

Technical Paper No. 4

**Reconnaissance Forest Inventory Report
for Potential FMU-Area of Gogona**

(Wangdiphodrang Dzonkhag)

Bhutan-German Sustainable RNR Development Project

compiled by

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Table of Content

1 Introduction	1
2 General Information	2
2.1 Location and Terrain	2
2.2 Climate	2
2.3 Soils	2
2.4 Wildlife	3
2.5 Fauna	4
2.6 Human Impact	4
3 Forest Situation	6
3.1 Forest Types and Forest Condition	6
3.2 Inventory Results	6
3.2.1 Stratification	6
3.2.2 Average Gross Volume per ha	7
3.2.3 Average Basal Area per ha	8
3.2.4 Average Number of Trees per ha	9
4 Operable Area and Areas of Priority for Forest Management	10
5 AAC-Estimate	11

Annex

1 References	
2 Map of inventory sample location and forest strata	
3 Distribution of forest strata within preliminarily identified potential productive forest area	
4 Inventory Results	
4.1 Average gross volume per ha	
4.2 Average basal area per ha	
4.3 Average number of trees per ha	
5 Map of Potential Forest Areas (Scale 1:50.000)	

Acronyms

AAC	Annual allowable cut
BG-SRDP	Bhutan - German Sustainable RNR Development Project
CV%	coefficient of variation
DEM	Digital elevation model
EFS	Economic Feasibility Study
FDC	Forest Development Corporation (former BLC)
FMPL	Forest Management Planning
FMU	Forest Management Unit
FRDS	Forest Resources Development Section
FSD	Forestry Services Division
GIS	Geographic Information System
GPS	Geographic Positioning System
LUPP	Land Use Planning Project
LUPP-map	LUPP land use working maps, scale 1:50.000
PEE	Preliminary Environmental Examination
PLOT	tailor made EDP program for forest inventory analysis
PIS	Preinvestment Survey
PIS-map	PIS-map at scale 1:50.000
RECO	Reconnaissance Survey
RFI	Reconnaissance Forest Inventory
RS	Reconnaissance Survey
SE%	standard error
SES	Socio-Economic Study
Topo-map	Topographic map with 40m height lines, scale 1:50.000

1 Introduction

In Gogona valley a reconnaissance inventory was carried out in order to identify the potential of the forest area for commercial timber production. The inventory is a crucial component of the reconnaissance survey which is, at present, undertaken in the valley. It is the objective of this survey to provide the decision makers with information whether it is worthwhile to open Gogona valley as a forest management unit for commercial timber production or not. This report concentrates on information required for the EFS (Economic Feasibility Study) on commercial timber production. Additionally it provides some information relevant for the PEE (Preliminary Environmental Examination) and the SES (Socio-Economic Study). All relevant environmental, social and economic aspects will be dealt with in detail in the above mentioned studies.

The inventory team was headed by Mr. Prabhat Kumar Muchia, Deputy Forest Ranger of the Forest Resources Development Section and, at present, in charge of reconnaissance inventories. Field work was carried out between April and first week of June 1996.

The inventory design applied can be described as stratified satellite inventory based on randomly distributed cluster samples. Field work was carried out according to the guidelines specified in the "Reconnaissance Forest Inventory Field Manual" prepared by SCHINDELE in 1995.

Throughout Gogona valley altogether 20 inventory satellites, comprising of 60 independent samples or 180 individual plots, were randomly distributed within predefined forest strata (see Annex 1: Location of Satellite Samples). Due to difficult terrain features (steepness, gorges, etc.) three satellites could not be assessed at all (AA5, AB2 and AB8), while for satellite AB6 two samples were inaccessible.

2 General Information

2.1 Location and Terrain

Gogona valley is located in Whangdi-Phodrang Dzongkhag. The northern part belongs to Bjena, the southern part to the Athang Gewog. In the west Gogona valley borders on Kothoka FMU, in the east it is adjoining to Phobjika Protected Area. The southern boundary is formed by steep slopes and the northern boundary by a mountain ridge.

The area identified as a potential forest management unit covers a total area of 8677 ha of which about 6000 ha are suitable for forest management (estimated operable area).

The altitude varies from 2690 m in the south (Kangkha Chu valley) up to 4189 m in the east (Suetingla). The Gogona Valley is formed by the watershed of Kangkha Chu and Lämchhekha Chu). Both rivers flow towards the south and meet within the convergent of the valley. Numerous ephemeral streams have formed a highly dissected relief in particular in the west and southwest. Here accessibility is quite difficult. While towards the valley bottom gentle to moderate slope dominate, the terrain becomes more and more steep towards the mountain ridges in the west, north and east. Here some steep rocky parts forms a natural frontier for timber exploitation.

Gogona valley is only accessible by a mule trek which runs from Phobjika to Gogona (two and a half hours) and from Gogona to Kothoka. The distance of the motorable road from Phobjika to Wangdue is about 90 km.

2.2 Climate

Gogona valley lies within the temperate to the sub-alpine zone. The climate is wet and cold. The snow starts to cover the valley from the first week of December until the end of February. Moderate rainfall occurs from the midst of May to the end of September.

2.3 Soils

The soils in the valley are generally clayish or sandy loam. In well drained areas the reddish-brown coloured soil is quite fertile and of high productivity for tree growth.

Flat or gently sloped areas are mainly water-logged and here the dominating soil types are pseudogleys, gleys and podsols. On higher elevations and, in particular, on steep slopes, the soil becomes quite shallow and sometimes bare rocks appear.

In general it can be mentioned that the soils in Gogona valley are quite suitable for sustainable timber production.

2.4 Wildlife

The forests within Gogona Valley are rich in wildlife. Himalayan black bear (*Selenarctos thibetanus*) and Red Panda (*Ailurus fulgens*) occur mainly in remote areas with dense bamboo understorey. Barking deer (*Muntiacus muntiak*) and Sambar Deer (*Cervus unicolor*) are quite common throughout the area, while the population of Musk deer (*Moschus chrysogaster*) is already restricted to very remote areas. Monal pheasants (*Lophophorus impejensus*) and Blood pheasants (Bab in Dzongdah) are quite common, too. Tracks and signs of long-tailed capped Langur (*Presbytis pileatus*) and Wild dogs (*Cuan alpirus*) were also identified during field work.

