4.8.6. Guidelines

- Construction of management roads serving also as firebreaks around the forests would be desirable. Construction machinery such as bulldozers must be introduced for their construction and repair. Four-wheel drive vehicles able to be equipped with ground scratching or clearing attachments must be introduced for dual management and repair purposes.
- There is a shortage of small sized forestry machinery and equipment. It is necessary to provide them. In particular, it is necessary to introduce long-handled bush cleaners to enable clearing of thorny bushes.
- Construction of seed storehouses is necessary to improve the results of reforestation by direct sowing.

4.9. Linkage of Forests and Local Residents

A general trend is often to consider that residents living near forests understand the forests most deeply and take the most care of the forests. In the currently surveyed region, however, this situation was rare. In particular, it was felt that many people were uninterested in the existence of national and public forests.

4.9.1. Situation

Forests are collections of large sized trees. Large diameter trees are used primarily as material for lumber. The workers employed by sawmills and living near the towns ride vehicles to the forest, cut down large trees, and bring back the resultant logs. As opposed to this, local residents use solely small diameter trees as materials for making their homes and fuel. Local residents find the large diameter trees in the forests to be completely irrelevant. There are large evergreen trees scattered near the villages and there are quite a few large sized trees which are used for shade or fruit, but, rather, local residents seem strongly to be disinterested in groups of large trees forming forests. Forests seem to have no attraction for local residents.

4.9.2. Perception of local residents

In the forest belts of Japan and the West, the residents of the villages near the forests are engaged in forestry and forest management. The people who best understand and protect the forests are the residents of those nearby towns. The perception of the residents in Zambia, however, seems to be considerably different. Residents do not seem to care or to regret if even a forest fire starts and large trees decades of years old are burned up.

It seems that forests are feared as the habitats of dangerous animals liable to attack humans and that in the past most people felt uneasy about them rather than close to them. Accordingly, apparently quite a few people believed that when forests burn up, their lives become safer. Recently, the importance of the forests has been stressed in the world in relation to protection of the environment, but local residents apparently care nothing about this. Here, people will not accept the complicated ecological theory that while they may feel that the decline in the number of carnivorous animals makes their lives safer, this decline will result in an increase in the population of rats, rabbits, and deer which in turn will have a harmful effect on their crops and young trees. The environmental theory that burning causes a decline in the productivity of the soil and leads to desertification of the region and that burning of tropical forests increases the CO_2 in the atmosphere which will bring on abnormal weather conditions (desert climate) would be even more incomprehensible to them. However, it is most important to get the residents to realize that these difficult to understand changes in the ecological and environmental mechanisms are in fact starting to threaten their livelihoods and to convince them of the value of forests, including forest undergrowth.

4.9.3. Understanding and cooperation of senior chiefs

When moving to implement forest management plans, it is necessary to get the local people and sub-chiefs, of course, and also the higher level senior chiefs to sufficiently understand the background and content of the management plans and to obtain their opinions and agreement. After this process, the management plans could probably be implemented smoothly. In particular, there is a high need for this in relation to issues close to the locals such as burning, agroforestry, and firewood.

4.9.4. Guidelines

Previously, allusion was made to the magnitude of the damage to forests caused by forest fires. It was learned that the biggest cause of this was the burning conducted by residents. Here, the most important thing in the relation between local residents and forests is the issue of burning. The following countermeasures are considered necessary to fundamentally deal with this problem.

- It is crucial to make the residents feel a sense of closeness to and usefulness in the forests. Basically, it is important to change their perception through education, but no immediate results can be expected by this. For a more direct effect, a possible shortcut would be to set up some kind of compensation system. For example, assistance could be given to nearby villages for the digging of wells able to provide water on a year round basis if there were no fires in the nearby forests and woodlands for a certain year-long period. Alternatively, assistance could be given to modernisation of farm equipment or other practical compensation provided.
- In parallel with the above measures for prevention of forest fires, planting projects (reforestation by direct sowing in the forests and planting of seedlings of intolerant species in excessively open land or treeless land) should be launched and local residents employed. Since the area for reforestation would be large, if the projects proceed stably, the residents would have an increased opportunity to earn cash from the forests and therefore would become more interested in them.
- Educational and public relations campaigns should be promoted to increase the understanding of residents about scientific ecological mechanisms and environmental mechanisms.

4.10. Expansion of Demand

Recently, the annual demand for wood (annual cutting volume) is estimated to be 13,000 to 14,000 m^3 for Mukusi and 2,000 m^3 for Mukwa in terms of standing stock. As mentioned earlier, the total annual growth of Mukusi (corresponding to allowable amount of cutting) is estimated to be 14,000~18,000 m^3 and of Mukwa to be at least 3,700 m^3, so in both cases demand falls below growth. If attention is paid to ensuring that seed trees are left, then there would be no particular problem in sustaining the forests. Since there is a surplus as compared with the allowance, it is necessary to develop demand further from the standpoint of effective utilisation of resources. If demand increases rapidly in the near future, however, then there would be no major excess supply capacity.

4.10.1. Lumber demand

(1) Mukusi

At the present time, about half of all Mukusi are used for railroad sleepers. Other uses are board materials, flooring materials, plywood panels, etc. Demand for railroad sleeper, the principal product, is expected to shrink in the future. If current trends continue, then demand may well drop to under 14,000 m^3. On the other hand, forests dominated by Mukusi are disappearing due to forest fires. In the past 20 to 30 years, total growth has dropped from 25 to 50%. Accordingly, at first there was a concern that supplies would be insufficient for demand, but actually the opposite is true.

In the future, if reforestation is proceeded with aiming at healthy forests, the total growth (allowable amount of cutting) can be expected to grow each year. On the other hand, if current trends continue, demand will shrink. Therefore, effective utilisation of resources will not be able to be expected. Positive effort is required to develop demand so as to prevent this gradual dwindling of fortune.

Viewed from the current sawing and processing capability in the wood industry, the hardness or softness of the material is usually not a technical problem. However, there are no universal machines able to simultaneously saw both hard and soft materials. It is necessary to prepare sawing machines for hard materials and corresponding machines for soft ones. Here, the important thing when investing in sawmill equipment is whether there is a sufficient amount of the available resource to warrant the installation of machinery. If there is a certain amount of stock of a resource in a certain area, then it can be processed and used freely in any form such as column materials, batten materials, board materials, composite materials, plywood materials, particleboard materials, etc. The point is what kind of applications can demand be developed for.

In this regard, Mukusi is a hard species and is of the most concentrated stock in the forests of the southwestern region. Further, it is known to be widely distributed not only in the region covered by the current survey, but also in the region on the west bank of the Zambezi River (though the density of distribution is inferior to the region covered by the present survey). Accordingly, this species can be evaluated as having sufficient conditions for capital investment. The point is to develop and seize applications. If this can be done, then Mukusi should become the number one useful species for the sector of the wood industry using natural forests.

In current wood houses, the portions of the flooring materials close to the ground (sills, sleepers, joist, etc), column materials, wall materials, etc. are required to be resistant to moisture and rotting. Wood of species meeting these requirements is being traded at high prices. In this regard, Mukusi wood, which satisfies the requirements for durability as railroad sleepers, very possibly has enough durability as a building material as well. Demand could be developed for such applications

(2) Mukwa

At the present time, Mukwa is mainly used sawn into boards for making furniture. In the near future, however, production of furniture using solid boards is expected to taper off. Plywood production using Mukwa and other good quality wood as the decorative materials (facings) will become the mainstream. (Sawing machinery has already been replaced and capital investment made.) This plywood would be very export competitive, so there are great hopes for future growth.

While there is large demand for Mukwa as a furniture material in this way, there is no accurate grasp of the amount being sawed. Further, there is no accurate grasp of the distribution of the resource or the allowable amount of cutting based on the forest composition. Therefore, it is uncertain if enough of the resource can be secured in the future if demand for Mukwa as plywood or decorative materials increases. The rate of intermixing of Mukwa in stands is much lower than that of Mukusi, but the species is widely distributed and can be found almost everywhere in the country. Accordingly, it may be comparable to or greater than Mukusi in total amount over a wide area. It is unknown how much can be cut while leaving enough seed trees for continuation of the forests. This must be surveyed in the future.

(3) Export and transport costs

Due to the slow demand for wood in the country, there is a desire to increase exports. At the present time, 30% of the railroad sleepers are being exported. Further, exports of plywood etc. are being promoted. The future is not necessarily bright, however. Zambia is an inland country far from any seaport, so the bottleneck when considering broader exports would be the overland transport. In this regard, it would be more advantageous to transport higher added value lumber products, plywood, etc. rather than raw materials, but this would require fuller market surveys.

4.10.2. Firewood demand

The annual consumption of firewood in Sesheke is estimated to be 35,000 m³. On the other hand, the permissible forest yield in this area is 90,000 m³ even in traditional areas. So the demand is less than the permissible volume. In this regard, there is considered to be no problem in apparent sustaining the forests. The problem here, however, is that the trees used for firewood are small trees of diameters at breast height of less than 25 cm. Further, these small diameter trees have been severely reduced in numbers and volume due to the recent increasingly frequent forest fires. Most small diameter trees are succeeding trees in the forests. If there are sufficient numbers, there it would be possible to sustain the forests even if cutting an amount corresponding to the allowable amount of thinning. If there are too few small diameter trees, however, this is not possible. In this case, no cutting of small diameter trees should be allowed. Only large diameter classes should be allowed to be cut. Accordingly, while there is no problem with cutting large diameter class trees for use as firewood, cutting small diameter class trees would make continuation of the forests impossible.

From this viewpoint, it is judged that cutting of firewood from forests where there are little small diameter class trees and further where selective cutting should be performed, that is, the national and public forests, should be prohibited. On the other hand, the national forests include considerably large amounts of unused materials remaining after the cutting of the dominant Mukusi trees, etc. (about 7,000 m³ of Mukusi), so it should be possible to use this for firewood. Further, there are large numbers of trees of species other than those used as industrial materials which die without having been utilised. These also can be used as firewood. One possible approach could be to allow residents of villages with a record of preventing forest fires to cut firewood in the national forests as a form of compensation. By allowing the cutting of wood in the national forests for use in their daily lives, residents could be made to feel closer to the forests. If this happens, reckless burning can be expected to be reduced.

In traditional areas, the distribution of forests and woodlands tend to be located away from the villages, and the stock per unit area of closer woodlands is very small. On top of this, these are regions in which burnings are frequent. For this reason alone, there is a good possibility that the number of small diameter trees is falling. Accordingly, when considering the healthy continuation of forests, the chances are that the allowable amount of cutting of firewood near villages is less than the demand of residents. Probably, there may be quite a few locations where firewood is becoming short in supply. The later mentioned Mupane forests, however, do not have as complicated forest compositions as stands for industrial wood production, so continuation is easy and use as firewood based on separate standards would be possible.

4.10.3. Guidelines

- Demand for Mukusi wood is currently slow. Mukusi, however, has a superior durability and, further, has a distribution as a forest resource conducive to mass production. Therefore, if demand is developed, it is judged that it would become the material of the greatest usefulness. Development of new demand taking note of the properties of Mukusi is desirable.
- Mukwa enjoys stable demand as a furniture material. Higher added value processing should be targeted. The amount of the demand and the allowable amount of cutting are not clearly determined, however, so future surveys are required.
- Zambia is an inland country and therefore high overland transport costs would be a bottleneck in transport and export. To overcome this problem, it is necessary to develop sawn products with a

higher added value.

- The demand for firewood is at least on the surface less than the growth of the forests. In so far as this situation is judged using just these figures, there would appear to be no problem. In fact, however, since there are few small diameter trees available for use as firewood (due to forest fires), it is judged that there is a slight shortage of supply. Unregulated cutting of small diameter trees is endangering the continuation of forests and woodlands, so it is crucial to create suitable firewood forests and devise methods for their utilisation. More specifically, consideration should be given to forming firewood resources by separate short-cutting-cycle forestry projects, preparing suitable harvesting guidelines and making residents observe them.

