was used for all analysis.

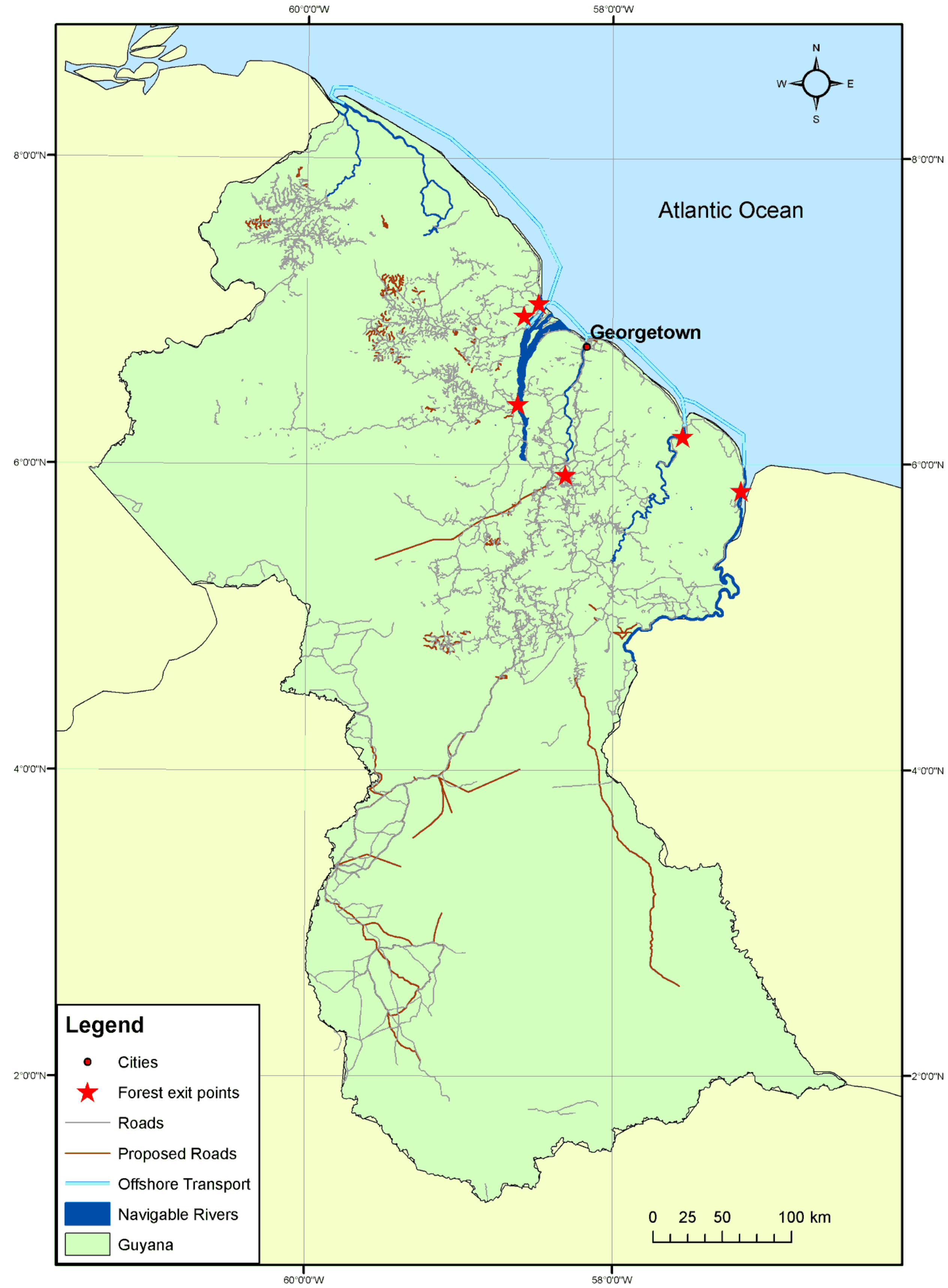
A transportation cost grid was developed that defined the cost to move through a data cell. By assigning a cost to each cell within the analysis extent a least cost path could be calculated between each grid unit centroid and the "closest", in terms of cost, and forest exit point. Figure 6 shows an example of the derived least accumulative cost paths from grid unit centroids to the "closest" forest exit location. After identifying the least accumulative cost path, the total path distance could be calculated as well as the distance along each path type (e.g. new road, existing road, navigable waterway, etc.)

6
Least-cost paths example



The cost to move through a cell intersecting an existing road, proposed road, or navigable waterways layer was set to 1. Offshore routes along the coast were created to link river and road transportation networks and assigned a value of 1. All other cells were set to 270. This reflects the cost of constructing a new road the width of the cell (90m) based on a reference cost of $3000/km. Figure 7 shows the transportation cost grid.

7 Transportation cost grid



Vegetation area calculations

The total area for each vegetation type within each grid unit was calculated based a version of the Vegetation Map layer simplified to six vegetation classes (Table 0-1). The 2009 non-forest and waterbody layers was used to excluded mask non-forest areas within each grid unit.

0-1
Simplified vegetation classes

	Vegetation Classes
	1 - mixed forest
	2 - Wallabe/Dakama/Muri shrub forest
	3 - Swamp/Marsh forest
	4 - Mangrove
	5 - Savannah > 30% cover
	6 - Montane & steep forest

Assumptions and Limitations

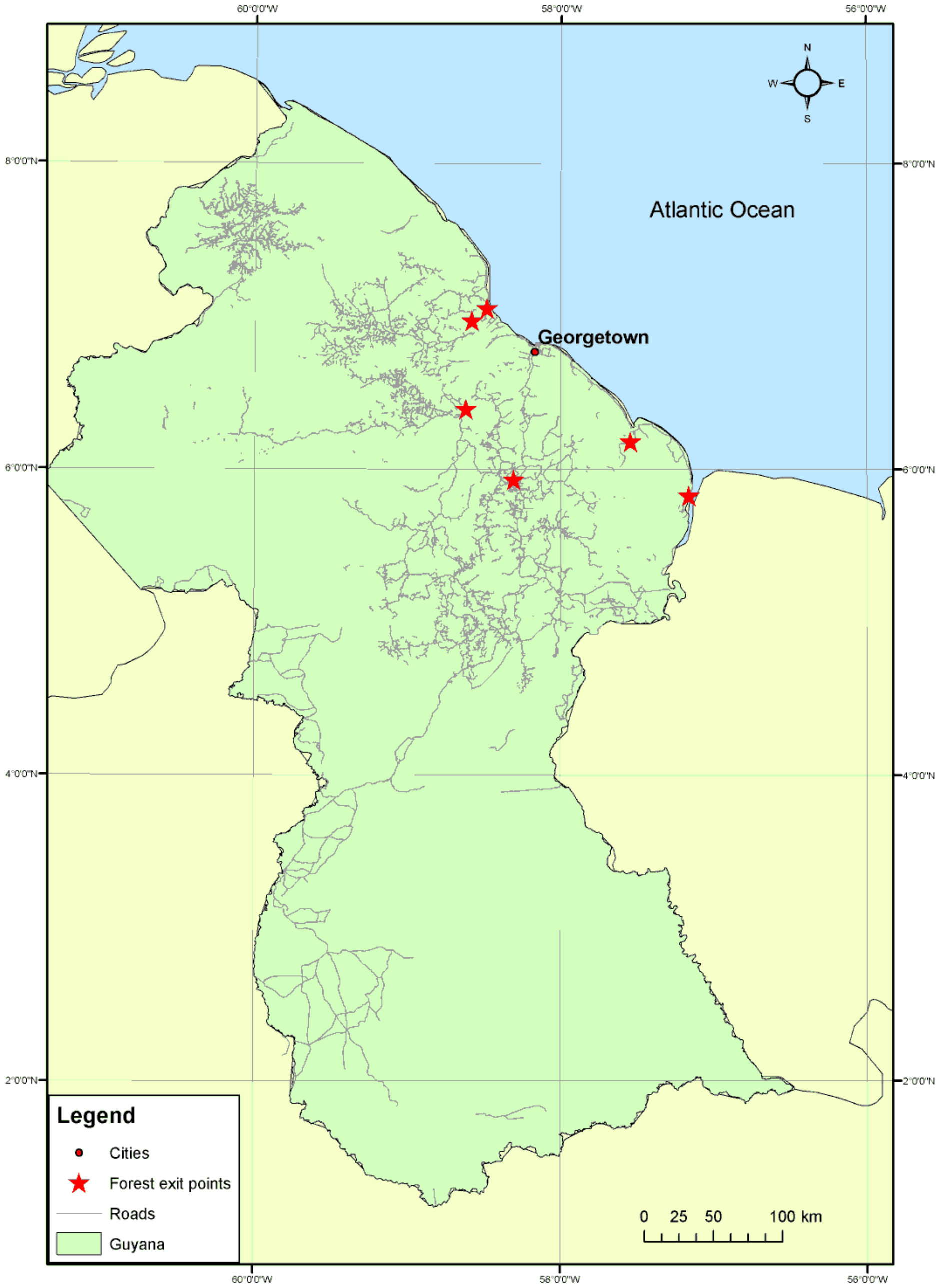
It is important to keep in mind a number of limitations and assumptions relevant to the spatial data analysis.