According to the village people there are even some individuals of Tigers (*Panthera spp.*) Snow-leopards (*Panthera uncia*) and "Gorilla" (Megaey in Dzongdah) found in Gogona valley. As for the "Gorilla", a few years back two individuals were identified, while nowadays only one individual can be seldomly observed roaming in the higher parts of the valley.

Wild boar population has been increased during the last years, which makes it necessary for the people to fence their gardens.

In altogether 45 sample plots observations of wildlife were collected during the inventory (see table below).

<u>Type of Animal</u>	<u>Observation in % of Plots</u>	<u>Protection Status</u>
Musk deer	27%	protected
Sambar deer	36%	
Barking deer	53%	
Himalayan bear	22%	protected
Red Panda	2%	protected
Pheasant	44%	protected
Wild boar	40%	

As already mentioned, the Gogona valley is very rich in wildlife and quite a number of endangered and protected animals still occur in this valley. Once it comes to commercial timber exploitation the habitats of, especially the endangered species, should be exempted from timber exploitation and declared as wildlife protection areas.

2.5 Fauna

The dominating tree species are hemlock (*Tsuga domosa*) and fir (*Abies densa*) which are mixed with some juniperus (*Juniperus spp.*) and spruce (*Picea spinosa*) mainly in the mixed conifer zone. Rhododendron is quite common in the fir and mixed conifer forests where also a few maple (*Acer spp.*) and birch are intermixed.

Especially in the fir forests sometimes dense pockets of various bamboo species appear. *Daphne*, *Meconopsis spp.*, *Peptanthus spp.*, *Rumex nepalensis*, *Primula spp.* and *Potentilla spp.* are common species of the groundflora. During the rainy season a large variety of edible mushrooms is found in the forest.

2.6 Human Impact

In the valley bottom there are several small villages or settlements which are Gogona, Thankha, Ibcha, Dangchu and Gangak. The forests around these settlements are quite intensively used by the village people for firewood collection and the production of fence post and construction timber. Shingleps are mainly produced in the fir belt and in the mixed conifer zone. Most of the forest area is used for browsing, however, the browsing intensity depends on terrain, accessibility and distance to the settlements. In wintertime, Gogona valley is used for Yak wintering. Beside cattle, there are large numbers of horses and sheps kept in the valley.

Some part of the forest area has been damaged by fire. It is assumed that in most of the cases the fires were set intentionally in order to clear dense understorey vegetation for pasture improvement, large trees were usually not affected. There are only very few areas where the forest has been completely destroyed by fire. Due to the remoteness of the area till today, no commercial timber exploitation has been carried out so far. Also there have been no indications for abandoned shifting cultivation areas or cardamon cultivation. From the 45 plots where the human impact was assessed, the following observations were made:

<u>Type of Use</u>	<u>Observation in % of Plots</u>
domestic wood extraction	80%
grazing	84%
fire	15%

The forest areas around the villages and settlements which are right now intensively used for wood production should be exempted from commercial timber production and declared as community forests. When it comes to commercial timber production conflicts may arise between grazing and forest management.

3 Forest Situation

3.1 Forest Types and Forest Condition

Most of Gogona valley lies within the conifer belt. Only in the south, down towards the lower elevations, there are some mixed conifer/hardwood and pure hardwood forests. The conifer belt is mainly formed by:

- pure hemlock forest;
- mixed hemlock and fir forests;
- mixed fir and juniperus forests; and
- mixed conifer forest.

Most of the forest area is over-matured. Where intensive grazing takes place (which is the case for most of the forest area) there is hardly any natural regeneration coming up. The percentage of cull fir is quite high, especially in the old and over-mature fir forests. There are also some over-mature hemlock forests with trees of diameters up to 200 cm and 50 m height. Along the footpath to Gogona and in the east along the ridge, the percentage of over-mature forests in the fragmentation phase is quite high. In the southeastern part some of the mixed conifer/hardwood forests are heavily damaged - sometimes even completely destroyed - by fire, heavy snowfall and beetle attack. While the potential for timber utilization is still quite high, the forest condition will worsen in the long run, if no proper forest management will take place.

3.2 Inventory Results

3.2.1 Stratification

Based on the analysis of LUPP-maps and PIS-maps the potential productive forest area was preliminarily identified and, after that, stratified (see Annex 1 and Annex 3). Based on the size of the different strata altogether 20 satellites were randomly distributed (see table below). The objective of stratification was to reduce the total number of sample plots required to obtain statistically reliable stand data (+/- 20% on 95% confidence level). For more details on stratification see SCHINDELE, 1996.

Stratum Satellites	Area (ha)	No. of
1 fir forest, density > 60%	1825	3
2 fir forest, density < 60%	242	2
3 mixed conifer, density > 60%	4020	9
4 mixed conifer, density < 60%	483	2
5 broadleaf mixed with conifer	440	2
6 broadleaf	287	2
total	7297	20

For data analysis the above mentioned strata were combined into three strata in which the following number of samples were actually assessed (not accessible samples excluded):

Stratum Samples	Area (ha)	No. of
fir forest	2067	12
mixed conifer forest	4503	30
mixed conifer/broadleaf forest	727	7
total	7297	49

3.2.2 Average Gross Volume per ha

In Annex 4.1 the average gross volume per ha is listed for the different strata. The average gross volume per species and diameter class is shown in Figure 1 below and in Annex 4.1.