4.11. Land-Use Management

The classes of land-use found in this region, as shown in Table 52, are forests, grasslands, village land, farm plots, and pastureland. Under current laws and regulations and from the standpoint of ecological and environmental theory, there is very little chance that new areas of land will be opened up for use in the national and public Forest Estates. Therefore, problems relating to land utilisation may be considered to all relate to traditional lands.

4.11.1. Cultivation in alluvial land

Examination of the sites of previous farm plots reveals that almost all were on alluvial land including low terraces (including alluvial terraces of tributary valleys). There is abundant ground water linked with the water level of the river under the alluvial land. These locations can be expected to be stably supplied with water by capillary action. Usually, a surface layer has abundant large pores, so the capillary action is broken and the supply of ground water is not always abundant, but in many cases the land becomes somewhat packed from the middle to the end of the rainy season and considerable capillary action can be expected. Accordingly, on clear days during the rainy season or for a short while after the end of the rainy season, there is a good chance for the appearance of considerably stable moisture conditions. Of course, since the soil is sandy, the amount of water held in the soil is not abundant by any means, but such locations feature the stablest moisture conditions in this region.

On the other hand, in this region, with the exception of some areas, fertilizer is not being applied, so the crops depend solely on the nutrients (humus) naturally contained in the soil for their nutrition. The soil nutrients have been built up by the forest. The farmers cut down the forests, burn off the vegetation, and use the resultant cleared plots for cultivation. The nutrients are however consumed completely after three to four years of continuous cultivation, so the farmers fell trees and carry out burning in new forest land for cultivation.

In general, organised burning and shifting cultivation practised around the world assumes the land will return to a forest state after the end of the cultivation. In regions where this is practiced, sometimes the next generation of trees is even planted in parallel with the cultivation. The common practice is to wait for the farm plot to return to its natural forest state and the fertility of the soil to be restored, then again shift-cultivate the land. Accordingly, in regions where sound shifting cultivation is performed, there should be farm plots and forests adjoining each other. In this region, however, the land is not being used in a manner enabling such coexistence of farm plots and forests.

When cultivation ends, herbs and bushes invade even these areas and start to grow, but perhaps because the residents do not know about the mechanism for soil restoration by herbs or perhaps from the viewpoint of effective utilisation of the herb, this is fed to the livestock. In some cases, the land is repeatedly burned off. Grazing by a suitable number of livestock and suitable burning in a manner allowing herbs to sufficiently grow would not hinder the supply of humus by the root systems of the herbs and conversely would promote the regeneration of new herbs, so do not have to be prohibited.

However, in many cases, an excessive number of livestock is allowed to graze and the growth of herbs declines with each passing year. This trend is a problem. In particular, grazing by goats destroys even the root systems of herbs, so causes a rapid decline in herb growth.

Further, while some locations may be forests or woodlands with large diameter trees growing in them, the insides of the forests are overgrazed or overly burned, so the soil is degraded. That is, locations where the soil fertility was being restored by the forests are being ruined and are becoming substantially no different from devastated treeless land. As a result, the soil is exposed, the surface is leached out, and pans are formed at the medium to low layers. The fertility declines and barren land of a quasi-desert state appears.

As a result, not only does the abandoned cultivated plot not recover, but it is further reduced in strength. A scenic feature of this region is the expanse of overly grazed weakened pastureland around the cultivated plots.

Therefore, the state of cyclic utilisation where cultivator return to their original plots after 20 years is not observed. The cultivated plots and abandoned land just steadily increase. As a result, cultivator lose places to go in the alluvial plains and search for new land in the highland forest belts. There, however, as explained at the start, they cannot enjoy the benefits of the ground water, so good farming cannot be expected.

Residents, however, do not understand this land mechanism (water mechanism) and appear to be encroaching upon forest belts in search of soil with better nutrients. There are reportedly calls for the forests to be opened up.

Note that since abandoned cultivated plots are not returned to forest land, these areas will soon find themselves short of firewood.

4.11.2. Utilisation of farmland and pastureland in floodplains

The floodplain along the Zambezi River and the floodplains of its major tributaries are often flooded, so no trees are seen growing there. There is abundant growth of herbs, however. Further, the flooding is accompanied by the supply of fertilizer components from upstream, so there is much fertile soil.

The roots of the herbs, however, are densely distributed. In addition, the soil is in many cases closely packed. Therefore, many locations cannot be tilled by simple spades etc. Accordingly, almost none of the land is used as farm plots. Once a powerful tilling machine is used to till the land, however, there would be quite a few cases where tilling the next year would become relatively easy. Since these locations could be used continuously as farmland, positive measures for their utilisation would be desirable.

Since there is abundant growth of herbs, positive utilisation as pastureland would also be possible.

4.11.3. Possibility of intensive agricultural operations in alluvial plains

Alluvial plains are abundant in ground water. If the water is pumped up and the land fertilised and tilled, continuous agricultural production resistant even to drought would be possible. Further, there is a large area of the alluvial plain in this region meeting these conditions. If the objective is simply to support the population in the area, then such intensive agriculture should be able to produce a surplus.

At the present time, residents do not have any cash income, so cannot engage in agricultural production. If they could, then it is believed that there would no longer be senseless forest destruction.

4.11.4. Guidelines

The following recommendations are made from the perspective of correcting and adjusting the above situation:

- Abandoned farm plots resulting from shifting cultivation should in principle be restored to forests. Even if left alone, they will in many cases gradually return to a forest state. When there is too much treeless land, however, positive reforestation is required.
- Herbs will grow in the process of restoration to a forest. It is crucial that the number of livestock allowed to graze on this be kept down to a suitable level. In particular, care must be taken with grazing by goats as there is a high risk of overgrazing.
- Burning should be limited to specific objectives and not be allowed to spread. When burning in forests and woodlands is unavoidable, it should be restricted to areas of thorny bushes in the forests and not be performed in the stands.
- Since there is a good chance that firewood will become increasingly short in supply, broad-leaved tree forests comprised mainly of small diameter trees with about 25 year cutting cycles should be created. By combining this periodic cutting of broad-leaved trees and shifting cultivation, it should be possible to sustain continuous Land use on alluvial land.
- The forest belts in highland areas are inferior in terms of water conditions to alluvial land although containing some soil nutrients. Accordingly, they are not suitable for cultivation. Shifting cultivation in highland areas should in principle be prohibited.
- In floodplains which flood during the rainy season, the land cannot be used during the rainy season, but many locations feature good water conditions even during the dry season, so can be seasonally used as farm plots. At the present time, they are not being used due to the difficulties in tilling, but they should be put to use as somewhat intensive farm plots by the introduction of tilling machines.
- Alluvial plains offer abundant ground water for use. If ground water is pumped up, fertilizer applied, and the land tilled and used as intensive farm plots, then it would be possible to engage in farm operations without even being affected by droughts. Further, a large area of the alluvial plain satisfies these conditions. If full-scale agricultural production were engaged in there, then harvests far exceeding the demand of the local residents could be expected. Further, by switching over to stable agricultural production in this way, it is believed that senseless forest destruction would also be suppressed. At the present time, this would be impossible to implement in view of the fact that local residents have no cash income, but it would be desirable for officials and related organisations to work to move them to intensive Land use in the near future.

4.12. Planting Plan and Cutting Plan

4.12.1. Cutting Plan

Among the forest land consolidation site group (hereinafter referred to as "unit site group") in each Forest Estate, Site I C_3D_3 and Site II C_3D_3 are considered to be stands where the cutting of Mukusi is permitted, and data on these stands are listed with regard to the area, volume, feasible Mukusi cutting volume, and corresponding compartment numbers of stands with a Mukusi mixing rate of 50% or more. Table 56 shows the names of pertinent unit site group in National Forest Estates, and the area and accumulation according to compartment.

The unit site group in the Forest Estates are divided into a feasible cutting site in Sesheke and a feasible cutting site in Mulobezi (each to be referred to as "greater site"), and the cutting order is determined for each greater site. The volume and other data on the individual sites within eachgreater site are listed according to the cutting order in table form.

In determining the cutting order, a high-accumulation site where cutting is currently underway is ranked first, and the adjacent high-accumulation sites are ranked second, third, etc. Specifically, in the Sesheke greater site, cutting shall start from the Simungoma west site, while in the Mulobezi greater site cutting shall start from the Situmpa site. Compartments designated as forest reserves are excluded from the cutting plan.

The total allowable cut volume of the two greater sites is assumed to be from 14,000 m³/year, and is allotted between the greater sites. Currently, the sawmill in Mulobezi is operating at a higher rate; in addition, sawn timber is transported by railway so that the total cost is judged to be lower in Mulobezi. Consideration is therefore made given to cut a larger volume in the Mulobezi greater site during the first 10 years. However, since the Mukusi growing stock in the Mulobezi greater site is comparatively small, the cut volume will be increased in the Sesheke greater site. If the Mukusi accumulation in the Mulobezi greater site develops a shortage, then the Kamangao district will be also included as a feasible cutting area from the 11th year onward. If an accumulation shortage continues to exist despite this, the cutting volume in the Mulobezi greater site will be reduced, and emphasis will be placed on the Sesheke greater site.

In view of the above, the annual cutting volume is determined for each site, and the annual cutting volume for the greater sites have been decided as shown in Table 57. The cutting volumes in the table are based on the assumption that the cutting cycle of the main crop is 100 years and that the cutting rate is 20%. However, it is also allowed to set the cutting cycle of the main crop to 80 years and the cutting rate to 25%. Thus, the plan enables a 25% increase in the cutting volume from 6,000 to 7,500 m³/year and 8,000 to 10,000 m³/year in case the cutting volume must be expanded.

As is explained later, if the regeneration and growing methods for Mukusi seedlings (succeeding trees) in the open stands are determined during the next 10 years, it will become possible to cut Mukusi (as much as approximately 20% of Mukusi growing stock) in the C_3D_3 and C_3D_2 forest stands where the Mukusi mixing rate is no more than 40%. Thus, it will be possible to increase the total Mukusi cutting volume from the 11th year onward.

4.12.2. Reserve Forest Plan

The compartments in which known reserve forests exist and the compartments in which a permanent plots has newly been established are designated as reserve compartments and are excluded from the cutting plan. All artificial activity should be eliminated from inside these reserve compartments so as to maintain a natural forest state.

Table 58 shows the names of unit sites, the numbers of compartments, area and volume, etc. in relation to the reserve forests inside the Forest Estates.