- The existing roads layer GFC_roads was combined with roads extracted from the roads digitized during the REDD change mapping. This was not a perfect solution partly because roads existed in both data layers but were not always co-registered and it did not always correct isolated road segments. Some GIS processing was performed to reduce this issue but it's effectiveness was limited. However, it is reasonable to assume that the merged layers provided the most accurate representation of the existing road network.
- The navigable waterways layer was derived from the GFC waterbodies layer and edited to remove waterways based on the navigable river point layer provided by GFC. All sections of river upstream of the defined points were removed as well as river networks not marked as navigable.
- The offshore transport routes were defined based on the navigable river point layer provided by GFC. Rivers were connected via offshore transport routes if they were identified as navigable.
- The vegetation map layer contained overlapping polygon and was edited to remove the overlap. The lowest value forest type selected as the correct type where overlap was identified
- Selection of forest exit locations may need to be revised based on local input.
- Sawmill and lumberyard points were not connected to the existing road or river network. Road links were created and combined with the roads layer to connect points to, generally, the closest existing road.
- The least-cost path for new roads was typically a straight line. To account for additional "real world" distance of roads, samples were collected to along segments of existing roads to compare the straight line distance versus the actual distance. The mean value 1.36 was used as a multiplier to increase the least-cost path distances for new roads.