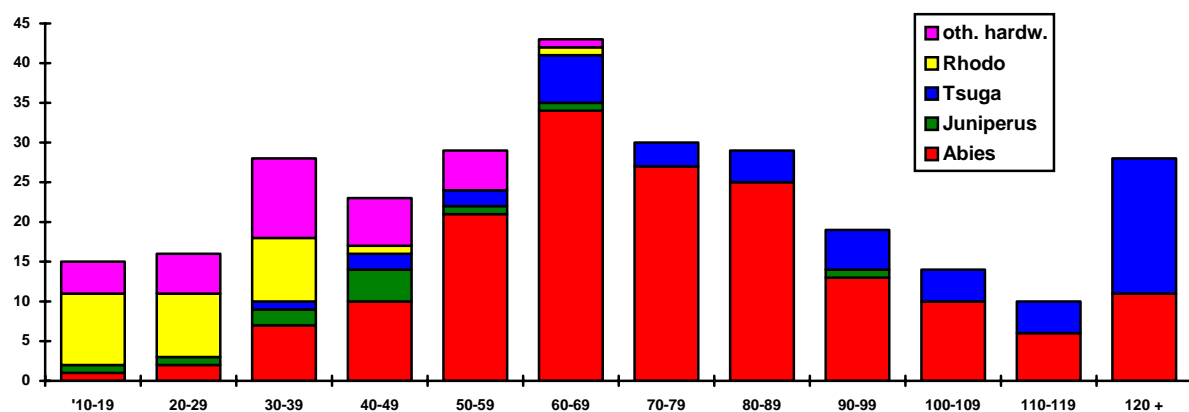


Figure 1: Average gross volume (per ha) per species and diameter class

The average gross volume per ha is 285 m³/ha of which 79% are conifers and 21% are broadleaf species. The total volume above 50 cm dbh is 204 m³/ha of which 96% are conifers. Above 60 cm dbh, the average gross volume is still 175 m³/ha of which all are conifers. The standing stock of the fir forest (389 m³/ha) is quite high compared to the mixed conifer forest of 277 m³/ha (see Annex 4.1). The standing stock of the mixed/conifer hardwood forest is extremely low, as two samples were located in severely damaged forest area. (Note: the results per strata are from the statistical point of view not very much reliable).

Fir has with 59% the highest percentage of the standing stock followed by hemlock (17%). The high percentage of fir is critical from the economic point of view, as the percentage of cull trees is usually fairly high.

The average gross volume of Gogona is about 10% less than the average gross volume of Kothoka of 317 m³/ha.

3.2.3 Average Basal Area per ha

In Annex 4.2 the average basal area per ha is listed for the different strata. The average basal area per species and diameter class is shown in Figure 1 below and in Annex 4.2.

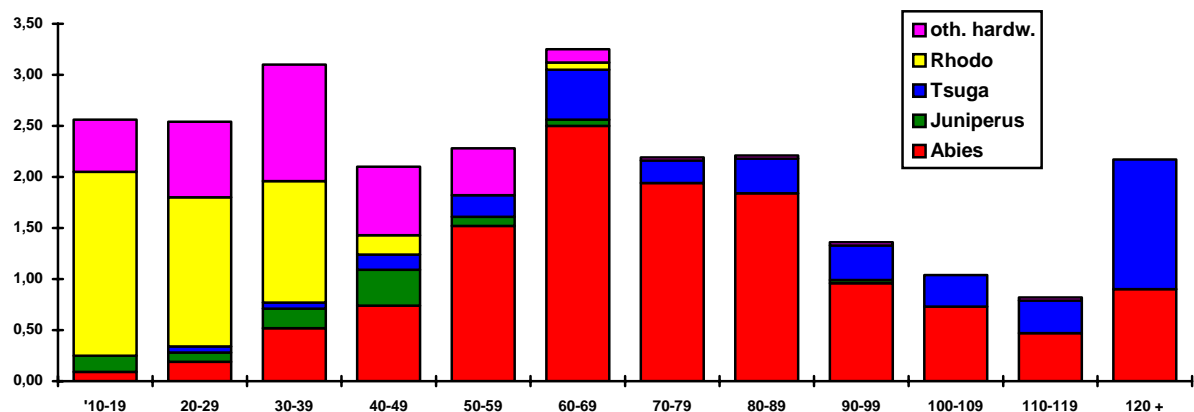


Figure 2: Average basal area (per ha) per species and diameter class

The total basal area is 26 m²/ha which is less than the average in Kothoka (33 m²/ha). Hardwood species and rhododendron dominate in the lower diameter classes, while the conifers have their peak in the diameter class 60-80 cm. It has to be mentioned, that there is a high percentage of big size hemlock in Gogona valley which should be harvested as soon as possible.

3.2.4 Average Number of Trees per ha

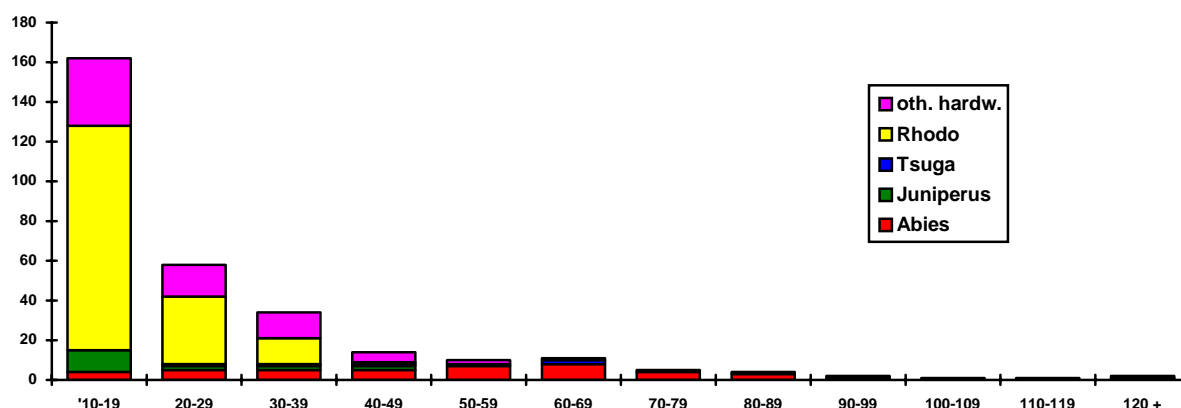


Figure 3: Average number of trees (per ha) per species and diameter class

The distribution of the average number of trees per ha shows a typical distribution for natural forests. However, the percentage of the conifers classes is definitely too low in the lower diameter. This becomes more obvious if we have a look at the tree species distribution of the fir and mixed conifer strata in Annex 4.3. Especially in the mixed conifer forest, fir and hemlock are completely missing in the diameter class 10-19 cm and their percentage is still very low up to a diameter of 60 cm. The lack of young conifers in a forest of comparatively low average basal area, the lack of natural regeneration as observed during inventory field work and the high percentage of forest area used as cattle grazing ground are clear indicators, that too high cattle intensities over the last decades have prevented the natural regeneration of the conifers. On the other hand a large percentage of the forests in Gogona are over-mature and already in the fragmentation phase or rejuvenation phase. To prevent the degradation of these over-aged forests it is of greatest importance that natural regeneration can come up within the next 20 to 40 years.