Table 56 Objective forest compartment of cutting plan (1)

Forest name	Compartment No.	Area (ha)	Forest condition: Mukusi mixing rate	Crown density class	Crown diameter class	Site index	Volume per ha	Total volume	Mukusi volume	Allowable cutting volume		Remarks
	Com	F	M_4M_4	$D_1D_2D_3$	$C_1C_2C_3$	H_1H_2	m^3/ha	m^3	m^3	20%	25%	
Kasiki	16	37	4	3	3	1	196	7,252	6,346	1,269	1,587	
Kasiki	31	77	3	3	3	1	196	15,092	9,433	1,887	2,358	
Kasiki	35	21	3	3	3	1	196	4,116	2,573	515	643	
Malavwe	12	6	3	3	3	1	196	1,176	735	147	184	
Malavwe	14	27	3	3	3	1	196	5,292	3,308	662	827	Botanical reserve /Permanent plot No.1
Simungoma west	11	506	3	3	3	1	196	99,176	61,985	12,397	15,496	
Simungoma west	25	500	4	3	3	1	196	98,000	85,750	17,150	21,438	
Simungoma west	34	141	3	3	3	1	196	27,636	17,273	3,455	4,318	
Simungoma west	38	153	3	3	3	1	196	29,988	18,743	3,749	4,686	
Simungoma west	46	191	3	3	3	1	196	37,436	23,398	4,680	5,850	
Simungoma west	47	119	3	3	3	1	196	23,324	14,578	2,916	3,645	
Simungoma west	75	255	4	3	3	1	196	49,980	43,733	8,747	10,933	
Simungoma west	80	115	4	3	3	1	196	22,540	19,723	3,945	4,931	
Simungoma west	10	62	3	3	3	2	136	8,432	5,270	1,054	1,318	
Simungoma east	2	544	4	3	3	1	196	106,624	93,296	18,659	23,324	
Simungoma east	4	15	3	3	3	1	196	2,940	1,838	368	460	
Simungoma east	18	33	3	3	3	1	196	6,468	4,043	809	1,011	
Simungoma east	23	241	4	3	3	1	196	47,236	41,332	8,266	10,333	
Simungoma east	27	34	3	3	3	1	196	6,664	4,165	833	1,041	
Simungoma east	41	775	4	3	3	1	196	151,900	132,913	26,583	33,228	
Simungoma east	53	124	4	3	3	1	196	24,304	21,266	4,253	5,317	
Simungoma east	57	84	4	3	3	1	196	16,464	14,406	2,881	3,602	
Simungoma east	62	479	4	3	3	1	196	93,884	82,149	16,430	20,537	
Simungoma east	65	35	4	3	3	1	196	6,860	6,003	1,201	1,501	
Sikubingwa	29	98	4	3	3	1	196	19,208	16,807	3,361	4,202	
Sikubingwa	44	165	4	3	3	1	196	32,340	28,298	5,660	7,075	
Sikubingwa	47	40	3	3	3	1	196	7,840	4,900	980	1,225	
Sisisi	46	10	3	3	3	1	196	1,960	1,225	245	306	
Sisisi	48	168	3	3	3	1	196	32,928	20,580	4,116	5,145	
Sisisi	81	318	4	3	3	1	196	62,328	54,537	10,907	13,634	
Sisisi	102	20	3	3	3	1	196	3,920	2,450	490	613	
Sisisi	108	6	3	3	3	1	196	1,176	735	147	184	
Sisisi	109	15	3	3	3	1	196	2,940	1,838	368	460	

Table 56 Objective forest compartment of cutting plan (2)

Forest name	Compart-ment No.	Area (ha)	Forest condition: Mukusi mixing rate	Forest condition: Crown density class	Forest condition: Crown diameter class	Forest condition: Site index	Forest condition: Volume per ha	Forest condition: Total volume	Forest condition: Mukusi volume	Allowable cutting volume		Remarks
	Com	F	M_0M_4	$D_1D_2D_3$	$C_1C_2C_3$	H_1H_2	m^3/ha	m^3	m^3	20%	25%	
Nanvota	3	86	3	3	3	1	196	16,856	10,535	2,107	2,634	
Lumino forest	12	81	3	3	3	1	196	15,876	9,923	1,985	2,481	
Kayumbwana	2	161	3	3	3	1	196	31,556	19,723	3,945	4,931	
Kayumbwana	18	152	3	3	3	1	196	29,792	18,620	3,724	4,655	
Kayumbwana	25	177	3	3	3	1	196	34,692	21,683	4,337	5,421	
Sijulu	17	260	3	3	3	1	196	50,960	31,850	6,370	7,963	
Kazu-Namena	22	187	3	3	3	1	196	36,652	22,908	4,582	5,727	
Kazu-Namena	70	243	3	3	3	1	196	47,628	29,768	5,954	7,442	
Nanga	4	751	3	3	3	1	196	147,196	91,998	18,400	23,000	Permanent plot No.2
Lonze	43	5	3	3	3	1	196	980	613	123	153	
Lonze	47	238	3	3	3	1	196	46,648	29,155	5,831	7,289	
Lonze	51	46	3	3	3	1	196	9,016	5,635	1,127	1,409	
Lonze	57	705	3	3	3	1	196	138,180	86,363	17,273	21,591	
Lonze	66	26	3	3	3	1	196	5,096	3,185	637	796	
Lonze	68	18	3	3	3	1	196	3,528	2,205	441	551	
Lonze	73	74	4	3	3	1	196	14,504	12,691	2,538	3,173	
Lonze	76	26	3	3	3	1	196	5,096	3,185	637	796	
Lonze	85	138	3	3	3	1	196	27,048	16,905	3,381	4,226	
Situmpa	5	45	3	3	3	1	196	8,820	5,513	1,103	1,378	
Situmpa	6	17	3	3	3	1	196	3,332	2,083	417	521	
Situmpa	15	62	3	3	3	1	196	12,152	7,595	1,519	1,899	
Situmpa	21	28	3	3	3	1	196	5,488	3,430	686	858	
Situmpa	36	100	3	3	3	1	196	19,600	12,250	2,450	3,063	
Situmpa	42	160	3	3	3	1	196	31,360	19,600	3,920	4,900	
Situmpa	47	58	3	3	3	1	196	11,368	7,105	1,421	1,776	
Situmpa	52	715	3	3	3	1	196	140,140	87,588	17,518	21,897	
Situmpa	54	37	3	3	3	1	196	7,252	4,533	907	1,133	
Situmpa	56	100	3	3	3	1	196	19,600	12,250	2,450	3,063	
Situmpa	58	29	3	3	3	1	196	5,684	3,553	711	888	
Situmpa	62	16	3	3	3	1	196	3,136	1,960	392	490	
Situmpa	87	68	3	3	3	1	196	13,328	8,330	1,666	2,083	
Total		10,223						1,999,988	1,438,364	287,673	359,591	

Table 57 Long term yearly plan for forest cutting of Mukusi
(1) Sesheke area, (2) Mulobezi area

(1) Sesheke area

Forest name	Cutting order	Number of compart-ments	Compartment	Area (ha)	Forest condition: By aerial photographs: Mukusi mixing rate	Crown density class	Crown diameter class	Site index	Volume: per ha	Total Volume	Mukusi Volume	Abailable cutting volume (25%)	Annual cutting volume	Period	Total cutting volume	Remarks
				F	M_0M_4	$D_1D_2D_3$	$C_1C_2C_3$	H_1H_2	m³/ha	m³	m³	m³	m³	Year	m³	
	1	8	11,25,34,38,46, 47,75,80	1,980	3/4	3	3	1	196	388,080	285,183	71,296	6,000	10	60,000	
Simungoma west	1	1	10	62	3	3	3	2	136	8,432	5,270	1,318	8,000	1	8,000	
Sikubingwa	2	3	29,44,47	303	3/4	3	3	1	196	59,388	50,005	12,501	8,000	1	8,000	
Simungoma east	3	10	2,4,18,23,27,41 ,53,57,62,65	2,364	3/4	3	3	1	196	463,344	401,411	100,353	8,000	8	64,000	
Sisisi	4	6	08	537	3/4	3	3	1	196	105,252	81,365	20,341			0	
Kasiki	5	3		135	3/4	3	3	1	196	26,460	18,352	0			0	
Malavwe	6	2		33	3	3	3	1	196	6,468	4,043	0			0	
Nanyota	7	1		86	3	3	3	1	196	16,856	10,535	0			0	
Subtotal				5,500						1,074,280	856,164	205,809		20	140,000	

(2) Mulobezi area

0

Forest name	Cutting order	Number of compart-ments	Compartment	Area (ha)	Mukusi mixing rate	Crown density class	Crown diameter class	Site index	per ha	Total Volume	Mukusi Volume	Abailable cutting volume (25%)	Annual cutting volume	Period	Total cutting volume	Remarks
Situmpa	1	13	5,6,15,21,36,42,47, 52,54,56,58,62,87	1,435	3	3	3	1	196	281,260	175,790	43,948	8,000	5	40,000	
Lonze	2	9	43,47,51,57,66, 68,73,76,85	1,276	3/4	3	3	1	196	250,096	159,937	39,984	8,000	5	40,000	
Kazu-Namena	3	2	22,70	430	3	3	3	1	196	84,280	52,676	13,169	6,000	2	12,000	
Nanga	4	1	4	751	3	3	3	1	196	147,196	91,998	23,000	6,000	3	18,000	
Sijulu	5	1	17	260	3	3	3	1	196	50,960	31,850	7,963	6,000	1	6,000	
Kayumbwana	6	3	2,18,25	490	3	3	3	1	196	96,040	60,026	15,007	6,000	2	12,000	
Lumino	7	1	12	81	3	3	3	1	196	15,876	9,923	0			0	
Subtotal				4,723						925,708	582,200	143,069		18	128,000	
Total				10,223					196	1,999,988	1,438,364	348,878			268,000	

Note: The Kasiki, Malavwe, Nanyota and Lumino forests are not included in the cutting plan due to their locations and small areas.

Table 58 Natural conserve forest

Forest name	Compartment					Permanent plot No.
	No.	Area (ha)	Total volume m³	Mukusi volume m³	Remarks	
Malavwe forest	14	27	5,292	3,308	Batanical reserve	No. 1
Nanga forest	4	751	147,196	91,998		No. 2
Kalama forest	7	65	5,525	2,072		No. 3
Samatela woodland	W12	524	8,908	0	Sheet 1724B1	No. 4

4.12.3 Reforestation Plan

(1) Order of reforestation plan sites

1) Site I C_3D_2 and Site II C_3D_2 and C_2D_2 are designated as first-order reforestation areas. Many of these forests have a past history of Mukusi cutting and, accordingly, feature a low mixing rate of Mukusi as the mother tree. Furthermore, these forests contain only a small number of Mukusi saplings (i.e., succeeding trees) due to recent burnings. If the presence of succeeding trees can be assured by means of artificial planting, then it will be unnecessary to set expectations on natural seeding regeneration and the need for the conservation of mother trees will decrease. As a result, it will become possible to cut approximately 20% of the existing Mukusi trees (C_3D_2). If an in-forest reforestation method is established in the next 10 years, it will become possible to expect an increase (by 3,000 to 5,000 m³/year as shown in the low section of Table 59) in allowable cutting in the next plan spanning from the 11th to the 20th year. Similarly, in C_3D_3 forests where the Mukusi mixing rate is less than 50%, cutting will become permissible on the precondition that Mukusi saplings will be planted after cutting.

   - In present and future Mukusi cutting areas (canopy open, gap of forest canopy, or direct sowing areas), natural seeding regeneration takes place if left to the work of nature. Consequently, under a healthy natural condition, there will be no need for a planting plan for these areas. However, saplings are often destroyed by burning or cutting, so it may be necessary to select the areas as first-order reforestation areas.

2) Site I C_3D_1 and Site II C_3D_1 and C_2D_1 are designated as second-order reforestation areas. If the growth of succeeding trees is assured inside these compartments, it will become possible to harvest trees 30 to 40 years from now.

3) Bare areas and woodlands are selected as third-order reforestation areas. Even if reforestation is feasible in these areas at present, it will take at least 80 years before final cutting is permitted.

   According to the above order, planting should be implemented first in the Masese and Machie areas. A plan should be formulated so that the first 10 years will be set as a test period, while full planting will be completed between the 11th and 30th years. During the first 10 years, planting needs to be concentrated in sites C_3D_2 and C_2D_2, and test planting will be carried out in other areas.

(2) Selection of reforestation methods

1) Reforestation by direct sowing

At present, available and reliable information indicates that reforestation by direct sowing is an effective technique, and that Mukusi in their sapling period are likely to be shade tolerant trees. Consequently, an immediately feasible reforestation method would be to carry out direct sowing in an environment with a moderate shade in the upper layer. For this reason, open stands with canopy closures of 45-70% are selected as first-order reforestation sites, while extremely open stands with canopy closures of 5-45% are ranked second-order.

