5.1 (A) Annual Allowable Cut

The Annual Allowable Cut (AAC) calculation in DFR (see Table 5.2 (A)) is based on the standard approach, that is, a combination of area, volume and felling cycle. The formula is as follows:

$$AAC = \left[\frac{V \times A}{N} \right] \times E \times S$$

Where:

V = Nett Volume per ha of commercial species above the specified diameter set
A = Available net productive areas (estimate) that can be harvested
N = The length of the felling cycle, in years
E = Exploitation factor to provide for losses in volume due to stem breakage, decay and other harvesting losses
S = Safety factor to provide for damage to the residual stand during logging

Table 5.2 (A): Calculation of annual allowable cut for the planning period 2015 –2024

Forest Land-Use	Harvestable Nett Area* (Ha) (A)	DBH Limit (cm)	Exploitation Factor (E)	Safety factor (S)	Net Vol. (m^3/ha) (V)	Year (N)	AAC (m^3)
NFM	41,541.7	60	0.60	0.8	36	40	**17,946**
Note: * Based on estimated areas that have been assumed to have a minimum economic cut of 40 m^3/ha with 90% efficiency in forest harvesting = 36 m^3/ha.							

Based on the formula above, the calculated AAC is 17,946 m^3. However, based on the past planning record production (see Table 3.2), the average annual production was 11,423.22 m^3 of which, the estimated AAC of 17,600 m^3 as set in the 2nd FMP was not met due to various reasons as explained in Chapter 3.2.2 of this plan. **Therefore, the estimated AAC of 17,600 m^3 as set in the 2nd FMP will be maintained for the current planning period (3rd FMP).** This means that the total harvest for the entire planning period should not exceed 176,000 m^3 while, the gross area to be harvested annually is 1,242.8 ha, which is expected to sustain continuously throughout one cutting cycle (40 years). There will be no re-entry of all harvesting compartments, which have been logged for the first time since 1989 - see Chapter 6.2.3 for further details.

5.2 AAC Verification

In order to verify the sustained yield or AAC (refer Chapter 5.1 (A)), the measurement of harvest damage and growth of residual stands were analyzed based on the 30 permanent sample plots (refer Chapter 3.2.3) established by the Forest Research Centre Team from 2002 to 2007. These permanent sample plots (PSP) were established prior to logging. The physical conditions of the trees were also assessed prior to logging and after logging. A year after logging, the physical conditions and growth of the trees were again assessed and measured for a period of 4-5 years. The measurements were used within a growth simulation program (Myrlin – Methods of Yield Regulation with Limited Information) based on measuring basal area growth developed by Alder, Baker & Wright (2002). The results of the data analysis can be referred to in **Appendix 11**.

Based on the PSPs inventory data analysis, the overall mean annual increments (MAI) of bole volume of residual trees over 10 cm dbh in DFR was estimated at 3.54m³/ha/yr. The volume of standing trees damaged by logging was estimated at 14.4m³/ha. This amount included the volume of injured trees, which died four or five years after logging. So based on these results, the estimated volume of timber generated in DFR as estimated in the 2nd FMP was approximately 151,463m³/yr (42,789 ha x 3.54m³/ha/yr) or 6,058,520 m³ for 40 years (one cutting cycle), while estimated volume of standing trees damaged by logging was 3,658m³ (14.4m³/yr x 254ha) or 1,320,160 m³[1] for the whole net productive area. As described in Chapter 3.2.2, timber harvesting in DFR (over the 2nd FMP period) has not gone over the allocated AAC of 176, 000m³ of logs. The actual total volume produced was 127,780.75 m³ **(**see Table 3.2**).** This being the case, the balance between these figures is **4,610,579 m³** (6,058,520 m³ – 1,320,160 m³- 127,780.75 m³), which indicates that the volume harvested and standing trees damaged by logging during the 2nd FMP period was not more than the volume increment in the forest within a harvest cycle of 40 years.

For this 3rd FMP, due to some adjustments on the land-uses, the net production area was reduced from 42,789 ha to 41,572 ha. However, the AAC of 17,600 m³/yr is maintained. This means that the volume harvested and standing trees damaged by logging will not be more than the volume increment in the forest, which is sustainable yield.

5.3 Yield Regulation

The main purpose of yield regulation is to determine an AAC or prescribed annual yield for the planning period. For this, growth projections of the inventory data were made to determine when a compartment is likely to yield an economic harvest. Although the management-planning period spans over a period of 10-years, growth projections were made for one cutting cycle, in order, to ensure that harvesting is sustainable over the long-term.