4 Operable Area and Areas of Priority for Forest Management

The total area identified as potential for forest management based on PIS- and LUPP-maps was estimated at 7297 ha. During field work it was experienced that some of the areas considered as potential were not accessible due to difficult terrain features (ie. too steep, many gorges and heavily intersected terrain). From altogether 60 inventory samples only 49 samples (82%) were accessible.

GIS-anlysis of the slope, in combination with field knowledge gained during inventory implementation, and with generalisation of the polygon boundaries (see Annex 5) come to an estimate of approximately 6700 ha accessible forest area. To be on the safe side, another 10% should be substracted for inoperable areas. Thus the total operable area for timber production is estimated to be around **6000 ha**.

As priority areas for forest management within the next decade over-mature forests which still have a good potential of harvestable trees should be selected. Taking into account an average rotation period of 160 years and an average of 3 felling operations until the forest is regenerated then the working area for the first planning period of 20 years can be estimated as follows:

$$6000 \text{ ha}/160 \text{ years} * 3 * 20 \text{ years} = \mathbf{2250 \text{ ha}}$$

It is proposed to start with forest management in the northern half of Gogona valley. Here there are quite a number of forest areas of good harvesting potential which are already over-matured. On the other hand most of these areas will become easily accessible once a motorable main access road has been constructed from Phobjika. The priority area for forest management for the next 20 years is marked on the map in Annex 5. Its total area is about 2200 ha.

5 AAC-Estimate

Whether it is worthwhile from the economic point of view to open Gogona valley as a FMU, an estimate of the annual allowable cut of commercial marketable timber is of greatest interest. As Hemlock and fir are almost the only commercial species in Gogona the AAC is calculated based on the standing stock of these two species.

According to experiences made in Ura (HERBST, 1993a) the percentage of decay on fir is fairly high (ie. 57% in Shingkar East). To provide a conservative estimate of the AAC only the usable volume of fir and hemlock is considered.

The AAC calculation is based on the following assumptions:

rotation period: 160 years

estimated harvesting waste: 20%

estimated cull related waste (for fir only): 60%

usable volume:

hemlock	$49 \text{ m}^3/\text{ha} * 0.8$	=	$39 \text{ m}^3/\text{ha}$
fir	$168 \text{ m}^3/\text{ha} * 0.8 * 0.4$	=	$54 \text{ m}^3/\text{ha}$
total			$93 \text{ m}^3/\text{ha}$

a) Clear cut equivalent method:

Yield = annual cut * usable volume

Annual cut in ha: $6000\text{ha} / 160\text{years} = 37.5 \text{ ha/year}$

AAC: $37.5\text{ha} * 93 \text{ m}^3/\text{ha} = \mathbf{3488 \text{ m}^3}$

b) Von Mantel's method

Yield = $2 * \text{Growing Stock} / \text{Rotation Period}$

AAC = $2 * 93\text{m}^3/\text{ha} * 6000\text{ha} / 160\text{years} = \mathbf{6975 \text{ m}^3}$

An AAC-estimate of 5000 m^3 can be considered as rather conservative.

Annex 1

References

References

GOI/MOA; 1980: Report on Reinvestment Survey of Forest Resources in Central and Eastern Bhutan. Volume 1: Forest Resources. Dhera Dun.

HERBST, P.; 1993(a): Report on Forest Management Plannings (Management Plan Shingkar East). Volume 1: Current Situation, Future Management, Implementation and Control. ADC Austria, Project 1111/90 Bhutan.

HERBST, P.; 1993(b): Management Plan for the Block Shingkar East, Bhumtang District. (1993-2002). Volume 2: Stand Descriptions and Prescriptions, Stand Characteristics. ADC Austria, Project 1111/90 Bhutan.

KOWALCZYK, S.; undated: User's Manual for <PLOT> System. Forest Inventory Data Processing. FAO BHU 91/002.

SCHINDELE, W.; 1995 (a): Forest Resources Potential Assessment for Punakha and Wangdue-Phodrang District. Mission Report on Forest Resources Assessment and Forest Management within the Scope of the Bhutan - German Integrated Forest Management Project. BG-IFMP, Working Paper No 5.

SCHINDELE, W.; 1995 (b): Reconnaissance Forest Inventory Field Manual. Mission Report on Forest Resources Assessment and Forest Management within the Scope of the Bhutan - German Integrated Forest Management Project. BG-IFMP, Technical Paper No. 1.

SCHINDELE, W.; 1997: Guidelines for a Reconnaissance Forest Inventory. Mission Report on Forest Resources Assessment and Forest Management within the Scope of the Bhutan - German Sustainable RNR Development Project. BG-SRDP, Technical Paper No. 1, 3rd. revised version.