Sites permitting the growth of seedlings include not only open stands that are not covered by a canopy, but also locations only slightly covered by a canopy. It is assumed that here are approximately 135% of such canopy-open areas (: 100% of non covered areas + 35% of slightly covered areas) for the direct sowing areas. And feasible sowing area (ha) in the unit forest area is caluculated as following:

Feasible sowing area $As \approx 10{,}000 \times 1.35\,(1\text{-}Cc/100)$ [m^2/ha]

Where $As < 10{,}000\ m^2$

Cc: Crown closure [%]

Assuming the sowing interval in a feasible sowing area is 1.5 m x 1.5 m = 2.25 m^2, the sowing density per ha is roughly 4,500. Therefore, the number of sowing points Sp is:

$$Sp \approx As \cdot 4{,}500 / 10{,}000 \quad [Sp/ha]$$

Then the number of seeds Sn is derived, assuming that three seeds are planted at each point at an interval of 10 cm or more from each other. Seeds to be used should be those treated for germination promotion (treatment with heated water, sulfuric acid, etc.) so as to obtain a germination rate of 60% or more.

Number of seeds $Sn \approx 3 \cdot Sp$ [Sn/ha]

The sowing area and the numbers of sowing points and seeds, assuming Cc is from 45 to 70%, are derived as follows:

Feasible sowing area	As ≈ 4,000 to 7,500 m^2/ha
Number of sowing points	Sp ≈ 1,800 to 3,400/ha
Number of seeds	Sn ≈ 5,400 to 10,000/ha

2) Uniform reforestation

In the Forest Estates, there is a total area of about 23,000 ha having a canopy closure of less than 45% and a bare area of approximately 50,000 ha. Although these areas require early reforestation for the recovery of wood and environmental resources, basic practical reforestation techniques are still incomplete and it is difficult to formulate a planting plan in a short time period. Specifically, these areas, except those areas directly below the crowns of some remaining trees, cannot expect a sufficient shading effect, so that the sunlight is too intense, resulting in stunted growth of saplings, which require a shaded environment. At present, the only reliable reforestation technique for Mukusi forests is the direct sowing method. Nevertheless, uniform reforestation by direct sowing is not likely to succeed in extremely open stands and bare areas.

For this reason, it is necessary to seek another reforestation method. Since it will take a long time to develop a new forestry technique, it is judged difficult to establish a planting plan for uniform reforestation for some time to come. As an alternative approach, the following test may be implemented, and if this test proves successful, it will become possible to begin a full-scale planting project.

Prior to the planting of Mukusi, Mukwa and other light-demanding trees (woodland intolerant species) may be planted. After a shaded environment has been created by these trees, full-scale direct sowing of Mukusi may be started. Since Mukwa do not form a pure forest, they should be mixed with deciduous other species. Because Mukusi will be planted years later, the number of Mukwa and deciduous trees to be planted is approximately 2,000 to 3,000/ha.

At present, there is a lack of basic information on preliminary reforestation with regard to suitable species, seeding, planting and direct sowing techniques, so it is important to test diverse cases of planting in order to accumulate information. With a view to formulating a forest management plan 10 years later, test planting should be implemented in areas totaling several hectares to 10-plus-several hectares per year. In addition, if a Mukusi seedling planting method is developed in the near future, this should be tested as well.

Also, forests with canopy closures of 45% or less (D_1) but with 20% or more provide possibilities for partial shading; therefore, a Mukusi direct sowing test should be conducted in these forests as well.

(3) Reforestation implementation plan

1) Direct sowing reforestation (gap reforestation)

Currently, forests with canopy closures of 45-70% (C_3D_2 and C_2D_2) in the Forest Estates total approximately 19,000 ha in area. Focusing on these areas, direct sowing reforestation should be implemented in approximately 2,000 ha/year in unit sites where cutting will be carried out or in adjacent sites. Table 59 lists the sites and compartments selected for direct sowing regeneration. The implementation order is the same as the order in the cutting plan. Reforestation is to be implemented mainly in C_3D_2 compartments, and if possible, direct sowing should be completed in all selected sites in 10 years.

2) Uniform reforestation

Full-scale uniform reforestation starts after the first 10-year period, but test planting is carried out during the first 10 years. Test planting should take place at the same sites where direct sowing reforestation is implemented, and in the same years. The test planting area starts from several hectares, progressively increases every year, and reaches 10-plus-several hectares in the 10th year, with approximately 10 ha being the 10-year average. After the execution of preliminary reforestation, the direct sowing of Mukusi seeds is carried out in the 5th and 6th years. A uniform reforestation method is to be established during the first 10-year period, so that full-scale reforestation can be implemented from the 11th year onward. As shown in Table 60, uniform reforestation areas (partly including direct sowing reforestation) are selected from among areas with canopy closures of 5-45% (C_3D_1 and C_2D_1), totalling about 23,000 ha in area. Uniform reforestation in bare areas with canopy closures of no more than 5% (approx. 50,000 ha in C_3D_0, C_2D_0, C_1D_0 and C_0D_0) will be carried out after the uniform reforestation of 5-45% canopy closure areas.

Table 59 Objective areas of gap reforestation by direct sowing in the opend-crown forest

Forest name / crown /volume	Division of Forest Structure								Total		
	IC₃D₂ (116m^3/ha)			IIC₃D₂ (77m^3/ha)			C₂D₂ (60m^3/ha)		Number	Area	Volume
	N.C.	A(ha)	V(m^3)	N.C.	A(ha)	V(m^3)	N.C.	A(ha)	of Cmp	(ha)	(m^3)
Sesheke Area											
Simungoma west	18	1,589	184,324	2	71	5,467	10	171	30	1,831	189,791
Sikubingwa	16	1,596	185,136	1	58	4,466	2	29	19	1,683	189,602
Simungoma east	21	2,136	247,776	2	39	3,003	3	113	26	2,288	250,779
Sisisi	14	887	102,892	3	31	2,387	12	340	29	1,258	105,279
Samatela	3	110	12,760	1	34	2,618	5	236	9	380	15,378
Kasiki	23	1,037	120,292	0	0	0	6	100	29	1,137	120,292
Malavwe	11	604	70,064	0	0	0	7	68	18	672	70,064
Mululwe	5	176	20,416	1	34	2,618	4	95	10	305	23,034
Kateme	6	250	29,000	2	50	3,850	1	64	9	364	32,850
Sichinga	0	0	0	0	0	0	2	63	2	63	0
subtotal	117	8,385	972,660	12	317	24,409	52	1,279	181	9,981	997,069
Mulobezi Area											
Situmpa	25	2,188	253,808	0	0	0	6	214	31	2,402	253,808
Lonze	22	1,828	212,048	2	33	2,541	9	191	33	2,052	214,589
Kazu-Namena	8	594	68,904	0	0	0	13	513	21	1,107	68,904
Nanga	1	112	12,992	0	0	0	1	23	2	135	12,992
Sijilu	5	303	35,148	1	158	12,166	4	73	10	534	47,314
Kayumbwana	4	159	18,444	0	0	0	3	102	7	261	18,444
Nangonbe	1	19	2,207	0	0	0	5	63	6	82	2,207
Lumino	5	401	46,516	0	0	0	1	31	6	432	46,516
Lwangula	3	428	49,648	0	0	0	4	110	7	538	49,648
Kanyanga	3	616	71,456	1	26	2,002	2	72	6	714	73,458
Nalwama	8	625	72,500	2	21	1,617	3	94	13	740	74,117
subtotal	85	7,273	843,668	6	238	18,326	51	1,486	142	8,997	861,984
Total	202	15,658	1,816,328	18	555	42,735	103	2,765	323	18,978	1,859,053

* N.C. : Numbers of compartment,
A : Area of opend forest to be reforestation by sowing.

When reforestation are succeeding in the future

Allowable cutting volume	ΔV(all tree)	ΔVm(Mukusi)
Sesheke	6,020 ~ 9,970 m^3/y	1,720 ~ 2,850 m^3/y
Mulobezi	5,240 ~ 8,620 m^3/y	1,500 ~ 2,460 m^3/y
Total	11,260 ~ 18,590 m^3/y	3,220 ~ 5,310 m^3/y

Table 60 Objective areas of complete reforestation by planting and sowing

Forest name /crown structure /stand volume (m^3/ha)	Division of Forest Structure								Total	
	IC_3D_1 63		WL 63		IIC_3D_1 42		C_2D_1 35			
	N.C.	A(ha)	N.C.	A(ha)	N.C.	A(ha)	N.C.	A(ha)	N.C.	A(ha)
Kalama	0	0	0	0	0	0	4	192	4	192
Kanyanga	4	407	2	57	0	0	1	50	7	514
Kasiki	12	349	0	0	4	119	9	146	25	614
Kateme	3	219	0	0	1	7	0	0	4	226
Kayumbwana	4	77	0	0	0	0	3	113	7	190
Kazu-Namena	7	624	1	23	0	0	17	1,005	25	1,652
Lonze	20	1,767	0	0	3	63	7	618	30	2,448
Lumino	5	711	2	32	0	0	1	40	8	783
Luwangula	4	237	0	0	0	0	6	231	10	468
Malavwe	12	988	0	0	3	120	19	408	34	1,516
Monze	20	461	0	0	4	145	7	95	31	701
Mululwe	5	145	1	127	0	0	2	41	8	313
Nalwama	5	611	0	0	2	534	3	115	10	1,260
Nanga	3	34	0	0	0	0	3	72	6	106
Nangonbe	0	0	0	0	0	0	2	150	2	150
Nanyota	3	383	5	212	0	0	3	102	11	697
Samatela	4	207	0	0	1	70	11	1,604	16	1,881
Sichinga	1	264	0	0	0	0	29	874	30	1,138
Sijilu	2	83	3	77	0	0	3	242	8	402
Sikubingwa	15	1,077	1	118	3	49	1	37	20	1,281
Simungoma east	14	870	0	0	2	61	9	284	25	1,215
Simungoma west	16	1,183	0	0	0	0	20	469	36	1,652
Sisisi	19	633	0	0	14	415	17	474	50	1,522
Situmpa	16	1,959	0	0	0	0	3	246	19	2,205
Zungubo	1	20	0	0	2	65	2	64	5	149
Total	195	13,309	15	646	39	1,648	182	7,672	431	23,275

* N.C. : Numbers of compartment.
A : Area to be complete reforestation (ha)
(including partial sowing under remained trees).

(4) An Example of Successful Reforestation Project

The Republic of Korea is an industrialized nation which boasts a high level of gross national income by world standards. However, 30 or 40 years ago it was a low-income country with its land devastated by a war between the northern and southern halves of the country. During this period of poverty, Korea strove to improve its national environment through a reforestation program employing local people. As a result, greenery was restored to its bare mountains, and today most of its mountains and hills are covered with forests. Yet experts doubt if the same reforestation program could be executed in present-day Korea with its stable employment of people and its high level of income, for it would be difficult to attract a sufficient number of workers needed for planting. Korea now has the finances necessary for the reforestation of its land, but reforestation cannot be achieved by finance alone. This example suggests that, although the income level in Zambia is expected to increase in the future, the reforestation of waste land is a project to be implemented before the income level rises.

In the light of the Korean example, it is hoped that reforestation in south-western Zambia will be completed within the next 20 years.

4.12.4. Implementation Plan for Construction of Forest Roads in Connection with Planting and Cutting

(1) Forest Roads

In case there is no road leading to the unit sites for implementing the cutting and reforestation plans, it is not customary to build a management road for access purposes. In most cases, forest roads are built for the purpose of managing those sites where planting and cutting plans are to be implemented. As explained below, management roads may be built to serve as firebreaks as well.

(2) Forest roads and spur roads

A road which is directly related to cutting and reforestation is constructed as a forest road or a spur road when the need for such a road arises. Except for special cases, forest roads are not constructed. A forest road or spur road is built simply by using a bulldozer, for example.

(3) Construction plan for combination firebreak-and-management roads

If forests are lost to fire, it will put an end to all plans for reforestation and environmental protection. Therefore, the prevention of forest fires is the most paramount task. Since seedlings to be planted are extremely weak against fire, a management road that also serves as a firebreak must be constructed around the planting site. It is desirable to build a combination firebreak-and-management road one year before the start of the planting plan.

Usually, in comparison with seedlings, a high forestsubject to cutting is less likely to be lost to fire. For this reason, fire prevention measures for high forests are taken only when there is a budget left to do so. In the case of reserve forests, however, rigorous protection is necessary and firebreaks are constructed around these forests including their adjacent high forests.