For the purpose of yield regulation, a 40-year cutting cycle is assumed for this management plan and a minimum economic cut of 40 m^3/ha is used to determine when a compartment is adequately stocked to justify a harvest. The main purpose of yield regulation is to determine

[1] This amount of damage can be reduced with improved efficiency in logging practices.

an annual allowable cut (AAC) or prescribed annual yield for the planning period. As described in Chapter 3.2.3, an essential part of yield regulation is the permanent monitoring of the growing stock by repeated inventories or by the use of permanent plots, a practice known as *continuous forest inventory* (CFI). Based on the results of the CFI on the 4 compartments (#1, #9, #105, #114) that have been developed over a five year period in DFR (see Chapter 3.2.3), it was reported that there was a slight improvement in stocking for all four compartments. For instance, the CFI shows 18.3 commercial trees ha^{-1} > 60 cm dbh for Compartment #105 in 2013, an improvement from 14.7 trees ha^{-1} in 2008. Therefore, Compartment #105 is considered sufficiently stocked for an 'economic' harvest (assumed at ≥ 15 trees > 60 cm dbh).

CHAPTER 6
MANAGEMENT STRATEGIES, ACTIONS AND IMPLEMENTATION

The previous chapters of this plan described the basic information and resource base, which have direct relevance to the management of DFR. In this chapter, specific management prescriptions are directly related to achieve each of the management objectives listed in Chapter 1.3.

6.0 (A) Forest Zoning

DFR (FMU 19A) was re-zoned and divided into 136 compartments and two (2) sub-compartments - see Table 6.1 and Figure 6.1. The list of compartments and sub-compartments with their respective functions can be referred in **Appendix 8 (A)**. The relevant land-use or function has been ascribed to these compartments based on site degradation risks, actual growing stock conditions, potential for water catchment, and socio-economic requirements, particularly for those residing in Kg. Balat.

Table 6.1 (A): Land use classification based on forest functions in DFR

Total Area (Ha)	Forest Function		
	Conservation (Ha)	Production (NFM) (Ha)	Community Forestry (Ha)
55,507	5,777.9	49,712.3	16.8
%	10.4	89.6	0.03

Note:
Conservation: Slopes > 25° (e.g. protection of water resources)
Slopes < 25° (e.g. HCVs)
Production: Slopes ≤ 25°
Community Forestry: Areas adjacent to human settlement
Suitable for community based land-use

From Table 6.1 (A), it is noted that approximately 5,777.9 ha in DFR are designated as conservation areas, which is an additional of 2,073.9 ha from the previous FMP. The designated conservation compartments comprise mostly hilly terrain with slopes above 25° and special forest types (e.g. Kapur barus species in Cpts. 17, 18, 19 and 20). On the other hand, a gross area of 49,712.3 ha is set aside for production, while the "two legs" [sub-compartments 109 (A) and (109 (B)] located in the south - east of DFR, have been designated for community needs. Some areas identified for HCVs are located in the production areas. These areas have not been specifically set- aside but they will be protected and monitored during the harvesting operations.