Annex 2

Map of inventory sample location and forest strata

Annex 3

**Distribution of forest strata within
preliminarily identified potential productive forest area**

Stratum 1: fir forest, density > 60%

Substratum No.	Area in ha
1.1	52
1.2	345
1.3	48
1.4	29
1.5	96
1.6	79
1.7	47
1.8	78
1.9	130
1.10	207
1.11	176
1.12	85
1.13	123
1.14	277
1.15	53
total	1825

Stratum 2: fir forest, density < 60%

Substratum No.	Area in ha
2.1	125
2.2	77
2.3	40
total	242

Stratum 3: mixed conifer, density > 60%

Substratum No.	Area in ha
3.1	358
3.2	500
3.3	548
3.4	386
3.5	472
3.6	97
3.7	1126
3.8	177
3.9	38
3.10	56
3.11	178
3.12	84
total	4020

Stratum 4: mixed conifer, density < 60%

Substratum No.	Area in ha
4.1	33
4.2	286
4.3	164
total	483

Stratum 5: broadleaf mixed with conifer

Substratum No.	Area in ha
5.1	440
total	440

Stratum 6: broadleaf

Substratum No.	Area in ha
6.1	287
total	287

Potential forest areas: 7297 ha

Non potential areas 1380 ha

Total area Gogona: 8677 ha

Annex 4

Inventory Results

4.1 Average gross volume per ha

4.2 Average basal area per ha

4.3 Average number of trees per ha

Annex 4.1: Average gross volume per ha (m³/ha)

Inventory Unit	: Gogona	Number of Strata	:	3
Stratum	: Combined	Number of Sampling Units	:	49
Area (ha)	: 7297.0	Estimate of Total	:	285.264
Period	: 16/03/96 to 05/06/96	t (0.975, 46)	:	2.013
Tree Status	: Survivor	Sampling Error% for Estimate (at P=0.95)	:	20.49
Timber Quality	: All (Dbh 10+ cm)			
Estimated Parameter	: AVERAGE GROSS VOLUME PER HA (m ³ /ha)			

Species Group	Dbh class (cm)												total	%
	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	-109	-119	120+		
Abies densa	1.01	2.22	6.59	10.23	21.21	34.48	27.28	24.91	13.20	9.53	6.07	11.39	168.12	58.94
Juniperus	0.97	0.93	1.75	3.51	1.05	0.60	0.00	0.00	0.43	0.00	0.00	0.00	9.24	3.24
Tsuga	0.00	0.48	0.59	1.69	2.42	5.95	2.87	4.42	4.70	4.17	4.30	17.30	48.90	17.14
total conifer	1.99	3.64	8.94	15.42	24.68	41.04	30.15	29.33	18.32	13.69	10.37	28.69	226.26	79.32
Rhododendron	8.99	8.32	8.06	1.47	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00	27.35	9.59
other broadl	3.58	5.22	9.67	5.92	4.70	1.38	0.30	0.30	0.31	0.00	0.28	0.00	31.66	11.10
total broadl.	12.56	13.54	17.73	7.39	4.70	1.89	0.30	0.30	0.31	0.00	0.28	0.00	59.00	20.68
total	14.55	17.18	26.67	22.81	29.37	42.92	30.45	29.63	18.64	13.69	10.65	28.69	285.26	100.00
%	5.10	6.02	9.35	8.00	10.30	15.05	10.67	10.39	6.53	4.80	3.73	10.06	100.00	

Statistical data:

STRATUM	: Combined
Area (ha)	: 7297.0 ha
Number of Sampling Units	: 49
Degrees of Freedom	: 46
t (0.975, 46)	: 2.01300000
t (0.950, 46)	: 1.67800000
Estimate	: 285.26415954
Standard Error	: 29.03985528
Sampling Error (P=0.95)	: 58.45722869
Sampling Error %	: 20.49231449
Reliable Minimum Estimate (P=0.95)	: 236.53528238

Inventory Unit : Gogona Number of Strata : 1
 Stratum : Fir Forests Number of Sampling Units : 12
 Area (ha) : 2067.0 Estimate of Total : 389.853
 Period : 19/03/96 to 02/06/96 t (0.975, 11) : 2.201
 Sampling Error% for Estimate (at P=0.95) : 35.90

Tree Status : Survivor
 Timber Quality : All (Dbh 10+ cm)
 Estimated Parameter : AVERAGE GROSS VOLUME PER HA (m³/ha)

Species Group	Dbh class (cm)												total	%
	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	-109	-119	120+		
Abies densa	3.58	6.53	12.48	23.51	41.53	66.75	42.14	34.44	16.82	15.02	2.96	12.70	278.45	71.43
Juniperus	3.44	3.28	6.19	12.38	3.70	2.13	0.00	0.00	1.50	0.00	0.00	0.00	32.62	8.37
Tsuga	0.00	0.88	0.00	0.00	1.32	1.20	1.30	0.00	3.16	0.00	6.26	14.27	28.39	7.28
total conifer	7.02	10.69	18.67	35.90	46.56	70.08	43.44	34.44	21.48	15.02	9.22	26.97	339.47	87.08
Rhododendron	11.63	4.85	4.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21.04	5.40
other broadl.	5.50	6.08	10.87	3.75	2.07	1.08	0.00	0.00	0.00	0.00	0.00	0.00	29.34	7.53
total broadl.	17.14	10.93	15.42	3.75	2.07	1.08	0.00	0.00	0.00	0.00	0.00	0.00	50.38	12.92
total	24.16	21.62	34.09	39.64	48.62	71.15	43.44	34.44	21.48	15.02	9.22	26.97	389.85	100.00
%	6.20	5.55	8.74	10.17	12.47	18.25	11.14	8.83	5.51	3.85	2.37	6.92	100.00	

Inventory Unit : Gogona Number of Strata : 1
 Stratum : Mixed Conifer Number of Sampling Units : 28
 Area (ha) : 4503.0 Estimate of Total : 276.615
 Period : 16/03/96 to 04/06/96 t (0.975, 27) : 2.052
 Sampling Error% for Estimate (at P=0.95) : 27.22

Tree Status : Survivor
 Timber Quality : All (Dbh 10+ cm)
 Estimated Parameter : AVERAGE GROSS VOLUME PER HA (m³/ha)