In the case of a direct sowing reforestation program where approx. 2,000ha/year is to be carried out over 10 years, an 18km length of firebreak-and-management road is required to surround the reforestation area for effective protection against forest fire. (Assuming a land area of 2,000ha is square in shape, the length surrounding the area is approx. 18km.)

In practice, the road length depends on the shape of the reforestation area; so, it is reasonable to assume the road length will be longer, and a firebreak-and-management road length of 20km/year is proposed.

4.13. Future Issues and Proposals

The issues which should be particularly stressed among those discussed up to now will be listed here under separate subheadings. At the same time, proposals will be made.

4.13.1. Forestation techniques for restoring resources

There is remarkable forest destruction in the southwestern region. About 40% of the area of Forest Estates is artificially degraded treeless grassland and 20% is forest land with extremely deficient forest canopies (Table 24, Total of D1 column). It is necessary to reforest these areas where the forests are disappearing so as to restore the forests. Even forests which appear to be healthy are suffering from strain in the composition of species, so reforestation is necessary to readjust them. In traditional areas as well, reforestation for raising the rate of intermixing of Mukwa in the woodlands, formation of forests for restoring fertility to the soil, and reforestation for forming firewood forests are necessary. Along with this, it is necessary to form groves of fruit trees required by residents.

Among the reforestation techniques for this, at the present time, only reforestation by direct sowing is being implemented. Methods of growing seedlings and methods for growing young trees individually for species and sites of course and the systems for the same have still not been developed. Further, there are many aspects of the ecosystem of the forests which remain unclear after the current survey. There is much for which follow up surveys should be performed over the coming years. Here, the forestry issues which should be tackled in the future will be listed:

Technology for growing seedlings and techniques of direct sowing for individual species

- Mukusi, Mukwa, and other main species. Other useful species.
- Species comprising preceding forests.
- Firewood species.
- Fruit tree species.

Planting for individual sites

- Reforestation by direct sowing in forests, planting of seedlings.
- Formation of preceding forests and reforestation by direct sowing and planting of seedlings under forest crown.
- Uniform reforestation at treeless areas.

Forest ecology survey

- Survey of permanent plots (Malvwe botanical reserve, Nanga forest, Kalama forest, Samatela woodland).
- Growth of saplings and young trees and forest environment (covering of upper storey trees, covering of herbs and bushes, relationship with early burning, etc.)
- Survey of root systems of main species by environment.
- Biological seasons of main species.

4.13.2 Wood utilisation and forest management

There is no problem if succeeding trees grow and forests regenerate under natural conditions after cutting, but in fact there are the following problems even under conditions where the amount of harvesting is less than the growth.

- Since specific species are mostly cut in forests for industrial wood production, strain occurs in the composition of the regenerated species.
- Succeeding trees needed for forming large trees are being eliminated by cutting for firewood and forest fires.

These matters have been already touched upon in the related chapters and the specific measures toward this have also been described. Here, it is necessary that forestation (including forestation in forests) be made obligatory so that the strains caused by harvesting are corrected by the harvesters themselves, and that they bear the financial burden. Although felling fees have been collected from sawmill operators since 1995, these monies should be used for reforestation.

Placing the stress on continued reproduction of forests in this way would enable a stable supply of wood, so it is crucial to promote the effective utilisation of wood in this manner. Recently, demand for Mukusi has been slow, so it is necessary to develop products and demand targeting at higher added value products.

- Along with developing demand, it will be necessary to improve the utilizing rate of log bucking at the sites (currently only lower part of stem are being used in many cases) and to improve the bucking yield from the raw wood so as to enable effective utilisation of resources.

4.13.3. Management of Mukwa woodlands with mixed in

Mukwa is distributed over a wide geographical range than Mukusi. In this regard, it is considered a species with a strong dissemination ability. The rate of intermixing in unit stands, however, is lower than even Mukusi, so in some cases the seed trees may be eliminated by cutting and their continuation become endangered.

Although the estimated value is a very rough value, the woodland area with Mukwa mixed in is at least 20,000 ha in the study area. The stock of Mukwa intermixed in the stands there is 15 m^3/ha and further if the total stock is 300,000 m^3 and the average tree age is 80 years, then the average annual total growth can be roughly calculated to be 3,700 m^3. As opposed to this, the current amount of cutting, calculated in terms of standing tree volume, is an estimated 1,500 m^3 even at the most in the sawmills and 500 m^3 in pitsawing or a total of 2,000 m^3, which is lower than the growth. Therefore, it is judged that there is still a margin of safety left for the resource. It will be important, however, to accurately grasp the figures that pertain to woodland areas with Mukwa mixed in, the stock, the rate of intermixing with Mukwa, etc. in future surveys.

Mukwa seeds have a large driftability, so do not require as many seed trees as with Mukusi, but even so it will be necessary to leave about five trees per ha. If there are less than five large trees of diameters of 30 cm, then even if the other conditions for allowance (diameter class of over 35 cm and cutting allowance of 20 to 25%) are satisfied, there should be no cutting.

Whatever the case, since there has not been any full-scale resource survey of Mukwa, a separate survey will become necessary.

4.13.4. Management of Mupane stands

Mupane, Mubako, Muhonono, Muhoto, etc. in the high floodplains etc. grow quickly and have a strong reproducibility and sustainability as stands. Since they take the form of woodlands with open forest crowns, the stand stock is a small 10 to 80 m^3/ha, but growth is fast and in about 20 to 25 years become sizes able to be used, so the average growth of the stands is estimated to be 1 to 2 m^3/ha. Here, the Mupane tree grasslands in the study area amount to about 30,000 ha, and since the area near the southeast of study area totals over 50,000 ha, the total growth volume exceeds 50,000 m^3. Thus, a large volume is available for firewood. Production as charcoal and firewood may be expected after introduction of an orderly method of cutting with due consideration given to reforestation (seedlings and regeneration by natural sowing).

At the present time, from the standpoint of preventing reckless cutting, charcoal making activities are prohibited in this region by the lodge common law, but modern (high yield) charcoal production could be possible under a reliable organisation created with close ties to the lives of the local residents. Through such charcoal production, the local people would earn some cash and would become accustomed to methods giving them a sense of forest management, so this would be advantageous.

Whatever the case, resource surveys, demand surveys, surveys on cutting methods (allowable cutting rates, forest rotation), planting methods, charcoal production methods, and institutional changes, and tests would be necessary.

4.13.5. Close linkage between survey findings and practical application

No matter how useful the recommendations made by a research, there will be many problems when moving to their implementation such as expenses, equipment, personnel (qualifications and quality), etc. New surveys, tests, and research will also probably become necessary for putting them into practice (practical application). The current research was aimed at elucidating and obtaining a grasp of the basic matters required for implementation and practical application, but it will be necessary to continue with more technically oriented activities.

4.13.6. Urgent need for practical reforestation tests (Reforestation research in tropical semi-dry regions)

In order to restore forest resources and the soil environment, reforestation is urgently needed in former forest areas having no tree stands left, in excessively open forest areas, and in forest areas requiring species adjustment. Nevertheless, the prerequisite for any reforestation project would be the sufficient development of techniques for seedling growth, transplanting, direct sowing, etc.

Unfortunately, information concerning these techniques has been virtually non-existent in tropical semi-dry regions, so it is not possible to undertake practical reforestation projects. To carry out such projects, it is necessary to acquire specific reforestation technologies (such as seeding and nursing technologies) and a comprehensive reforestation technology system incorporating all the specific technologies.

Without these technologies, it is not possible to formulate specific reforestation plans concerning such matters as the selection of planting species, determination of the number to be planted, evaluation of suitable afforestation sites and species, and selection of a specific transplantation technique. In order to develop the necessary technologies, implementation of the following practical tests is recommended:

(1) Nursing test

Applicable species: Select at least 10~20 useful species from among the aforementioned species, positive species including firewood species (for rapid growth forests), and fruit species; then, nurse the selected species with a view to starting actual forestry production activities at the earliest possible time.

Nurseries: Establish nurseries in a low terrace (near the Zambezi River) where ground water can be easily pumped and the water supply can be flexibly managed with regard to water supply timing, etc. The current nurseries in Masese are not a suitable location. Secure a total of 5 ha area, including seeding, transplantation and reserve beds.

(2) Direct sowing test

Germination and growth test: Test many species for different soil and water conditions. In addition, examine the growth of seedlings in relation to relative light intensity using different sunlight shading conditions.

Test nurseries: In view of water supply management, secure a direct sowing test area (2 ha) in a low terrace as in the case of the nursing test.

(3) Site adaptation test

Carry out seedling transplantation and direct sowing tests at various forest locations with different canopy coverage conditions (no tree stands, open forest, closed forest areas) as well as different soil and water conditions. Select test sites not only in the Forest Estates but also in traditional lands. Also conduct an ecological study in parallel.

(4) Collection and storage of seeds

Because seed availability and seed quality vary widely from year to year, conduct germination tests in a year of large seed harvest, and evaluate if the seeds are satisfactory in germination performance. If satisfactory, collect and store a large number of seeds and utilize them in subsequent years when necessary.

(5) Implementation of reforestation

As for nursing and direct sowing tests, set targets at obtaining rough results in three years and completing the technologies for major species in six years. Select species showing good results and determine their necessary reforestation methods and conditions, and accordingly formulate a reforestation implementation plan (including reforestation sites, environmental characteristics, species, transplantation and growing methods, growth density, site area, number of seedlings, number of seeds, ground conditioning methods, number of workers, etc.). Then, implement this plan.

5. ENVIRONMENTAL CONSERVATION

The state of the environment will be compared against the natural state of a forest which is evaluated as a natural origin and points to be maintained and points to be rectified clarified based on the relationship between the two. At the same time, measures necessary for the same will be recommended. A study will also be made of the impact on the environment of the forest management and Land use considered up to here.

5.1. State of Land and Environment

The southwestern region of Zambia has yet to be affected by urbanization, mining, etc., so almost all of the environmental factors in play are natural. Here, the necessary matters will be summarized from the explanations provided up to now.

5.1.1. Climate

The seven month period from the middle of March to the middle of October constitutes a dry season with almost no precipitation. The period from mid-October to mid-March of the following year comprises the rainy season. During the rainy season, there are strong squall-like rains, but the overall precipitation during that season is a low 800 mm or less. In the past 15 to 20 years in particular there has been little rain with the precipitation for the year totaling some 600 mm. This decline in the precipitation has been accompanied with a higher frequency of hot days. There has been a problem with prolong droughts causing close to semi-desert conditions.

5.1.2. Land conditions

In previous geological eras, the Kalahari desert was larger and the entire region was covered with a thick layer of sand. There were two major periods of desertification. The sand layer of the first period (early to middle diluvial epoch) was subjected to red weathering under the subsequent humid and high temperature climate and changed to soil with a relatively high clay content. The second period of desertification appears to have occurred at the relatively recent end of the diluvial epoch. There has not been that much weathering in that sand layer which remains distributed as a greyish white sandy soil. Since the sand layer is thick, the underlying rock is unexposed and no soil is created from the bedrock.

A sand layer has little ability to hold water and nutrients, so generally tends to be evaluated as soil of a low productivity, but in this region the sand layer is deep, so the problem of the low water retention is compensated for by the thickness and the overall amount of water held is increased. Even locations considerably distant from the river benefit from this water infiltration and constitute good sites in their own way due, for example, to the abundant ground water, which is linked with the level of river water.

In sand layers, however, fine grained soil leached from the top layer (surface portion) move downward and form an impermeabile pan. In quite a few cases, this results in an overly wet state in the rainy season and makes the site poor in quality.

5.1.3. Forests and vegetation

The environment for plant life in the region differs according to the site. The composition of the ground water differs tremendously depending on whether the site is on alluvial land or highlands and hills while the amount of water retained differs according to whether the sand layer is thick or thin. The natural vegetation differs slightly in species and density in accordance with two water conditions.