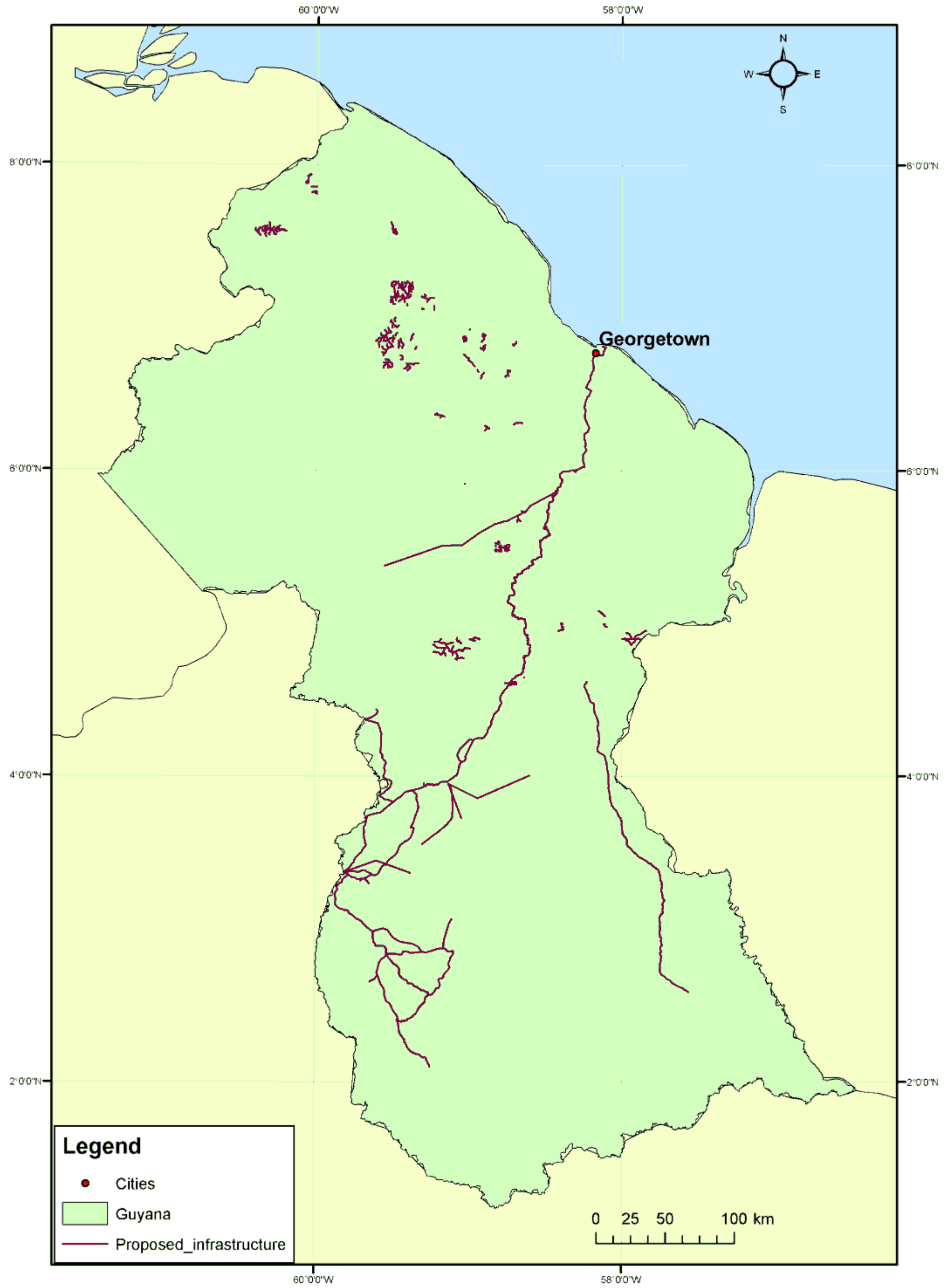
APPENDIX 3

Maps of Spatial Data Model Dataset

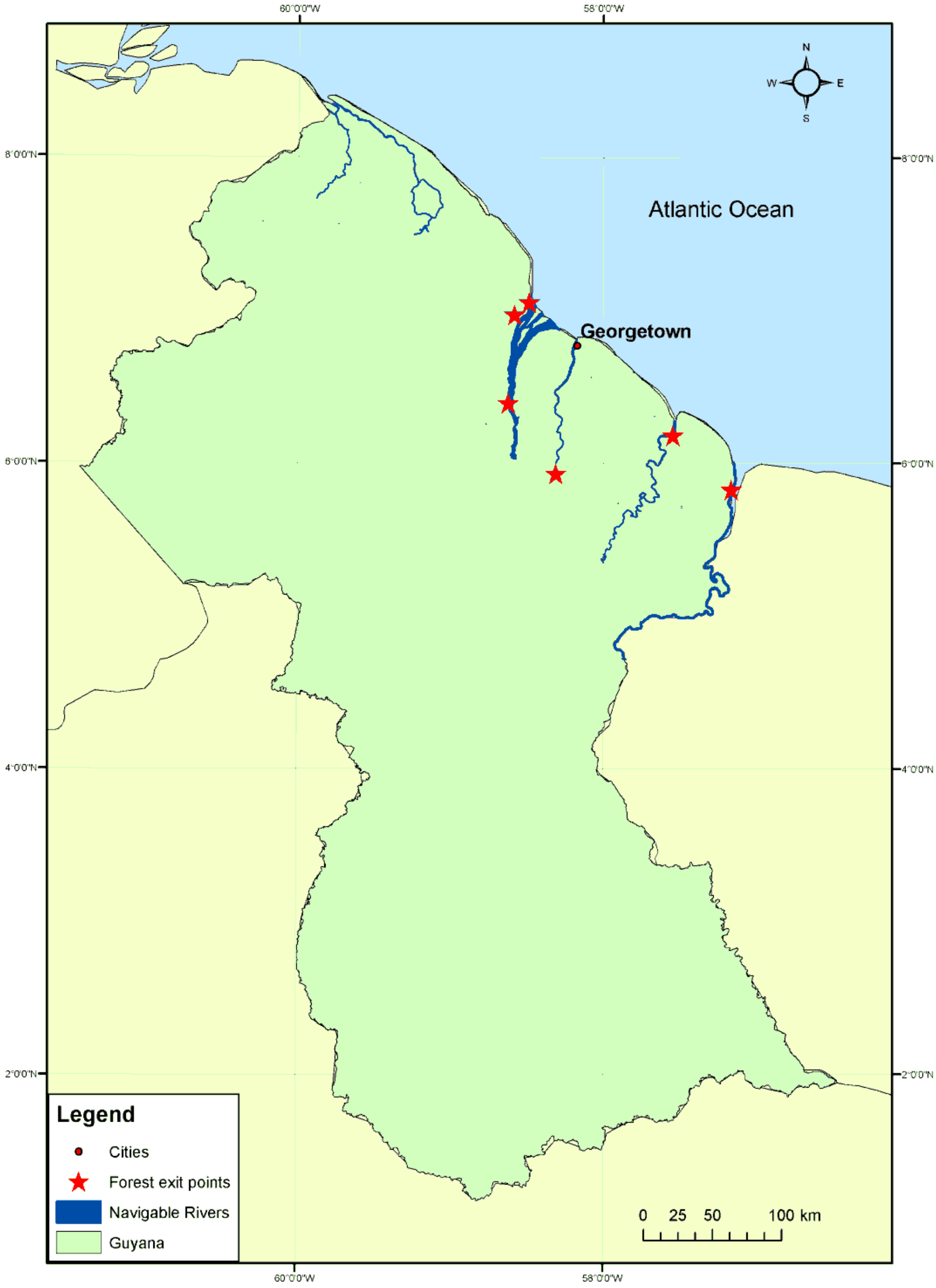
GFC road lines



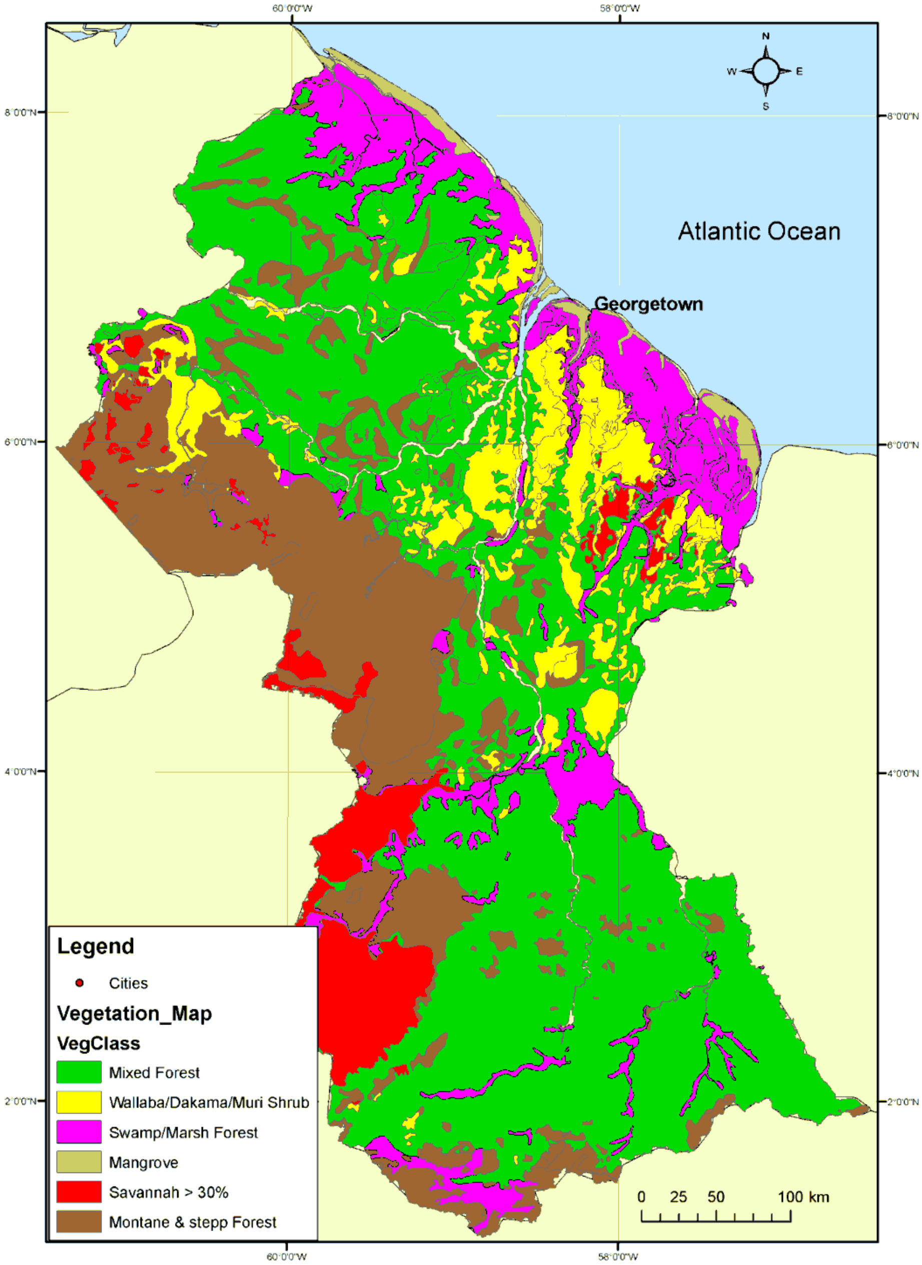
Proposed roads



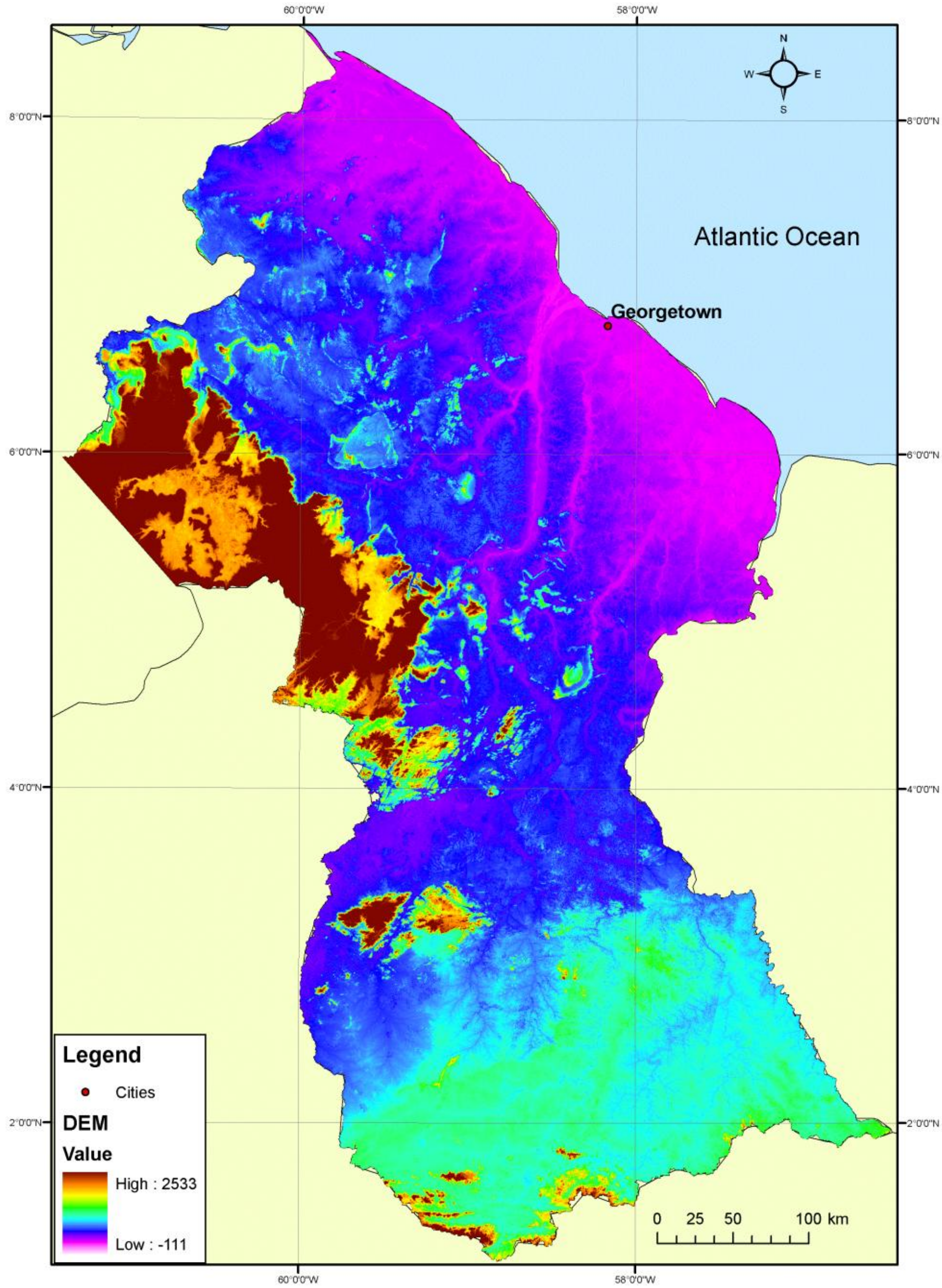
Navigable waterways



Vegetation type map



Digital Elevation Model



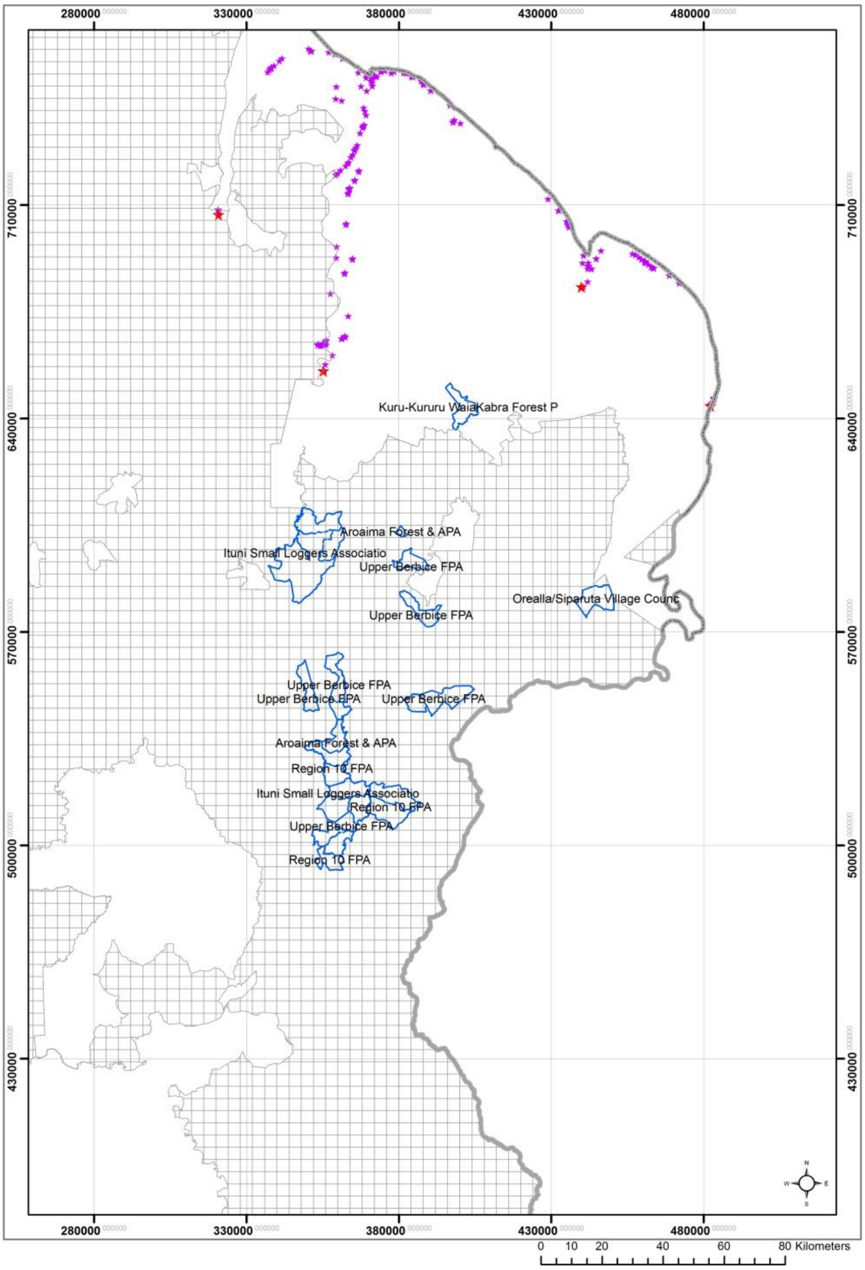
APPENDIX 4

Test Cases - Community Forest Area Analysis

The analysis undertaken on each of the sample community areas is a based on the assumptions presented in the model presented in this report. The results of the analysis may differ from what would be obtained from a more refined assessment based on ground data. This analysis provides a basis for further refinement of the model athis local level. A field verification form is provided for undertaking preliminary inventory. Note that for allocation of concessions, it is assumed that a full forest inventory will be undertaken to fully validate the concession value. The model presents a template for ongoing refinement of methodology and rapid assessment at national scale.

The road density values presented are also an indication of what might be required. However, a field validation exercises would confirm aspects such as terrain, proximity to navigable rivers, and site conditions. The requirement for roading is also dependent