Species Group	Dbh class (cm)												total	%
	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	-109	-119	120+		
Abies densa	0.00	0.61	4.96	5.78	15.31	25.24	24.87	24.56	13.66	8.54	8.48	12.62	144.62	52.28
Juniperus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tsuga	0.00	0.38	0.96	2.74	3.31	8.80	3.75	6.84	5.14	6.44	3.79	21.17	63.32	22.89
total conifer	0.00	0.99	5.92	8.52	18.62	34.04	28.62	31.39	18.81	14.98	12.27	33.79	207.95	75.18
Rhododendron	8.99	10.39	10.30	2.17	0.00	0.64	0.00	0.00	0.00	0.00	0.00	0.00	32.49	11.75
other broadl.	3.27	5.49	10.25	7.25	6.46	1.52	0.48	0.49	0.51	0.00	0.45	0.00	36.18	13.08
total broadl.	12.26	15.88	20.55	9.42	6.46	2.16	0.48	0.49	0.51	0.00	0.45	0.00	68.67	24.82
total	12.26	16.87	26.47	17.94	25.08	36.20	29.10	31.88	19.31	14.98	12.72	33.79	276.61	100.00
%	4.43	6.10	9.57	6.49	9.07	13.09	10.52	11.53	6.98	5.42	4.60	12.22	100.00	

Inventory Unit : Gogona Number of Strata : 1
 Stratum : Mixed Conifer / Broadleaf Number of Sampling Units : 9
 Area (ha) : 727.0 Estimate of Total : 41.469
 Period : 30/04/96 to 05/06/96 t (0.975, 8) : 2.306
 Sampling Error% for Estimate (at P=0.95) : 136.66

Tree Status : Survivor
 Timber Quality : All (Dbh 10+ cm)
 Estimated Parameter : AVERAGE GROSS VOLUME PER HA (m³/ha)

Species Group	Dbh class (cm)												total	%
	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	-109	-119	120+		
Abies densa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Juniperus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tsuga	0.00	0.00	0.00	0.00	0.00	1.79	1.85	2.02	6.34	1.93	1.93	1.95	17.81	42.94
total conifer	0.00	0.00	0.00	0.00	0.00	1.79	1.85	2.02	6.34	1.93	1.93	1.95	17.81	42.94
Rhododendron	1.47	5.42	4.15	1.28	0.00	1.11	0.00	0.00	0.00	0.00	0.00	0.00	13.43	32.38
other broadl.	0.00	1.08	2.66	3.88	1.22	1.39	0.00	0.00	0.00	0.00	0.00	0.00	10.24	24.68
total broadl.	1.47	6.50	6.81	5.16	1.22	2.50	0.00	0.00	0.00	0.00	0.00	0.00	23.66	57.06
total	1.47	6.50	6.81	5.16	1.22	4.29	1.85	2.02	6.34	1.93	1.93	1.95	41.47	100.00
%	3.54	15.68	16.43	12.44	2.95	10.35	4.47	4.86	15.29	4.65	4.64	4.71	100.00	

Annex 4.2 Average basal area per ha (m²/ha)

Inventory Unit	: Gogona	Number of Strata	:	3
Stratum	: Combined	Number of Sampling Units	:	49
Area (ha)	: 7297.0	Estimate of Total	:	25.615
Period	: 16/03/96 to 05/06/96	t (0.975, 46)	:	2.013
		Sampling Error% for Estimate (at P=0.95)	:	19.14
Tree Status	: Survivor			
Timber Quality	: All (Dbh 10+ cm)			
Estimated Parameter	: AVERAGE BASAL AREA PER HA (m ² /ha)			

Species Group	Dbh class (cm)												total	%
	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	-109	-119	120+		
Abies densa	0.09	0.19	0.52	0.74	1.52	2.50	1.94	1.84	0.96	0.73	0.47	0.90	12.40	48.40
Juniperus	0.16	0.09	0.19	0.35	0.09	0.06	0.00	0.00	0.03	0.00	0.00	0.00	0.98	3.81
Tsuga	0.00	0.06	0.06	0.15	0.21	0.49	0.22	0.34	0.34	0.31	0.32	1.27	3.76	14.67
total conifer	0.25	0.34	0.77	1.23	1.83	3.05	2.16	2.18	1.34	1.03	0.79	2.17	17.13	66.88
Rhododendron	1.80	1.46	1.19	0.19	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	4.71	18.39
other broadl	0.51	0.74	1.14	0.67	0.46	0.13	0.03	0.03	0.03	0.00	0.03	0.00	3.77	14.73
total broadl.	2.31	2.19	2.33	0.86	0.46	0.21	0.03	0.03	0.03	0.00	0.03	0.00	8.48	33.12
total	2.56	2.54	3.10	2.09	2.29	3.26	2.19	2.21	1.37	1.03	0.82	2.17	25.61	100.00
%	10.01	9.90	12.09	8.16	8.92	12.72	8.55	8.61	5.33	4.04	3.20	8.46	100.00	

Statistical data:

STRATUM	: Combined
Area (ha)	: 7297 ha
Number of Sampling Units	: 49
Degrees of Freedom	: 46
t (0.975, 46)	: 2.01300000
t (0.950, 46)	: 1.67800000
Estimate	: 25.61496324
Standard Error	: 2.43536599
Sampling Error (P=0.95)	: 4.90239174
Sampling Error %	: 19.13878108
Reliable Minimum Estimate (P=0.95)	: 21.52841911

Inventory Unit : Gogona Number of Strata : 1
 Stratum : Fir Forests Number of Sampling Units : 12
 Area (ha) : 2067.0 Estimate of Total : 33.000
 Period : 19/03/96 to 02/06/96 t (0.975, 11) : 2.201
 Sampling Error% for Estimate (at P=0.95) : 31.44

Tree Status : Survivor
 Timber Quality : All (Dbh 10+ cm)
 Estimated Parameter : AVERAGE BASAL AREA PER HA (m²/ha)