In the low and medium level floodplains near the river, which are frequently flooded during the rainy season, trees are not able to grow, so the result is a vast expanse of grasslands. At the high level floodplains where the frequency of flooding is somewhat lower, trees can grow and wet-tolerant species of trees such as Mupane and Muhonono appear. At the low level terraces which constitute non-floodplain alluvial land, the surface soil is somewhat dry, but ground water is stably and constantly supplied by capillary action, so the water retention is not bad. This forms an environment conducive to the strong growth of numerous species of trees in forests with high forest crown coverages.

Highland areas tend strongly to be drier than alluvial land, but pretty large amounts of water are held at locations with thick sand layers, so forests with closed crowns are able to be formed. As opposed to this, locations with thin sand layers retain little water, so competition for moisture is fierce and woodlands with open forest crowns appear. Further, local depressions and locations with broad pans often become overly wet or flood in the rainy season, so do not allow tree growth and become grasslands. The biggest problem in the forest belt is forest fires. These cause large-scale destruction. Burning of land is a long established practice in this region, but the frequency of burning has been abnormally high in the past 20 to 30 years and the number of forest fires caused by it has jumped as well. These forest fires have spread even to the National Forests Estate where burning of land is in principle not allowed. As a result, large areas of treeless land (about 40%) and open land (about 20%) have been created. Healthy forests constitute less than 30% of the area.

5.1.4. Land use

Land is being used as forests, village land, cultivated plots, pastureland, and firewood forests.

Villages and cultivated plots should be located on alluvial land where there is underlying ground water, the ground water rises through capillary action, and therefore the surface soil retains relatively large amounts of water. It is believed that this situation had been sustained in the past. Recently, however, perhaps because overgrazing has caused a decline in the fertility of the alluvial land as a whole, land suitable for cultivation is disappearing and people are seen to be moving to the highlands where water conditions are not as good.

In the normal shifting cultivation, cultivated plots are established by cutting down the forests and making use of the fertility of the soil in the cleared area. The practice has been to allow the area to return to its natural forest state after cultivation and to wait until the fertility was restored before next using it. On the other hand, wood required near the villages is fuelwood and wood for building use - both of which are small diameter materials, so the forests which are formed are seedling forests or secondary forests of short cutting cycles. Accordingly, if the land were utilised in a manner enabling the space area to be recycled, then there should be a pattern of cultivated plots and villages interspersed among fuelwood forests. However, when herbs and trees start to grow again after land finishes being cultivated, local residents use it for pastureland. Recently, they have even been allowing their livestock to graze in the forests. Grazing by a suitable number of livestock should not interfere with this cycle of land recovery, but in fact there is overgrazing and the land is being frequently burned, so there is almost no hope for restoration of the forests and the fertility of the soil is increasingly declining.

5.2. Forests and Farmland and Grazing (Agroforestry)

Here, the environment for agriculture around the forests will be studied comprehensively from the standpoint of the natural sciences and social sciences.

5.2.1. Features of cultivation (Shifting cultivation)

Cleared forest land is covered by the fertile soil which the forest had built up before then. Local residents burn off this land to form farm plots to make use of this natural fertility of the soil for cultivation of crops. If crops continue to be cultivated without artificial means of enriching the soil such as application of fertilizers, the nutrients in the soil are used up after three or four years and production there becomes difficult. When this situation occurs, residents move on to new land with a richer soil.

More specifically, residents cut down new forest areas and burn off the land to form new farm plots. Since the farmers move on to new land after a certain period of use, this practice is called burning and "shifting cultivation." This is quite a common mode of utilisation of land in developing regions.

Healthy shifting cultivation is made possible by allowing the land to return to its forest state after cultivating it for a certain period of time so as to enable the soil fertility to be restored. The soil fertility is restored 20 to 25 years after the land returns to the forest state, so the trees may then again be cut down and the land burned off to form farm plots. In shifting cultivation in Japan and Southeast Asia, cultivation of crops is accompanied by parallel reforestation so as to facilitate the regeneration of the forests.

If burned off land were cultivated for four years and then allowed to return to a forest state, then there would be forests of four years' growth, eight years' growth, 12 years' growth, 16 years' growth, and 20 years' growth, or five times the area of a farm plot, around a cultivated plot. It should appear at first glance that farm plots are scattered in the middle of a forest. This is called "agroforestry".

However, in the southwestern region of Zambia, there is a problem in that there are no forests around the cultivated plots and therefore there is no mechanism for restoration of the soil fertility.

5.2.2. Formation of firewood forests and restoration of fertility

The currently existing natural forests and woodlands are natural forests and woodlands comprised of dominant trees of at least 70 years age. When considering this age of the natural forests and shifting cultivation in combination, it is considered that even if assuming that clear cutting were possible, the period until reutilisation of spaces would be too long and, further, since the natural forests of this region are forests which should be selectively cut and managed, coexistence with shifting cultivation using clear cut land would be impossible. That is, forests which can be used with shifting cultivation have to be ones which can be clear cut in periods of 20 to 25 years. What therefore comes to mind are the firewood forests.

At the present time, the soil of the alluvial region where land is being cultivated is supplied with ground water by capillary action at the middle and lower layers of 50 cm or more depth. While not by any means rich, this constitutes the easiest environment for the growth of trees with roots of over 1 m length. That is, this land is easy to restore to the forest state after shifting cultivation.

At the present time, there are many villages in the alluvial belt along the Zambezi River. There are no large forest or woodland areas there, so a shortage is starting to be seen in fuel materials. If shifting cultivation and formation of fuelwood forests are combined from the perspective of restoration of soil fertility and harvesting of firewood, it is considered possible to enable both healthy shifting cultivation (agro-forestry) and sustainable harvesting of materials required for daily life.

5.2.3. Grazing

When cultivators stop working on the cultivated spaces, usually the fields are seeded by surrounding grasses, herbs start to grow, and the fields quickly are converted to grasslands. Trees are not as nimble as herbs in this sense and therefore start to grow later, but they finally increase in number and height and take over from the grass as the dominant species. After trees start growing, the density of herbage falls, but it never disappears. The coexistence of trees and herbs even after formation of forests is a feature of the broad-leaved forests of this region.

What is basic here, as stated already as one of the basic requirements for forest management, is that it is the root systems of herbs that supply the humus to the soil and thereby quickly restore soil fertility. When herbs grow fully, develop full root systems, then die (herbs have a short life span, so there is a high frequency of death), the residue of the root systems is supplied directly the soil as humus. New herbs flourish the next year, which again supply humus. This is the mechanism by which soil fertility is restored. Trees also function to restore and maintain soil fertility over a broader range in the long term, but when focusing on just the effectiveness in the short term of 10 to 20 years, herbs must be judged as functioning far better.

When grass begins growing after shifting cultivation, local residents use those locations as pastures for their livestock from the viewpoint of making effective use of the grass as feed. Herbs are destined to die anyway after they flourish, so being eaten as food slightly earlier does not inhibit the conversion of their root systems to humus, but when this grazing obstructs the growth of grasses in the following year, there is a problem in that it means a reduction in the supply of humus. Early consumption by livestock reduces the amount of the seeds and therefore reduces the amount of new growth the following year. Excessive consumption reduces the underground stems and the shoots from the root systems (perennial herbs). This is referred to as overgrazing and causes a steady decline in the growth of herbs with each passing year.

To avoid this overgrazing, it is necessary to keep the number of livestock allowed to graze at a suitable level, but the local residents have little awareness of this concept and so almost all areas are becoming increasingly devastated. Recently, in particular, there has been an increase in the number of goats being raised. Goats have voracious eating habits and consume even the underground stems and root systems, so in most cases this devastation is becoming even worse.

Burning is conducted in pastureland for the nominal purpose of promoting new growth of herbs the following year, but this appears to be having the opposite effect and causing a reduction in the herbs grown the next year.

In pastureland, it often appears at first glance that the surface soil is soft since the soil is stirred up by the hooves of the livestock, but it is known that the hoof pressure forms a dense layer at a depth of 20 to 30 cm in the soil layer. Further, at the exposed sandy soil, leaching causes fine grained soil to shift downward and form a dense pan. It is believed that hoof pressure speeds the formation of the pan. If such a pan is formed, then water stagnates there in the rainy season to cause over wetness of the land and reduces the soil strength. In extreme cases, it causes the formation of grasslands (savanna) where trees are unable to grow.

5.2.4. Cultivation and grazing in forests

Now the possibility of cultivation and grazing in forest land comprised of large-sized trees will be studied.

Certain species of vegetables, medicinal herbs, etc. require shading for growth and therefore could be cultivated in the forests, but general crops require large amounts of sunlight and therefore would be difficult to grow there. Accordingly, in principle, cultivation in the forests should be rejected.

As already indicated, forests are currently flourishing in the highland belt which, while excellent as a site for deep-rooted trees, has soil far worse than the alluvial land in terms the supply of water for shallow-rooted crops. Further, while farm plots should preferably be areas with no standing trees such as clear cut land, forests of large diameter trees require selective cutting and so there is a basic contradiction in terms. Accordingly, it may be considered scientifically impossible to establish farm plots in forest belts.

In forests, even when considerably bright, the relative luminance is lower than outside the forests and usually there is low density of growth of herbs there. Livestock allowed to graze in the forests would eat that small amount of herbage, so the herbs would immediately be drastically reduced in number and the forest floor would become bared. On the other hand, tree crown rain has a force no less powerful than that of rain outside the forests, so would cause serious soil erosion in areas of clay-like reddish (sandy) soil areas and strong leaching in sandy soil areas.

As indicated earlier, leached out sandy soil has a strong acidity which does not allow later herb growth. Futher, the fine grains of soil which deposit at the lower layers along with the leaching form a pan which creates a poor water environment. (Grazing assists the formation of pans due to the hoof pressure.)

Improper grazing should not be allowed in the forests due to the high risk of ruining the forest land with its precious advantageous physical conditions.

5.2.5. Cultivation and grazing in natural grasslands

Natural grasslands occur at locations which are flooded or become overly wet during the rainy season. Accordingly, they cannot be used for farmland or pastureland during the rainy season. During the dry season, particularly the start of the dry season, however, the moisture conditions of the soil are good and many locations are suitable for cultivation.

Locations with dense grass growth have thick humus layers and are replenished with nutrients from upstream when flooded so are rich in fertility, but often the root systems of the herbs are too dense and strongly bind the soil layer. Further, often a pan has been formed close to the ground surface. This would make it difficult for the land to be tilled using the spades owned by most small farmers.

Accordingly, while superior in terms of suitability for cultivation, this land is actually not being used. It should be possible to introduce powerful tilling machines to till the land once, after which tilling would be easy by human strength alone. It is necessary to quickly proceed with tests and research to confirm this.

If the grasslands are tilled, then since the number of years which they can be used as farmland would be long, it is believed that the periods where they are allowed to remain fallow could be kept short and the land therefore utilised efficiently. Further, if this land could be cultivated, then there would be less chance of the forest regions, which are poor in terms of moisture conditions and soil nutrients, being considered for use for shifting cultivation.

5.2.6. Guidelines

The farming in this region has in the past been on the alluvial plain (low terraces). This is believed because the moisture conditions of the soil are better on alluvial land compared with highland areas. The previous system in shifting cultivation had been for allowing the forests to regenerate and the fertility of the soil to be restored after cultivation and then reestablishing farm plots after the ground had recovered in strength. In the southwestern region, however, this system is being ruined by overgrazing after cultivation. As a result, it is becoming difficult to find new land for cultivation in the alluvial plain. To solve this situation, the following measures may be considered:

- Firewood forests able to be cut in 20 to 25 year cycles should be established on abandoned farm plots (there is currently a growing shortage of fuel materials) to promote restoration of the soil fertility.
- Limits on the number of livestock allowed to graze on land should be strictly observed. If limits on the number of livestock allowed are not observed, then grazing in forests including young trees should be prohibited.
- The highland areas are not suitable for cultivation, so encroachment of farms into the large diameter tree forests and woodland areas should be prohibited.
- Seasonal use of the medium and low level floodplains for cultivation should be promoted. First, however, strong mechanical tilling would be required.