upon the presence of timber and potential for high recoverable volume and other additional requirements depending on are suitability. The map below shows the community areas analysed in this exercise. Note that the Kuru Kuru Wai a Kabra was not analysed as it falls outside the area covered by the grid network.

General Location of Selected Community Forest Areas



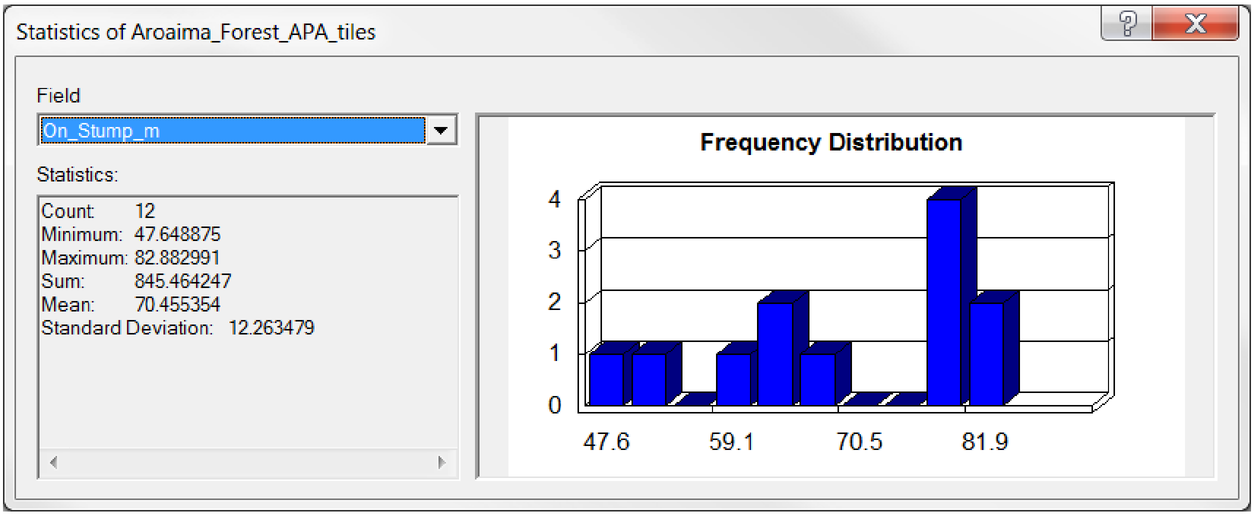
Aroaima Forest & APA

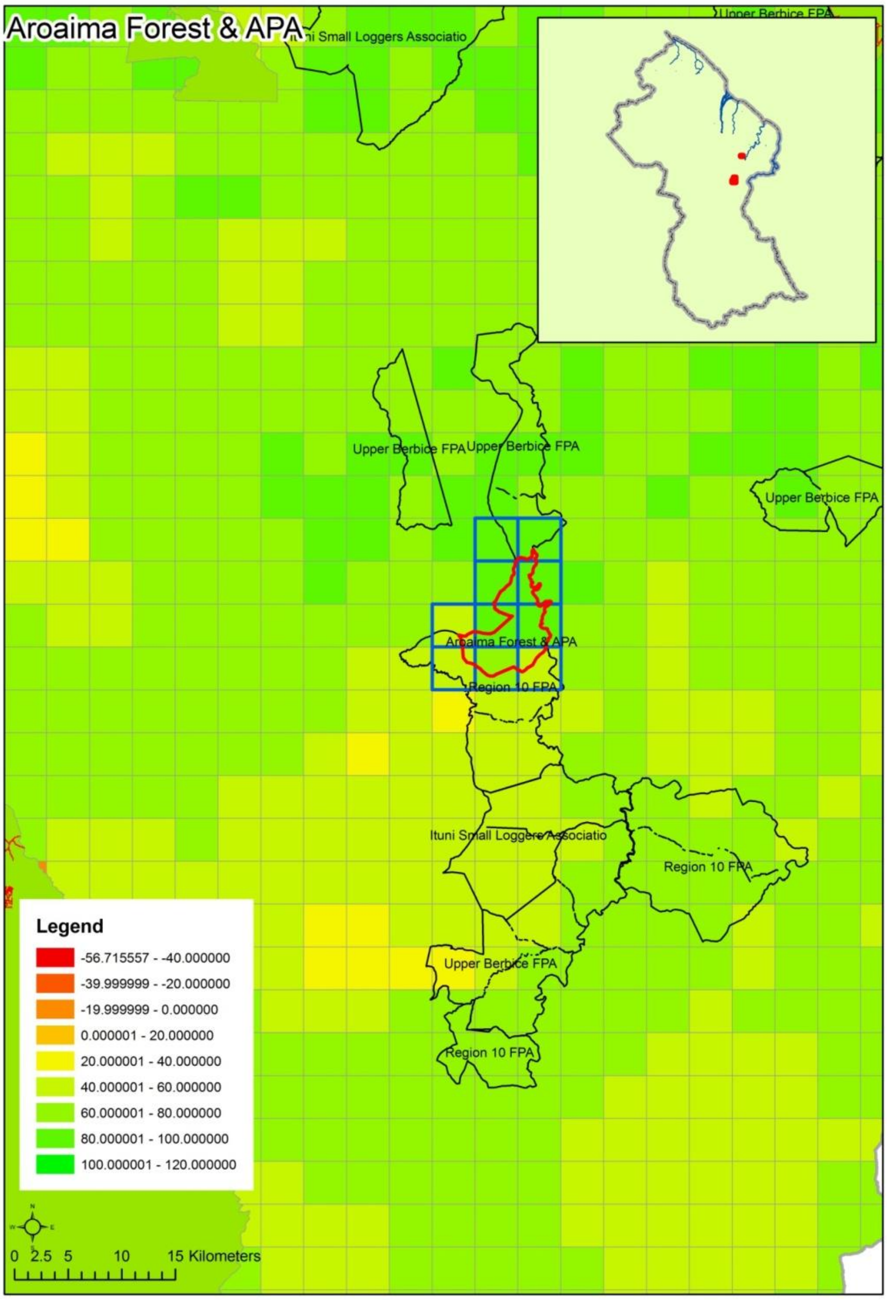
The Aroaima Forest & APA is in region which is general flat (Terrain Class 1) and is within the small concession category.

Taking into account the high level nature of the model, the estimated stumpage value per cubic meter within the tiles covering the Aroaima Forest & APA ranges between US$47 and US$83 per cubic metre with an estimated "at-market price" value ranging between US$120 and US$150 per cubic metre. These values are based on assumptions stated in the main report thus require further refinement from field verification data.

On the basis of the analysis undertaken, the maximum road density is estimated at 5 metres per hectare. It is unlikely that any roads are required to be established due to already existing nearby roads. The area is generally flat and therefore concession holders are likely to use temporary skidding roads than establish new roads.