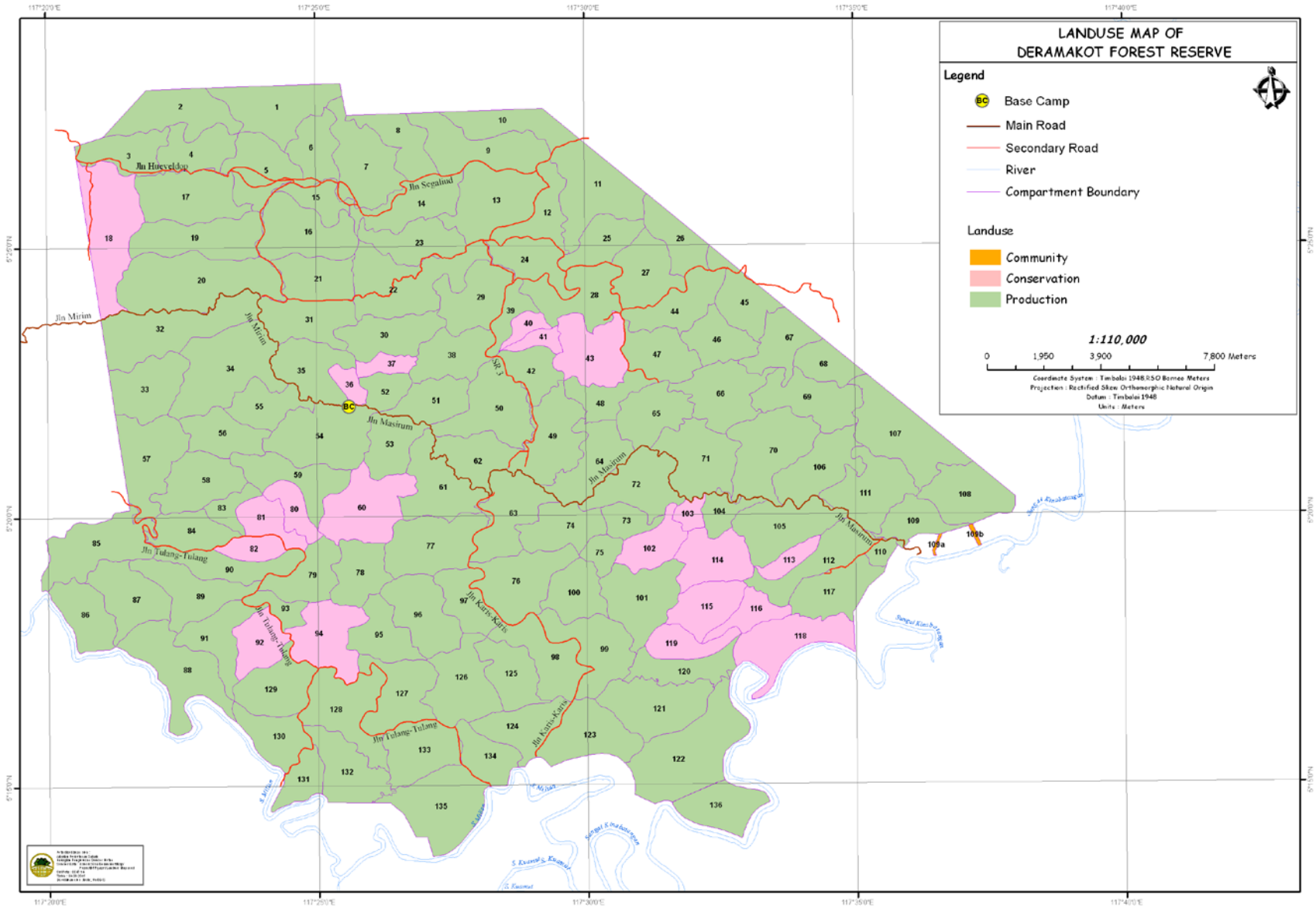

Figure 6.1 (A): Forest Land-use in DFR

6.1 Conservation Areas

6.1.1 (A) Management Objectives

There are 20 compartments with a gross area of 5,777.9 ha that have been designated for protection/conservation (see Table 6.1 (A) and Figure 6.1 (A)). These areas are mostly steep areas with slopes >25° that form part of the catchment areas. In addition, there could be another approximately 7,249.6 ha within the production area that have been identified for conservation areas (see Table 6.2 (A)). These areas comprise of slopes >25°, riparian reserves and HCVs. Therefore, the total protection/conservation area in DFR is 13,027.5 ha or 23.5% of the total area of DFR.

The steep areas are protected from forestry operations particularly logging, to prevent site degradation and soil erosion. The protection of the riparian reserves, on the other hand, is important because they are used to maintain and restore riparian structures and functions of intermittent streams, confer benefits to riparian dependent and associated species other than fish, enhance habitat conservation for organisms that are dependent on the transition zone between upslope and riparian areas, improve travel and corridors for many terrestrial animals and plants, and provide for greater connectivity of the watershed (see Chapter 2.3.1, Figure 2.9 and Table 2.3).

6.1.2 Focus of Management

Management will be confined to habitat and biodiversity conservation, boundary protection and the prevention and monitoring of any unwelcome activities such as, timber harvesting, illegal encroachment and hunting. Riparian reserves of 30 m wide on each side of the permanent watercourses will be protected in all compartments within the production areas. Sites should be revisited periodically as part of the overall monitoring program. Forest fire prevention, which may disturb the natural succession of the existing vegetation and wildlife populations, is also the management direction of the conservation areas. A Forest Fire Management Plan has been prepared and is currently being implemented in DFR.

6.2 Timber Production

6.2.1 (A) Net Timber Production Area

Not all areas within the production area are for timber production. Therefore, the net timber production area is derived by deducting permanent infrastructure (such roads and buildings), riparian reserves, HCVs and community needs from the gross production area. This is shown in Table 6.2 (A).

From Table 6.2 (A), the gross area of about 49,712.3 ha comprising 116 compartments in DFR is designated for timber production by selective harvesting. Forest harvesting is confined to the net production area of approximately 41,541.7 ha. Prior to harvesting, the timber resources have been assessed of its stocking level through forest inventory (refer Chapter 5) and also based on the comprehensive harvest plan (CHP) report.

Table 6.2 (A): Net timber production area in DFR

Area Designation	Area (Ha)
Gross Production Area	49,712.3
Less: Permanent Infrastructure	921
Riparian Reserves *	205.3
Slope > 25°	3869.3
HCVs	3175.0
Net Timber Production Area	**41,541.7**
Note: * Riparian Reserves – areas on 30m wide along both sides of the permanent watercourse measuring not less than 5m in width.	

6.2.2 Management Objective

The long-term objective of natural forest management (NFM) in general is to sustain production of high value timber for revenue generation based on the AAC limit while maintaining a high degree of species and structural diversity. Considering the importance of forest resource sustainability and timber quality, emphasis within this planning period is given to the improvement of growing stock based on the following regimes:

- **Natural regeneration** – these are the areas whereby the forest stockings are still high and the resources are to be managed sustainably.

- **Silviculture inputs** – the harvestable stock in these areas may be low, but existing growing stock is high. These areas require various levels of silvicultural measures before the forests could be restored of its sustainability.

- **Forest Restoration** – these are the areas where there is no or insufficient natural regeneration and needs to be restored by planting with fast growing indigenous tree species.