- Grazing should in principle be limited to the medium and low level floodplains.
- If possible, farmers should be moved to intensive agricultural operations in the low terrace land. There are plenty of prospective locations for this.

5.3. Desertification

5.3.1. History of desertification

A surface geological survey would enable the history of the desertification of this region to be deduced. Large-scale desertification of this region occurred once in the early and middle diluvial epoch, ran rampant for a while, and formed a thick sand layer Later, in the latter part of the diluvial epoch, however, the surrounding environment changed to a wet climate resulting in the formation of soil by forest vegetation, weathering, and relatively gentle erosion. Specifically, it is believed that plant life recovered over a considerably long period and signs of the desert were almost all eradicated. In that period, further, a red sand layer was formed conforming to the profile of the basal topography and that a dark red curass was formed under the sand layer (surface of basal topography). The red sand layer deposited in parallel to the natural ground suggests the situation at that time. From the late diluvial epoch to the post-glacial period, there was again strong desertification. A large amount of sand was supplied, so much so as to cover the shapes of the relief of the natural ground of the past red sand layer, and created a flat highland topology. After that, probably starting from several thousand years ago, the amount of precipitation improved and the advance of the desert conditions was stopped. The region then changed to climatic conditions conducive to the growth of plant life resulting in the current situation. From the state of the sand layers appearing in the geological profiles, it is possible to read that there were at least two periods of intense desertification from the mid to late diluvial epoch. In the case of the past red sand layer, while the sand layer is uneven, it is deposited in a manner parallel to the topology. Deducing from this, it is believed that after the desertification, the climate changed to a wet and pluvial one and that there was gentle erosion with growth of vegetation. The deposition of a sand layer in parallel with the profile of the basal topography shows that a small amount of sand particles shifted and deposited while the vegetation fixed the deposited sand layer. It can be deduced that something close to normal erosion occurred and a hilly topography richer in relief than even the present was formed. The prominent difference in the color tone, grain size, and compactness of the sand layer shows that there was a great difference in the mechanism of redistribution of sand and weathering during this period and suggests that there were long periods where no sand was deposited.

As opposed to this, during the last period of desertification (from end of diluvial epoch to start of post-glacial period), the vegetation does not appear to have resisted the sedimentation of the sand layer. The desertification was of an intensity enough to destroy and bury the existing topographic relief. This suggests that rather than there having been simply a large supply of aeolian soil blown and deposited from the adjoining Kalahari desert, the region itself became desert-like in state. As the modern age approached, the climatic conditions once again changed to abundant rain and the desert conditions ended. This suggests that the vegetation was restored recently. No phenomenon or information is known which would enable a guess to be made as to if this will continue for a long time or not. Based on the accounts of older people in the region, the flow of the Zambezi River and its tributaries has significantly dropped over the past few decades and the amount of precipitation in the rainy season has declined. There is concern that the region might climatically be heading in the direction of desertification.

Several decades ago, the level of the Zambezi River was much higher than it is at the present and reportedly split off at the left bank near Pimbwae, about 25 km upstream from Sesheke, and flowed down to Mulayi Dambo. Seen overall, the plateau stretching from the left bank of the Zambezi River to the right bank downstream of the Loanja River (downstream from near Masese) is believed to have once been the fan of the Zambezi River.

5.3.2. Occurrence of desertification

Desertification is generally believed to be caused by an extreme reduction in the precipitation. It may be defined from another perspective as a change from soil enabling plant growth to rocky land or inorganic sand devoid of nutrients where plant growth is difficult. "Rock desertification" is understood to be caused by the soil erosion attendant upon overgrazing or other destruction of vegetation in grasslands or forests in arid environments. In extreme cases, it can even occur in wet temperate areas. As opposed to this, sand-layer deserts are believed to be caused by a decline in the soil nutrients. This is suggested from the fact that the sand layer of land left after civil engineering works, which is devoid of nutrients, does not allow herb growth. In a sand layer area, water infiltration is high and there is no remarkable water-flow erosion, so the desert is not created by the physical destruction caused by erosion. However, instead, the destruction of the plant life is accompanied with destruction of the mechanism for replenishment of soil nutrients and causes the appearance of an inorganic sand layer chemically poor in nutrients, which in turn leads to the formation of a sand-layer desert. This region has recently been beset by an increased frequency what should be called pointless burning and forest fires caused by the same. Burning which inhibits regeneration of herbs is a practice which artificially speeds up the process of desertification and should be assessed very negatively.

Recently (about 20 to 25 years ago), modern roads were constructed in this region. There were large-scale civil engineering works accompanied by clearing, banking, and moving of earth. Nearby slopes were leveled, the areas at the sides of the roads were excavated, and large amounts of earth moved. Along the national highways, exposed subsoil originally below the soil and deposits of inorganic leftover soil dug up from the deep portions of the earth can be seen all over the place. The state of encroachment of vegetation on these exposed surfaces today, 20 years later, was examined. It was found that the density of herbage was extremely low (sparse growth) and, further, that the individual states of growth were poor. (App. Table 22)

When a sand layer is bared and struck by rain, the weathering substances and humus adhering to the surface of the sand particles are leached out leaving only the inorganic rock particles. The inorganic sand layer is white or greyish white in color and forms a strongly acid layer of a pH close to 3. This strong acidity is believed to make growth of plant life difficult. In quite a few cases the moisture conditions are no better or worse than the nearby soil (dense herb growth), so recovery of more hardy vegetation had been expected, but even when a white layer covers the soil by a thickness of several cm, no herb growth is seen. This shows that no much progress has been made in the recovery of the herbage despite as many as 20 years having passed.

When such a leached layer develops, the leached out fine particles collect at the bottom layer of the soil (30 to 50 cm under surface layer) and form a pan which causes an even greater problem. The pan usually has a value of over 30 mm as measured by a hardness meter and is extremely dense. It obstructs the entry of the root systems and forms a strong water-impermeable layer. If such a pan spreads, then even with a sand layer, water will not infiltrate it during the rainy season and a layer of stagnant water will be formed over the pan. Even if the soil acidity is reduced and a humus layer is formed, trees will not grow due to the over wetness and at the most a grassland with growth of short herbage will develop. At the present time, there are grasslands called pans or plains (wetlands in the rainy season) scattered in the highland belt, but these may have been formed by the mechanism of "exposure → leaching → formation of pans" of sand layers.

Conversely, a soil layer of a strong basicity from which silicates were leached out was formed in previous times under the fast decomposition of humus. This may also be considered a cause of the poor growth of the vegetation.

No chemical analysis was made of the soil, so no clear judgement may be rendered, but whatever the case the suggestion seems to be that growth of vegetation is extremely difficult in an inorganic sand layer devoid of fertilising components. In particular, strongly acidic sand layers which have lost their metals and base inorganic nutrients as well due to leaching and strongly basic sand layers which are reduced in silicates are considered unreceptive to plant growth.

5.3.3. Destruction of vegetation and desertification caused by burning and overgrazing

The growth of large amount of herbage on former cultivated area which had been reduced in nutrients derived from humus and been abandoned replenishes the humus in a major way (through repeated death and regeneration of highly dense root systems). This is advantageous to fallow farmland where restoration of the soil productivity is desired. During farming, however, there is a strong tendency to view herbage not just as a competitor of the crop being produced but as an enemy. Even after farming is abandoned, this tendency to view herbage adversely appears to continue. Accordingly, when grass starts to grow densely in fallow farmland, the land is frequently burned to remove it. This burning impairs the natural mechanism of soil regeneration (restoration of humus and ends up causing the soil, which has been exhausted by the farming, to further regress into sandy soil with little nutrient content.

Further, when herbage starts to grow on land which has stopped being cultivated, the land is being used for grazing with an eye to utilisation of the herbage. The eradication of the natural herbs which have just started to grow and restore the soil environment by feeding by livestock makes restoration of the soil impossible. Therefore, the soil environment deteriorates even more than when the land stopped being farmed. Recently, in particular, there has been a remarkable increase in grazing by goats. Goats have voracious appetites and consume the all herbs and bushes completely, so the problem becomes serious. Goats can tolerate rougher food than cattle, so are highly evaluated in terms of the production of protein from the soil and are treated as precious livestock. Goats thrive even in low quality environments which cannot sustain cattle, but from the environmental standpoint, what awaits after goats are raised on poor vegetation unable to sustain cattle and then even the goats cannot be sustained is a desert. It is a historical fact that the land devastation and desertification in the coastal regions of the Mediterranean (temperate zone with scant precipitation) were caused by goats. It is necessary to recognize this fact and take special care to avoid the damage caused by overgrazing.

Southern Africa has experienced a clear fall in the amount of precipitation in the past 20 years due to climatic changes. In particular, in the past two to four years, it has been hit by an abnormal drought. If this state of scant precipitation continues, it will have an effect on the state of growth of the natural vegetation and there may be the risk of desertification. A reduction in the soil moisture causes a reduction in the amount of growth of the plants there and causes a reduction in the amount of growth of forest trees and herbs. Frequent forest fires and overgrazing, however, further accelerate this. The soil right now is poor, but contains some amounts of organic matter and inorganic nutrients. Even the water conditions become just a little bit better, it is believed that immediate recovery of the growth of vegetation could be expected. However, there is a problem in that it is known that in the tropic or subtropical areas where the rate of decomposition of organic matter and the rate of weathering are fast, a decline in the amount of plant growth not only facilitates soil erosion (normally silt and clay soil areas), but also causes rapid deterioration of the soil enriching conditions (sandy soil areas) and makes growth (recovery) of vegetation difficult.

If the soil is washed away and just rocks and pebbles remain or if there is no soil erosion, but the land becomes inorganic sandy soil poor in nutrients, this creates conditions difficult for growth of plants. We call this situation desertification. In this regard, uncontrolled burning and overgrazing are speeding the change toward a desert environment even more than the deterioration in climatic conditions warrant.

Restoration of a once degraded soil environment is not easy either technically or naturally, so if the forests and vegetation continue to be destroyed at the current tempo, even if climatic conditions turn for the better in the coming years, only adverse desert-like environmental conditions will remain and restoration will become a major problem.

In the past few decades, the level of the Zambezi River has steadily dropped. There has reportedly been a clear decline in the volume of water of tributaries as well. Many of the dambos or plains (pans) between the hills or in the hills are drying out.

Not all of this drying has a disadvantageous effect on the grown of vegetation. Up until now, cases have been seen where growth of large-sized plants has been promoted, as shown below, due to the dropping of the water level at locations where the level of the ground water had been too high:

Grassland → Tree grassland

Tree grassland → Woodland

Woodland → Forest

However, this increase in vegetation caused by drying is seen only in limited areas. In the hills, plateaus, and highland regions as a whole, vegetation has retreated due to the disappearance of ground water and the reduction in the water held in the soil (desertification?):

Forest → Woodland

Woodland → Tree grassland

Tree grassland → Bared land (desert)

Burning, cultivation, and overgrazing are further aggravating this trend.

5.3.4. Guidelines

When the herb coverage disappears and the sand layer (sandy soil) is exposed both in the forests and outside the forests, the surface portion is leached out by the impact of rain and a highly acidic, inorganic sand layer appears. The leached fine particles collect in the soil layer to form a water-impermeable pan. This inorganic sand layer obstructs the growth of vegetation (herbs and young trees). Further, the pan causes the appearance of excessively wet land during the rainy season and inhibits the growth of trees. This deterioration of the soil leads to savanisation and desertification. The following measures are recommended to inhibit the spread of these phenomena:

- Actions which cause the reduction of herbs should be restricted both inside and outside the forests. Controlled burning and grazing by suitable number of livestock should not cause a reduction of the herbs, but the burning and grazing up to now have gone far beyond the limits and are causing massive devastation.