The estimated at-market price across all tiles is US$142 but this needs to be verified. Assuming this national average, a simple assessment below would suggest the Aroaima area to have an average return per cubic metre (about US$141) mostly because of the scattered to even distribution good quality timber trees with an uncertain potential for higher merchantable volume.




Aroaima Forest & APA
Ituni Small Loggers Associatio
Upper Berbice FPA
Upper Berbice FPA
Upper Berbice FPA
Upper Berbice FPA
Aroaima Forest & APA
Region 10 FPA
Ituni Small Loggers Associatio
Region 10 FPA
Upper Berbice FPA
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Legend
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20.000001 - 40.000000
40.000001 - 60.000000
60.000001 - 80.000000
80.000001 - 100.000000
100.000001 - 120.000000
0 2.5 5 10 15 Kilometers

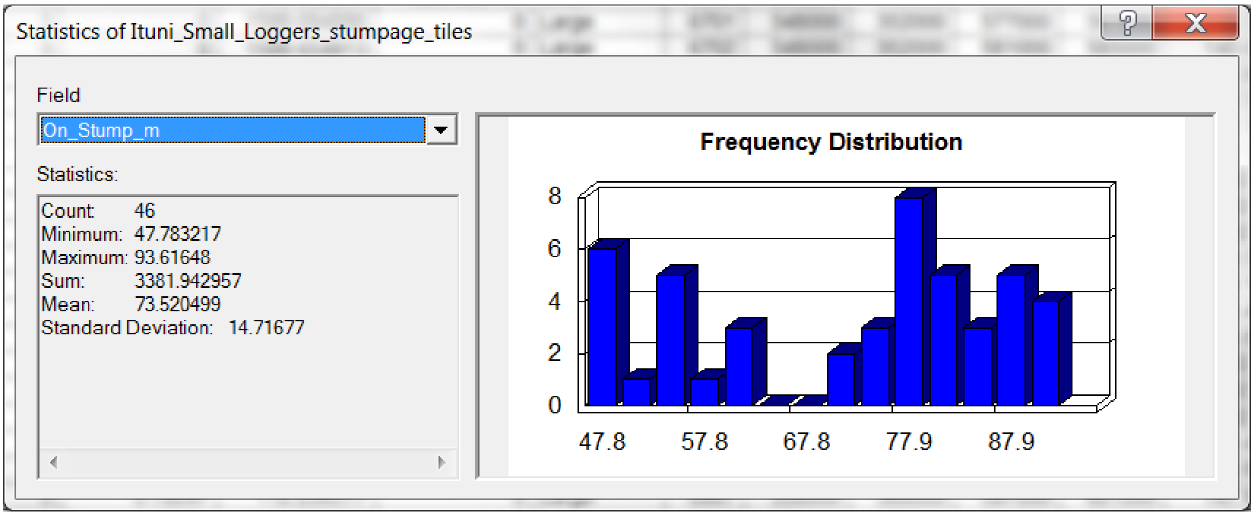
Ituni Small Loggers Association

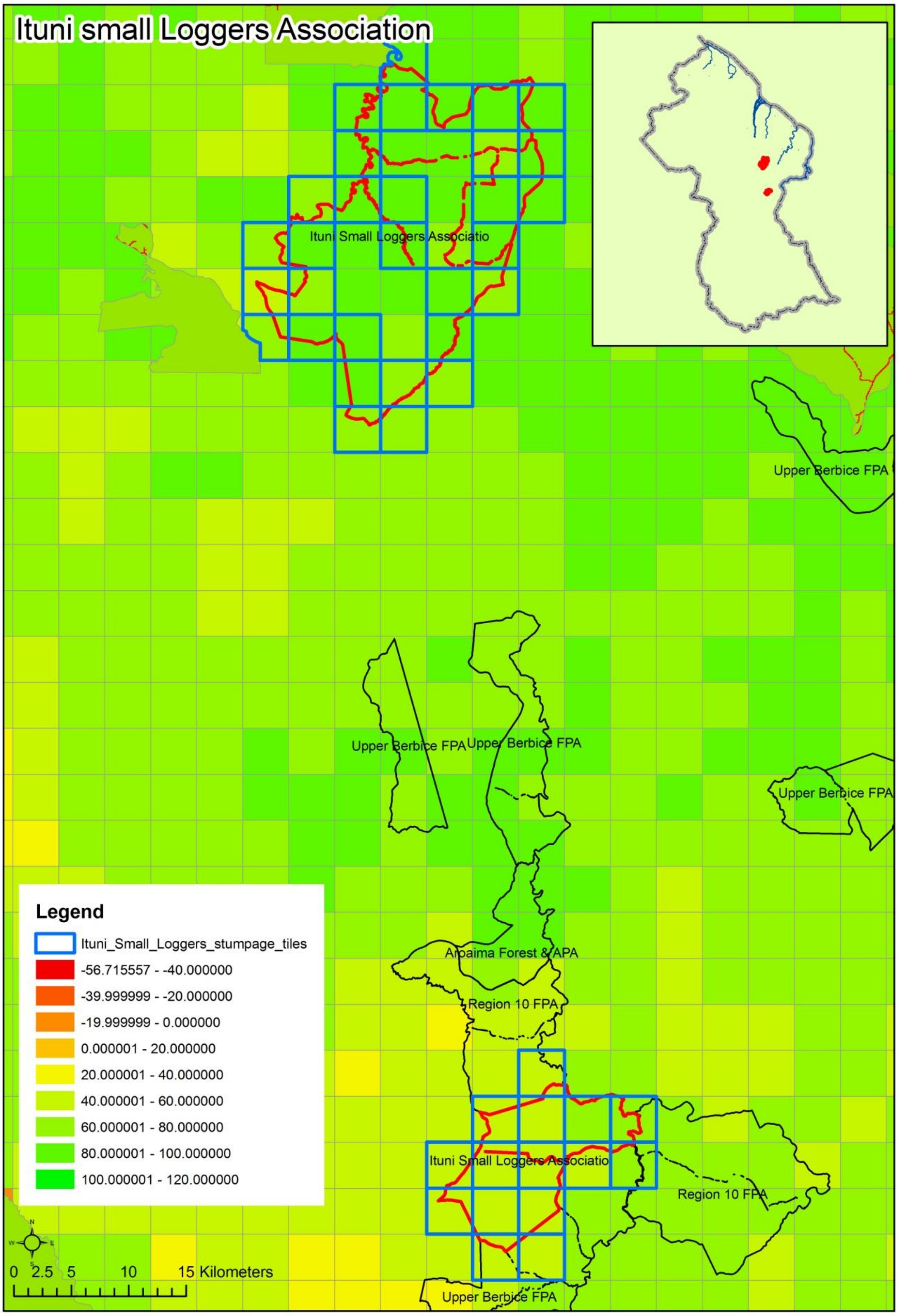
The Ituni Small Loggers' Association area is also in region which is general flat (Terrain Class 1) and is within the small concession category.

Taking into account the high level nature of the model, the estimated stumpage value per cubic meter within the tiles covering the Ituni area ranges between US$47 and US$93 per cubic metre with an estimated at-market value ranging between US$120 and US$150 per cubic metre. However, there is likely to be a higher frequency of areas that have a stumpage value above $67 per cubic metre on the basis of the frequency distribution graph below. The model estimates this area to have a near average return per cubic metre around US$138 (noting that the average across all tiles is estimated at US$142).

These values are based on assumptions stated in the main report thus require further refinement from field verification data.

Again this area is generally flat and an assumption can be taken that fewer roads are required to be established due to already existing nearby roads the likely use of temporary skidding trails. The mean road density in this area is estimated to be 2m per hectare.