Species Group	Dbh class (cm)												total	%
	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	-109	-119	120+		
Abies densa	0.33	0.56	1.00	1.67	2.89	4.78	3.00	2.44	1.22	1.11	0.22	1.00	20.22	61.28
Juniperus	0.56	0.33	0.67	1.22	0.33	0.22	0.00	0.00	0.11	0.00	0.00	0.00	3.44	10.44
Tsuga	0.00	0.11	0.00	0.00	0.11	0.11	0.11	0.00	0.22	0.00	0.44	1.00	2.11	6.40
total conifer	0.89	1.00	1.67	2.89	3.33	5.11	3.11	2.44	1.56	1.11	0.67	2.00	25.78	78.11
Rhododendron	2.00	0.89	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.56	10.77
other broadl	0.67	0.89	1.33	0.44	0.22	0.11	0.00	0.00	0.00	0.00	0.00	0.00	3.67	11.11
total broadl.	2.67	1.78	2.00	0.44	0.22	0.11	0.00	0.00	0.00	0.00	0.00	0.00	7.22	21.89
total	3.56	2.78	3.67	3.33	3.56	5.22	3.11	2.44	1.56	1.11	0.67	2.00	33.00	100.00
%	10.77	8.42	11.11	10.10	10.77	15.82	9.43	7.41	4.71	3.37	2.02	6.06	100.00	

Inventory Unit : Gogona Number of Strata : 1
 Stratum : Mixed Conifer Number of Sampling Units : 28
 Area (ha) : 4503.0 Estimate of Total : 25.619
 Period : 16/03/96 to 04/06/96 t (0.975, 27) : 2.052
 Sampling Error% for Estimate (at P=0.95) : 26.19

Tree Status : Survivor
 Timber Quality : All (Dbh 10+ cm)
 Estimated Parameter : AVERAGE BASAL AREA PER HA (m²/ha)

Species Group	Dbh class (cm)												total	%
	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	-109	-119	120+		
Abies densa	0.00	0.05	0.38	0.43	1.14	1.86	1.76	1.86	1.00	0.67	0.67	1.00	10.81	42.19
Juniperus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tsuga	0.00	0.05	0.10	0.24	0.29	0.71	0.29	0.52	0.38	0.48	0.29	1.57	4.90	19.14
total conifer	0.00	0.10	0.48	0.67	1.43	2.57	2.05	2.38	1.38	1.14	0.95	2.57	15.71	61.34
Rhododendron	1.95	1.81	1.52	0.29	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	5.67	22.12
other broadl	0.52	0.76	1.19	0.81	0.62	0.14	0.05	0.05	0.05	0.00	0.05	0.00	4.24	16.54
total broadl.	2.48	2.57	2.71	1.10	0.62	0.24	0.05	0.05	0.05	0.00	0.05	0.00	9.90	38.66
total	2.48	2.67	3.19	1.76	2.05	2.81	2.10	2.43	1.43	1.14	1.00	2.57	25.62	100.00
%	9.67	10.41	12.45	6.88	7.99	10.97	8.18	9.48	5.58	4.46	3.90	10.04	100.00	

Inventory Unit : Gogona Number of Strata : 1
 Stratum : Mixed Conifer / Broadleaf Number of Sampling Units : 9
 Area (ha) : 727.0 Estimate of Total : 4.593
 Period : 30/04/96 to 05/06/96 t (0.975, 8) : 2.306
 Sampling Error% for Estimate (at P=0.95) : 139.36

Tree Status : Survivor
 Timber Quality : All (Dbh 10+ cm)
 Estimated Parameter : AVERAGE BASAL AREA PER HA (m²/ha)

Species Group	Dbh class (cm)												total	%
	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	-109	-119	120+		
Abies densa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Juniperus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tsuga	0.00	0.00	0.00	0.00	0.00	0.15	0.15	0.15	0.44	0.15	0.15	0.15	1.33	29.03
total conifer	0.00	0.00	0.00	0.00	0.00	0.15	0.15	0.15	0.44	0.15	0.15	0.15	1.33	29.03
Rhododendron	0.30	0.89	0.59	0.15	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	2.07	45.16
other broadl	0.00	0.15	0.30	0.44	0.15	0.15	0.00	0.00	0.00	0.00	0.00	0.00	1.19	25.81
total broadl.	0.30	1.04	0.89	0.59	0.15	0.30	0.00	0.00	0.00	0.00	0.00	0.00	3.26	70.97
total	0.30	1.04	0.89	0.59	0.15	0.44	0.15	0.15	0.44	0.15	0.15	0.15	4.59	100.00
%	6.45	22.58	19.35	12.90	3.23	9.68	3.23	3.23	9.68	3.23	3.23	3.23	100.00	

Annex 4.3 Average number of trees per ha (N/ha)

Inventory Unit	: Gogona	Number of Strata	:	3
Stratum	: Combined	Number of Sampling Units	:	49
Area (ha)	: 7297.0	Estimate of Total	:	304.085
Period	: 16/03/96 to 05/06/96	t (0.975, 46)	:	2.013
		Sampling Error% for Estimate (at P=0.95)	:	27.91
Tree Status	: Survivor			
Timber Quality	: All (Dbh 10+ cm)			
Estimated Parameter	: AVERAGE NUMBER OF TREES PER HA (/ha)			

Species Group	Dbh class (cm)												total	%
	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	-109	-119	120+		
Abies densa	4.39	4.59	5.27	4.63	6.63	8.02	4.36	3.30	1.44	1.00	0.36	0.65	44.64	14.68
Juniperus	11.43	1.58	2.22	2.36	0.45	0.21	0.00	0.00	0.05	0.00	0.00	0.00	18.29	6.02
Tsuga	0.00	1.32	0.57	0.88	0.87	1.53	0.50	0.67	0.51	0.43	0.24	0.91	8.43	2.77
total conifer	15.82	7.50	8.06	7.87	7.95	9.76	4.86	3.97	2.01	1.43	0.59	1.56	71.37	23.47
Rhododendron	113.48	33.83	13.27	1.29	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00	162.08	53.30
other broadl	34.24	16.19	12.91	4.60	2.06	0.46	0.07	0.04	0.04	0.00	0.02	0.00	70.63	23.23
total broadl.	147.71	50.02	26.18	5.89	2.06	0.68	0.07	0.04	0.04	0.00	0.02	0.00	232.71	76.53
total	163.53	57.52	34.24	13.76	10.01	10.44	4.93	4.01	2.05	1.43	0.62	1.56	304.08	100.00
%	53.78	18.91	11.26	4.53	3.29	3.43	1.62	1.32	0.67	0.47	0.20	0.51	100.00	