Ituni small Loggers Association
Ituni Small Loggers Associatio
Upper Berbice FPA
Upper Berbice FPA
Upper Berbice FPA
Upper Berbice FPA
Arapaima Forest & APA
Region 10 FPA
Ituni Small Loggers Associatio
Region 10 FPA
Upper Berbice FPA
Legend
Ituni_Small_Loggers_stumpage_tiles
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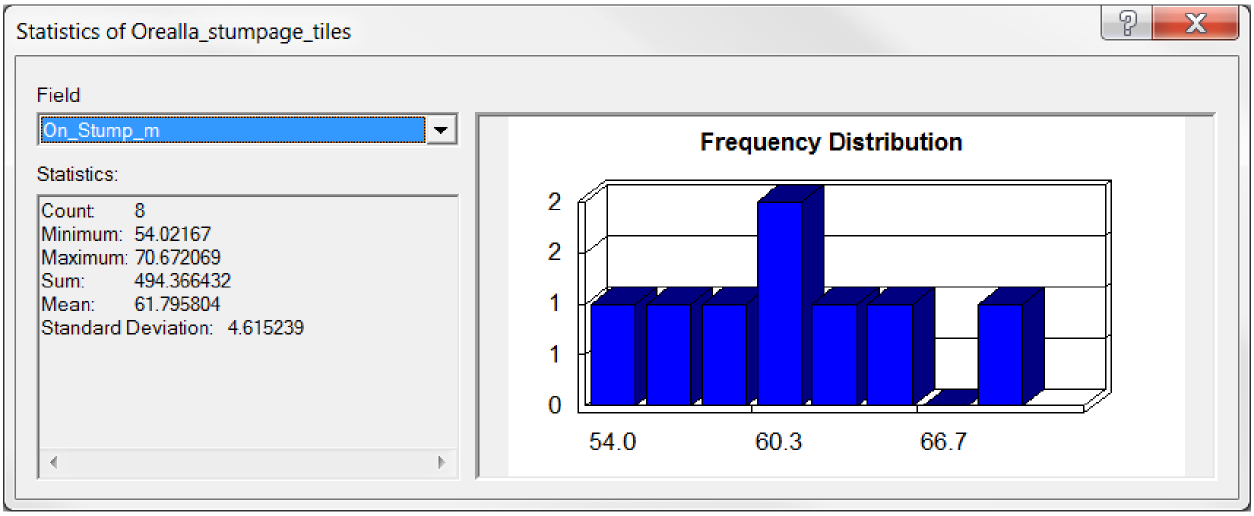
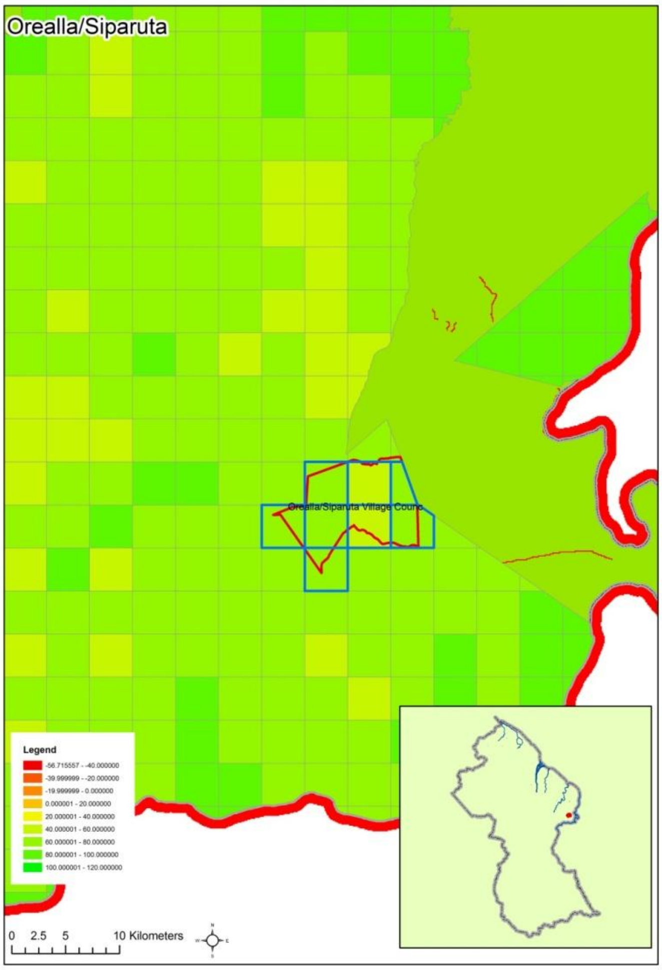
60.000001 - 80.000000
80.000001 - 100.000000
100.000001 - 120.000000
0 2.5 5 10 15 Kilometers

Orealla/Siparuta

The Orealla/Siparuta area is also in a region which is generally flat (Terrain Class 1) and is within the small concession category.

The estimated stumpage value per cubic meter within the tiles covering the area ranges between US$54 and US$71 per cubic metre with an estimated at-market value ranging between US$121 and US$148 per cubic metre.   The frequency distribution graph show a rather even range of values which suggests addtional inforamtion is required for refinement.




Orealla/Siparuta
Orealla/Siparuta Village Counc
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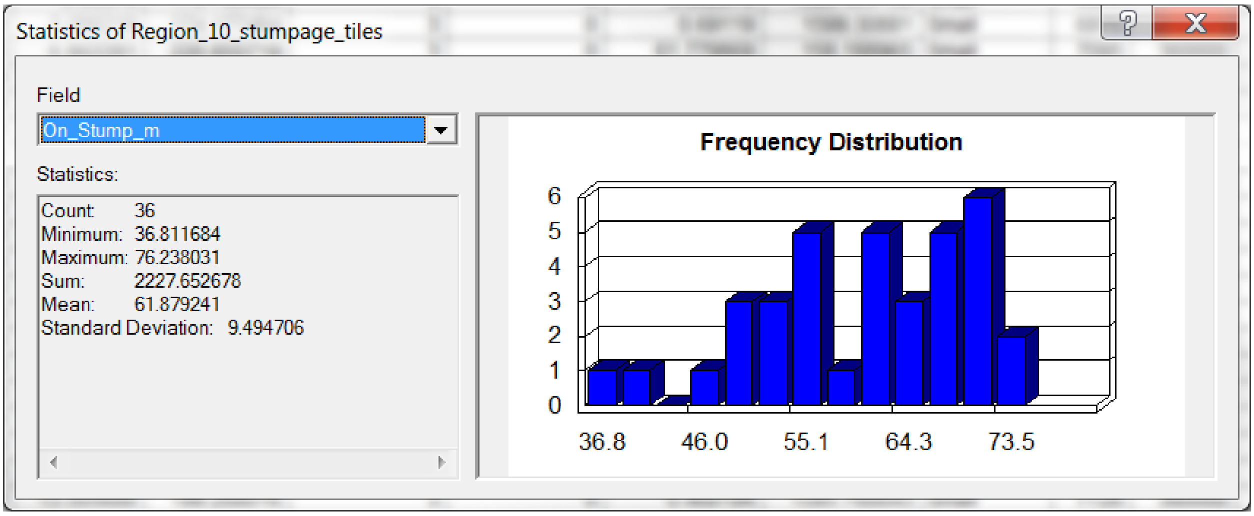
60.000001 - 80.000000
80.000001 - 100.000000
100.000001 - 120.000000
0 2.5 5 10 Kilometers

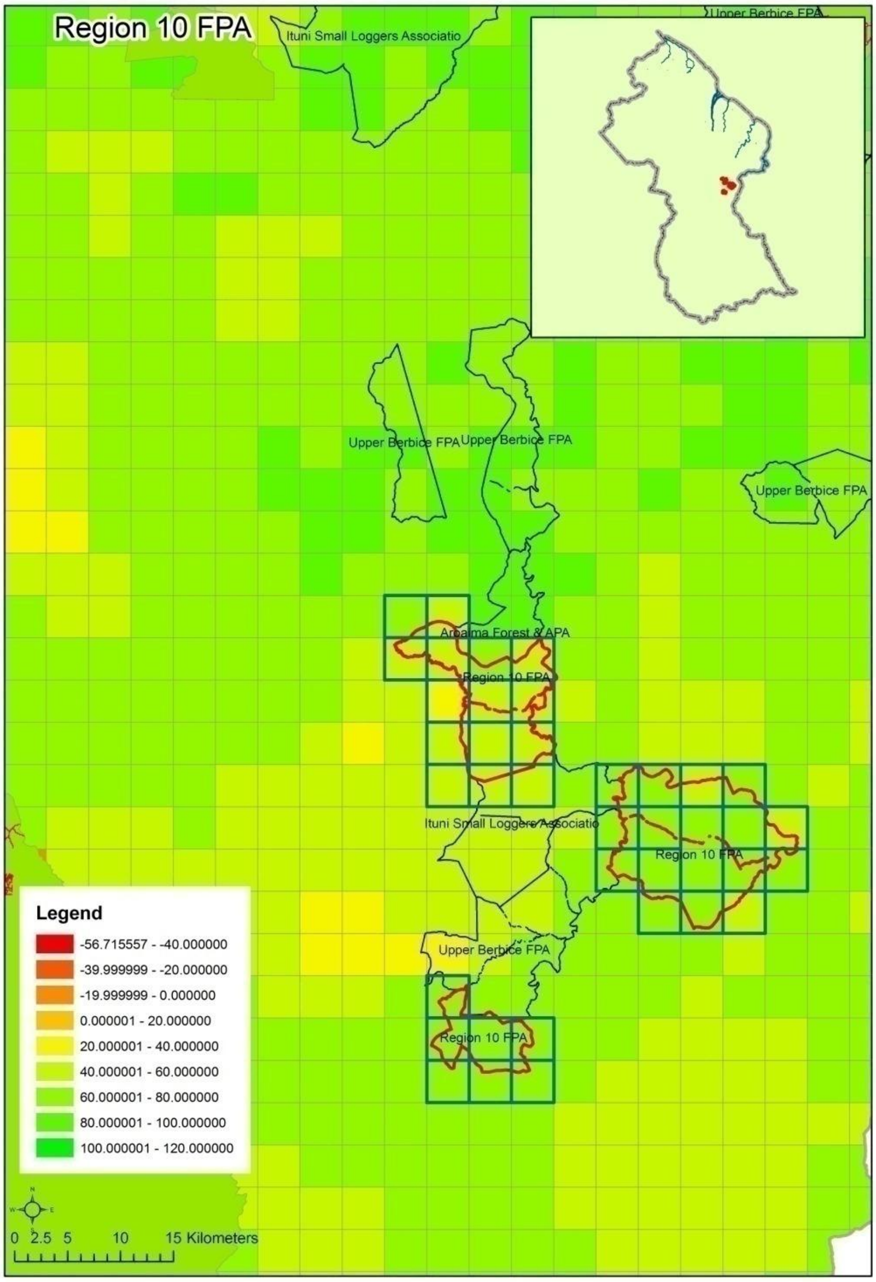
Region 10, Forest Producers Association

The Region 10 Forest Producers Association area is also in a region which is generally flat (Terrain Class 1) and is within the small concession category.

The estimated stumpage value per cubic meter within the tiles covering the Region 10 area ranges between US$36 and US$76 per cubic metre with an estimated at-market value ranging between US$122 and US$150 per cubic metre.

The maximum road density is estimated at just over 4 metres per hectare with a mean density across all tiles of less than 1 suggesting fewer roads maybe needed owing to the flat terrain and possibility for more use of temporary skid trails. It is unlikely that any roads are required to be established due to already existing nearby roads. Again, this area is predominantly of Veg1 category (mixed forest) and Veg2 (Wallaba/Dakama/Muri Shrub Forest).




Region 10 FPA
Ituni Small Loggers Associatio
Upper Berbice FPA
Upper Berbice FPA
Upper Berbice FPA
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Aroaima Forest & APA
Region 10 FPA
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Region 10 FPA
Upper Berbice FPA
Region 10 FPA
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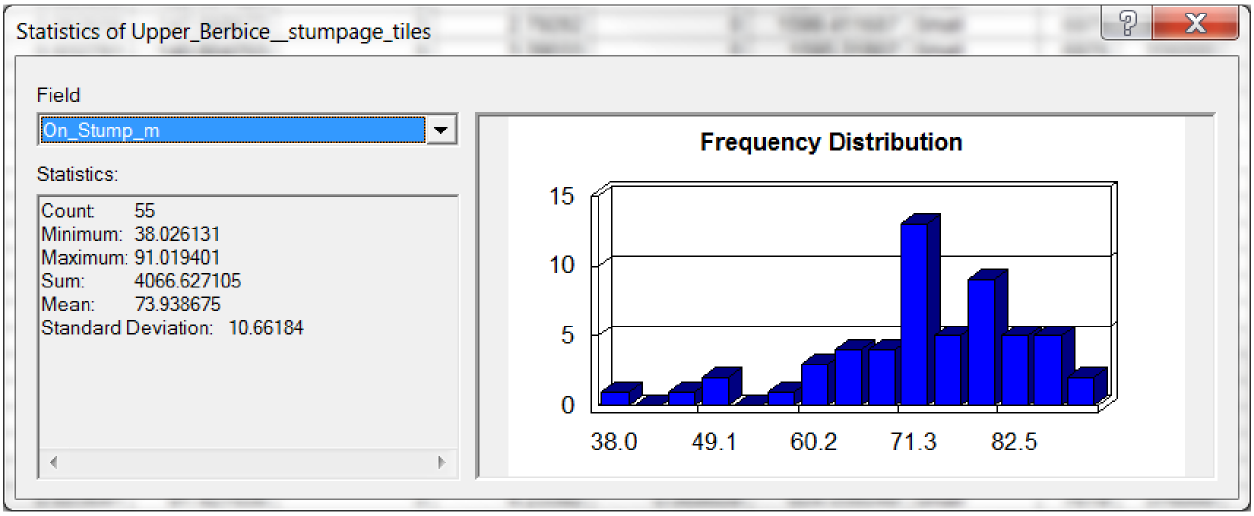
0.000001 - 20.000000
20.000001 - 40.000000
40.000001 - 60.000000
60.000001 - 80.000000
80.000001 - 100.000000
100.000001 - 120.000000
0 2.5 5 10 15 Kilometers

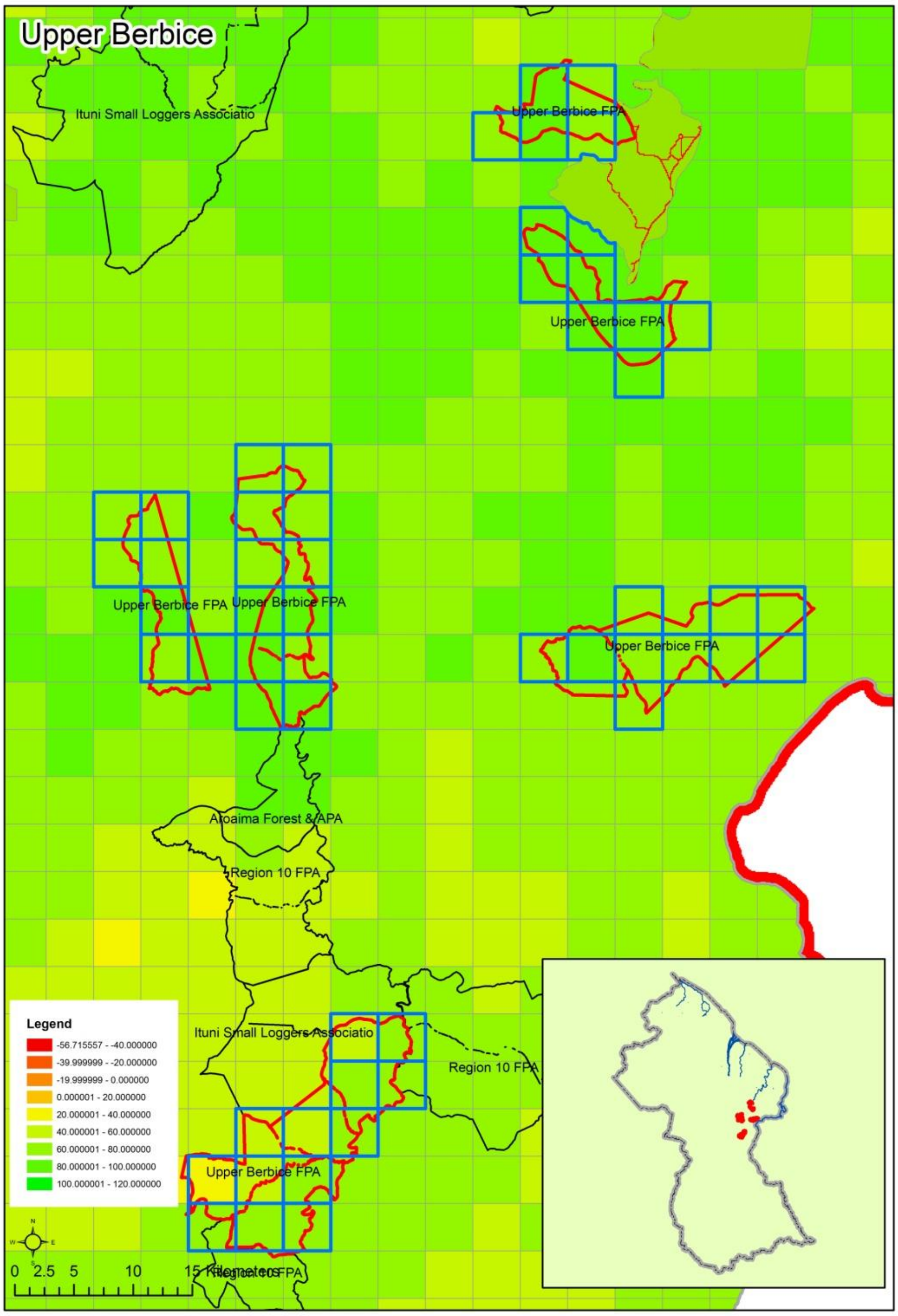
Upper Berbice Forest Producers Association

The Upper Berbice Forest Producers Association area is also in a region which is generally flat (Terrain Class 1) and is within the small concession category.

the estimated stumpage value per cubic meter within the tiles covering the Upper Berbice FPA area ranges between US$38 and US$91 per cubic metre with an estimated at-market value ranging between US$119 and US$152 per cubic metre. However, there is likely to be a higher frequency of areas that have a stumpage value above $65 per cubic metre on the basis of the frequency distribution graph below. Again these values are based on assumptions stated in the main report thus require further refinement from field verification data.

On the basis of the analysis undertaken, the mean road density is estimated at just over 2m per hectare. suggesting fewer roads maybe needed owing the flat terrain and possibility for more temporary skid trails. The assumption taken here is that with these high level results, overall resource estimates can be deduced.




Upper Berbice
Ituni Small Loggers Associatio
Upper Berbice FPA
Upper Berbice FPA
Upper Berbice FPA
Upper Berbice FPA
Upper Berbice FPA
Aroaima Forest & APA
Region 10 FPA
Ituni Small Loggers Associatio
Region 10 FPA
Upper Berbice FPA
Legend
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-19.999999 - 0.000000
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20.000001 - 40.000000
40.000001 - 60.000000
60.000001 - 80.000000
80.000001 - 100.000000
100.000001 - 120.000000
0 2.5 5 10 15 Kilometers

Field Verification

Ground surveys was done to identify each cause of deforestation and forest degradation. Vegetation type was used in the selection of areas for verification. Each vegetation type in the area covered by the medium resolution assessment, was verified through 5-10 hectares of ground truthing. For areas that was included in high resolution data coverage, 1 hectare per vegetation type was subject to ground truthing.