Statistical data:

STRATUM	: Combined
Area (ha)	: 7297 ha
Number of Sampling Units	: 49
Degrees of Freedom	: 46
t (0.975, 46)	: 2.01300000
t (0.950, 46)	: 1.67800000
Estimate	: 304.08459390
Standard Error	: 42.16816474
Sampling Error (P=0.95)	: 84.88451562
Sampling Error %	: 27.91477021
Reliable Minimum Estimate (P=0.95)	: 233.32641347

Inventory Unit : Gogona Number of Strata : 1
 Stratum : Fir Forests Number of Sampling Units : 12
 Area (ha) : 2067.0 Estimate of Total : 404.250
 Period : 19/03/96 to 02/06/96 t (0.975, 11) : 2.201
 Sampling Error% for Estimate (at P=0.95) : 60.09

Tree Status : Survivor
 Timber Quality : All (Dbh 10+ cm)
 Estimated Parameter : AVERAGE NUMBER OF TREES PER HA (/ha)

Species Group	Dbh class (cm)												total	%
	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	-109	-119	120+		
Abies densa	15.50	14.50	10.58	10.50	12.92	15.17	6.75	4.25	1.83	1.58	0.17	0.75	94.50	23.38
Juniperus	40.33	5.58	7.83	8.33	1.58	0.75	0.00	0.00	0.17	0.00	0.00	0.00	64.58	15.98
Tsuga	0.00	2.42	0.00	0.00	0.42	0.33	0.25	0.00	0.33	0.00	0.33	0.75	4.83	1.20
total conifer	55.83	22.50	18.42	18.83	14.92	16.25	7.00	4.25	2.33	1.58	0.50	1.50	163.92	40.55
Rhododendron	124.83	24.58	7.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	156.92	38.82
other broadl.	44.00	20.08	14.83	3.25	0.92	0.33	0.00	0.00	0.00	0.00	0.00	0.00	83.42	20.63
total broadl.	168.83	44.67	22.33	3.25	0.92	0.33	0.00	0.00	0.00	0.00	0.00	0.00	240.33	59.45
total	224.67	67.17	40.75	22.08	15.83	16.58	7.00	4.25	2.33	1.58	0.50	1.50	404.25	100.00
%	55.58	16.62	10.08	5.46	3.92	4.10	1.73	1.05	0.58	0.39	0.12	0.37	100.00	

Inventory Unit : Gogona Number of Strata : 1
 Stratum : Mixed Conifer Number of Sampling Units : 28
 Area (ha) : 4503.0 Estimate of Total : 298.607
 Period : 16/03/96 to 04/06/96 t (0.975, 27) : 2.052
 Sampling Error% for Estimate (at P=0.95) : 31.29

Tree Status : Survivor
 Timber Quality : All (Dbh 10+ cm)
 Estimated Parameter : AVERAGE NUMBER OF TREES PER HA (/ha)

Species Group	Dbh class (cm)												total	%
	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	-109	-119	120+		
Abies densa	0.00	0.79	3.68	2.68	4.82	6.04	3.96	3.39	1.50	0.89	0.50	0.71	28.96	9.70
Juniperus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tsuga	0.00	1.04	0.93	1.43	1.21	2.25	0.64	1.04	0.57	0.68	0.21	1.11	11.11	3.72
total conifer	0.00	1.82	4.61	4.11	6.04	8.29	4.61	4.43	2.07	1.57	0.71	1.82	40.07	13.42
Rhododendron	124.18	40.75	17.00	1.93	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.00	184.14	61.67
other broadl.	35.29	16.50	13.57	5.46	2.79	0.50	0.11	0.07	0.07	0.00	0.04	0.00	74.39	24.91
total broadl.	159.46	57.25	30.57	7.39	2.79	0.79	0.11	0.07	0.07	0.00	0.04	0.00	258.54	86.58
total	159.46	59.07	35.18	11.50	8.82	9.07	4.71	4.50	2.14	1.57	0.75	1.82	298.61	100.00
%	53.40	19.78	11.78	3.85	2.95	3.04	1.58	1.51	0.72	0.53	0.25	0.61	100.00	

Inventory Unit : Gogona Number of Strata : 1
 Stratum : Mixed Conifer / Broadleaf Number of Sampling Units : 9
 Area (ha) : 727.0 Estimate of Total : 53.222
 Period : 30/04/96 to 05/06/96 t (0.975, 8) : 2.306
 Sampling Error% for Estimate (at P=0.95) : 147.94

Tree Status : Survivor
 Timber Quality : All (Dbh 10+ cm)
 Estimated Parameter : AVERAGE NUMBER OF TREES PER HA (/ha)

Species Group	Dbh class (cm)												total	%
	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	-109	-119	120+		
Abies densa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Juniperus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tsuga	0.00	0.00	0.00	0.00	0.00	0.44	0.33	0.33	0.67	0.11	0.11	0.11	2.11	3.97
total conifer	0.00	0.00	0.00	0.00	0.00	0.44	0.33	0.33	0.67	0.11	0.11	0.11	2.11	3.97
Rhododendron	14.89	17.22	6.56	1.00	0.00	0.44	0.00	0.00	0.00	0.00	0.00	0.00	40.11	75.37
other broadl.	0.00	3.22	3.33	3.11	0.78	0.56	0.00	0.00	0.00	0.00	0.00	0.00	11.00	20.67
total broadl.	14.89	20.44	9.89	4.11	0.78	1.00	0.00	0.00	0.00	0.00	0.00	0.00	51.11	96.03
total	14.89	20.44	9.89	4.11	0.78	1.44	0.33	0.33	0.67	0.11	0.11	0.11	53.22	100.00
%	27.97	38.41	18.58	7.72	1.46	2.71	0.63	0.63	1.25	0.21	0.21	0.21	100.00	

Annex 5

Map of

Potential Forest Areas

(Scale 1:50.000)