Ground truthing was carried out by field assessments, with teams of 5 persons including a GIS officer, tree spotter, forest ranger, and forest planning officer. The following list of activities was carried out in this process:

- Identify main data classes based on remote sensing assessment for vegetation types, species classes (to the extent of details possible), and driver of deforestation and forest degradation.
- Cross check classification based on field assessment with results generated from remotely sensed data.
- Revise and update remote sensing classification to reflect findings and field assessment.
- Document classification variations based on finding from remote sensing data as opposed to field assessments. Outline ways of addressing this in future assessments.
- Remote Sensing Imagery Analysis has been finalised and presented in this report.
- Ground based assessment for the areas ground checked is compiled in separate excel files (10 files).

APPENDIX 5

Remote Sensing Data Acquisition

Remotely sensed data (satellite images spanning from 2010 to 2011) have been acquired to detect deforestation activities and generate GIS layers documenting logging activities and road networks. Such information will assist GFC in targeting areas of change. In early 2010, hot spot areas or areas expected to experience land use and land cover change were identified followed by a the development of a change monitoring strategy. The hot spot areas are identified in the map below. Over these areas, higher resolution datasets were ordered to be acquired over the period August 2010 to March 2011 from DMC and RapidEye.

DMC imagery has a ground resolution of 32 m and provides the opportunity to track larger-scale forest events and detect newly constructed roads. RapidEye is 5m resolution imagery and can be used to accurately delineated areas of change. High resolution satellite datasets are well suited to improved detection and mapping of small scale changes (< 1 ha).

As part of the assessment of remote sensing imagery acquisition, the Brazilian Satellite CBERS was examined. The China Brazil Earth Resources Satellites (CBERS 2 and 2B) carry two similar sensors, a multi-spectral camera with 20 m resolution and a wide field imager at 260 m spatial resolution. CBERS 2B also carries a panchromatic high resolution camera (HRC) with 2.7 m resolution 27 x 27 km extent. These images are also freely distributed by INPE, Brazil. A selection of the HRC scenes has been used to provide validation for the land cover stratification map and forest change. Due to a malfunction, CBERS 2B recently ceased acquiring image data.

IMAGE ACQUISITION STRATEGY

The acquisition strategy uses a combination of datasets to provide coverage at countrywide and hotspot areas. It assumes that currently inaccessible areas will not be subject to the same rate of change as areas close to access routes such as rivers and existing roads.

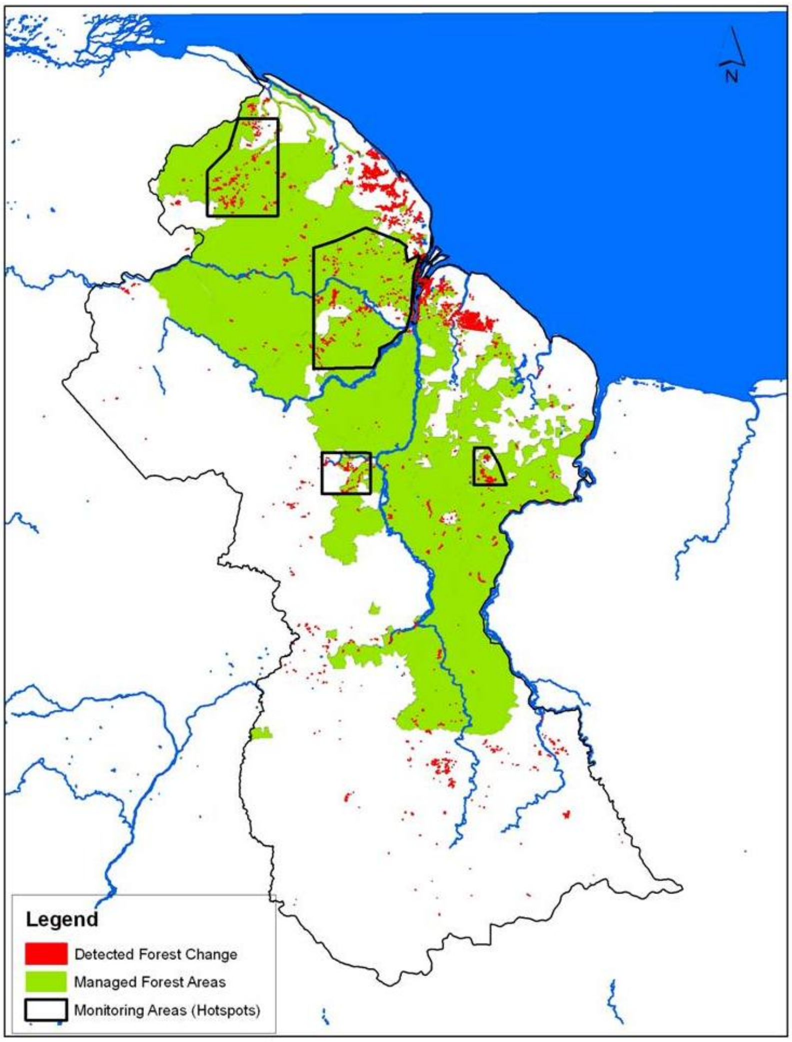
Hotspot areas located in the managed forest estate are identified in black on the map below. These are active areas of change identified during this project. The monitoring region has been enlarged as it is anticipated that these areas will continue to expand over time.

Remaining areas can be covered using countrywide and intermediate datasets.

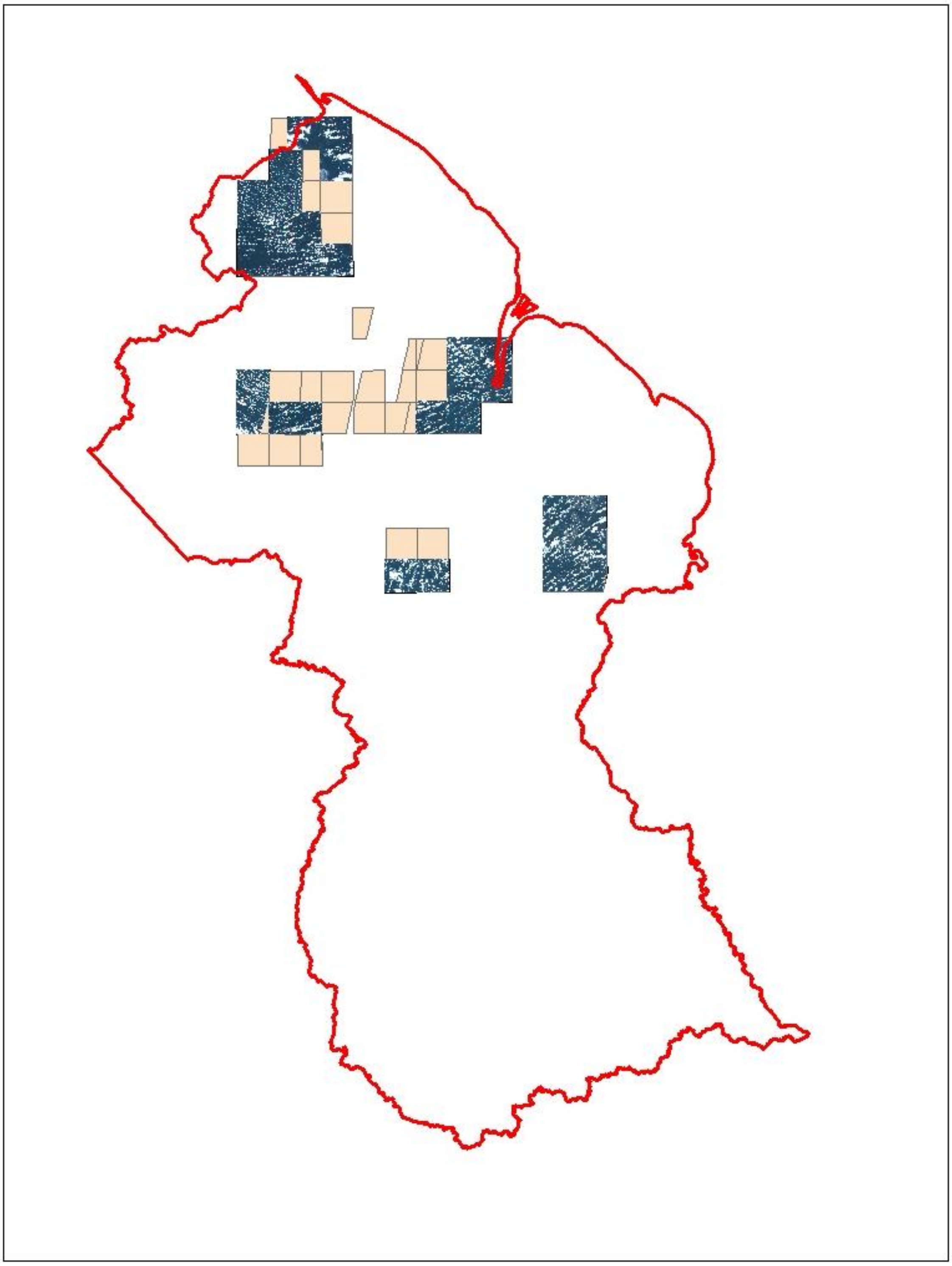
Countrywide & Hotspot Acquisition Strategy Coverage

The total area covered from the acquistion area consists of 11million (10.992) hectares covered by DMC and 1.7million hectares covered by Rapid eye. All imagery has been stored on the GFC file server. The foot prints for each sensor are presented in the maps below.

Hot Spot Target Areas



Rapid Eye Imagery Acquired 2010-2011



DMC Satellite Imagery Acquired 2010-2011