This situation should be stressed, clear guidelines set for the purposes and area of burning, compliance with these guidelines enforced, and grazing limited to inside the floodplain except during the rainy season so as to make maximum use of the floodplain grasslands and keep grazing at areas of tree growth (possible) to a minimum.

5.4. Burning and Forest Management

5.4.1. History of burning

Even the Forestry Department currently recommends "early burning", that is, burning in April to June. This practice is not believed to have existed prior to 1975, however.

At that time, early burning in the woodlands (grass growing in the forests) was experimented with under the supervision of British researchers for the purpose of preventing fires from spreading from the farmland and pastures (where the practice for a long had been to burn off the land in August to October before the rainy season). The top officials of the Forestry Department judged that a similar measure could be applied to the forests as well and therefore introduced the practice of burning in the forests. This was probably because there were numerous forest fires even when the practice of early burning was introduced. It is unclear, however, whether the incidence of fires declined after the practice was started. App. Table 23 (1), (2) is a record of the forest fires from 1975 to 1988 (survey of Forestry Department, no survey since 1989). This shows that there have been a considerable number of fires.

Whatever the case, in the past 20 to 30 years, over 60% of the national forest has sustained devastating damage. The damage caused by this practice of burning was found by the current survey as well. Knowledgeable persons and some local technical staff already recognize the damage caused by burning and consider it necessary to take some sort of measures against it. The following problems are caused by burning:

- Burning causes the disappearance of saplings and young trees. Since this has been a frequent practice, it is becoming difficult to find young succeeding trees of under 25 years age in the current forests. Seen from the perspective of sustaining the forests and woodlands, this practice is a critical destructive factor. Conversely, the harmful thorny shrubs etc. often remain after burning.
- In the past, burning had been conducted in the forests for clear objectives such as starting or expanding shifting cultivation or hunting. Recommendation of the practice of early burning and the official approval of various types of burning, however, seem to have created the impression in the minds of the local residents that burning is an everyday practice. This has spurred on meaningless burning which not only spreads but directly causes forest fires. At the present time, completely meaningless burning is being conducted all over the place and at a high frequency. The forested area of the national forests in the southwestern region has been halved and the stock has been reduced to half of that of 25 years ago even in the remaining forests.
- The impression gained from the field survey was that thorny shrubs growing at the edges of the forests could only be eliminated by burning. These thorny shrubs will not burn with early burning and will finally only burn with medium or late burning when they are drier. Local residents know that medium and late burning is effective for eradication of such obstructive plants and seem to prefer the same.

5.4.2. Government approach

Burning may be considered to be advantageous for the following purposes. When for one of these purposes, burning should be allowed or sometimes even encouraged.

[1] Promotion of growth of new pasture plants

[2] Cultivation of crops (shifting cultivation)

[3] Elimination of harmful insects (large areas are burned for this purpose even in the national parks)

[4] Elimination of thorny shrubs to facilitate access for harvesting fruit

[5] Collection of honey

[6] Hunting of wildlife

[7] Early burning

Burning for the above purposes is allowed by the government and seems even to be encouraged by some officials in charge of livestock production.

Recent survey reports etc. have pointed to the damage caused by excessive burning (in particular the fires in forest belts and woodlands). The exact mechanism of this damage, however, has not been clearly shown and no progress has been made in understanding the phenomenon in the scientific sense. In particular, the central government authorities, who are far from the local sites, do not appear to be very concerned about the fact that purposeless burning is frequently being conducted for no reason and that it is causing large-scale destruction of the forests and increasing destruction of the environment. In particular, they do not seem to be aware that this pointless burning is encouraged in mood by officially authorized burning. Even forestry officials have not realized the need to stop encouraging early burning.

The government has come out with clear statements to the effect that it is engaging in early burning to prevent fires from spreading to the forests and has on the surface at least established a full system for preventing fires such as the deployment of local staff and construction of fire towers. It appears to be satisfied with having set up this existing fire-preventing system. The system is not however working at all. The government does not appear to be aware that official allowance of various types of burning has rather served to reduce the awareness of local residents of the need for preventing fires and is fostering the outbreak of forest fires. The scientific facts should be explained to show the damage caused by burning and realistic, practical measures devised. This is also strongly requested by knowledgeable people at the actual locations.

5.4.3. Damage caused by burning

The damage caused by burning is, directly, the destruction of the forests and, indirectly, the ruining of the environment when considered from the standpoint of soil fertility and desertification. The forest management sector should endeavor to better understand the scientific facts, studies, and evidence and rethink the steps which can be taken in different areas.

5.4.4. Conservation measures

Fire prevention measures

- Education should be strengthened to make local residents and related parties understand the beneficial functions of forests and natural vegetation, in particular herbs, and teach the orderly approach to burning and the damage caused by uncontrolled burning.
- Species of trees (Mugongo, Muzauli, Mango, etc.) providing emergency food and secondary food to local residents should be planted in and around the forests and interest raised in preventing forest fires by a tie-in with protection of these trees.
- Local residents should be encouraged to engage in apiculture in the forests and the cultivation and production of special forest products so as to make them realize the need for preventing fires in the sense of avoiding damage to those activities.
- An incentive system should be set up for villages around forests which have been protected well for a long period (providing incentives for fighting forest fires has been found by experience to have a reverse effect in the past).
- Firebreaks (bare strip) should be established around the forests. If a work road (bare road surface) of a width of at least 6 m is constructed and used in parallel as a firebreak, then it would be possible to both improve forest management and firefighting capabilities.
- Firefighting capabilities should be strengthened (equipment and current budget).

Reassessment of Efficacy of Burning

- A quantitative survey should be made of the effects and damage of the currently authorized burning.
- A survey should be made of the psychological effects of currently authorized or promoted burning on local residents (who engage in meaningless burning).
- When the advantages and disadvantages of current burning become clear, consideration should be given to the balance between its plus and minus sides and the efficacy of burning should be reassessed. Specific steps should then be taken such as toughening regulations, establishing a period of prohibition, or establishing prohibited locations.

Forest Continuation

- It is necessary to raise awareness of the importance of sustaining the forests, at the Forestry Department and the rest of the government as well, and to take steps for reforestation.
- Measures stressing soil conservation in the forests, grasslands, and farmland and measures to prevent desertification should be taken (preservation of forests as areas for growth of both herbs and trees).

Shift to Commodity Economy

If the local residents can be shifted to a commodity economy, then farming in outlying regions for supplying personal needs should end and more intensive utilisation of land based on natural, scientific conditions of the land should be able to be promoted. (In the industrialized nations with high population densities, there are quite a few examples where the money economy has gone too far and rational Land use has become difficult, but this should be possible in Zambia where the population density is still low.) However, at the current level of society where people are forced to grow everything themselves, local residents are kept busy with the next day's needs and would probably not have the time or leisure to listen to reason no matter how well grounded in scientific fact. Unless penal provisions are toughened or some incentive system is set up, it would be impossible to promote regular Land use. It is crucial to devise ways for the local residents to earn cash and at the same time to encourage them to make more rational use of the land.

5.5. Other Environmental Phenomena

5.5.1. Soil erosion

The region surveyed is flat in topography and covered by a layer of sand with good water infiltration, so no soil erosion is occurring despite the lack of undergrowth and other soil coverage. In the northeastern part of the region surveyed and the region at the northeast close to the surveyed region, however, there are hilly locations covered with reddish sandy soil (including considerable silt and clay). There, soil erosion and gully erosion occur when the herb coverage is lost. Recently, this region has seen an increase in the number of livestock, particularly goats, being raised and the occurrence of signs of overgrazing. This point should be noted.

5.5.2. Water quality

There are no chemical plants or ore refineries etc. located in this region or regions upstream from it. Further, there is little fertilizer being used in agriculture or detergent being used by local residents. Accordingly, there is no water pollution at the present point of time. If there is an increase in the fertilizer or agricultural chemicals used in agriculture in the near future, however, caution is required in that the area is one of a high water permeation and therefore is susceptible to chemical contamination of the river water and ground water. Further, if serious soil erosion occurs in the red soil areas due to overgrazing, there will be a danger of suspension pollution by clay.

5.5.3. Protection of wildlife and rare plants

The southwestern region of Zambia is considered the habitat of wildlife listed in Annexes I and II of the Washington Convention. During the field survey, African elephants, duiker, impala, hippopotamus, monkeys, and other animals were sighted or their existence confirmed by their dung or tracks. In addition, there had been reports that lions and other carnivorous animals were living in the region, but contrary information was obtained from interviews with local residents. The only rare animals are considered to be those protected in the national parks.

Restoration of the stock and selective cutting of normal forests in forest management would enable the natural environment inherent to the region to be sustained, so should be assessed as having an advantageous impact on the habitat of the wildlife as well. The biggest problem here is that no matter how good the forest management by the forestry side, the effect is completely wiped out by forest fires. The forest fires caused by pointless burning are destroying the forests themselves and ruining the wildlife and plant environments as well.

None of the plants have been designated as being valuable species at the present point of time and their protection is therefore not particularly an issue. However, forest fires are in fact causing drastic changes in the makeup of the vegetation.

The fact that forest fires are causing the destruction of the forest biosystems was evident from the survey. Seen from this perspective, there are major doubts as to the meaningfulness of the burning currently allowed in the national parks.

5.5.4. Air pollution and global warming

There are frequent forest fires in the summer season resulting from burning. The soot (fine particles) causes remarkable smog-like pollution of the air. This is not considered to be a problem at the present time since it does not contain any particularly harmful chemical substances, but at the very least the air is not clean. There is a good chance that this will become an issue in the future.

The forest fires and overgrazing probably have reduced the forest stock in the region to less than a 25% state of health. It is assumed that even in Zambia as a whole the same degree or even worse a state of the forest stock is seen. The increase of carbon dioxide caused by burning of forests is considered a problem in terms of the global environment and there is concern over the global warming and abnormal weather caused by it. In Zambia itself, however, the loss of forests is also considered to be a major contributing factor. The southwestern part and southern part of Zambia have suffered from an abnormal shortage of precipitation in the past 20 years. This may be a manifestation of the climatic changes now occurring on a global scale, so should not be ignored.

According to a recent study, accompanying the reduction of forests, there has been a reduction in the abundance of aqueous vapour supplied by forests and also a reduction of ascending air currents. As a result, it is believed that this has led to a decrease in the amount of precipitation. In the southwestern part of Zambia, there has been a marked decrease in the amount of precipitation in the last 15 to 20 years. This period has coincided with the rapid destruction of forests resulting from forest fires. Since these two factors have coincided, it is feared that there is a relation between the two.

The reasons for these climatic changes have not been ascertained as yet, but in any case, a recovery of the forest volume is desirable as an environmental asset.

5.6. The Effect of Forest Management on the Environment

5.6.1. Environment factors that relate to forests

Two kinds of environment factors come into play with respect to forests. One is the environment required for the growth of trees, which comprise the forests. The other is the influence that existing forests have on the surrounding environment. Because forests are a part of nature and have occupied vast areas since ancient times, environment factors for the benefit of forests and forest environment factors that work for the surroundings act almost in common. If we do not take care in investigating their content, there are occasions when we may not know which we are talking about. For example, in taking the environment's relation to soil into consideration, a study that relates to soil fertility (water and nourishment) belongs to the former, while the study that relates to the public benefit of soil (watershed conservation, moisture preservation, prevention of soil erosion, etc.) belongs to the latter. In this report, environment factors that pertain to the former are investigated in Chapter 4, while those that pertain to the latter and work outside the environment are investigated in Chapter 5.

With respect to the environment that surrounds the forests, a study of individual factors has already been made. These items are listed below.

Soil	Soil erosion, sediment deposit
Soil & water	Function of soil watershed cultivation (soil infiltration capacity, soil storage capacity)
	Function of soil moisture preservation (Water purification, clay turbidity)
Atmosphere and mechanism	Atmosphere purification, pollution, CO_2 adjust (C fixed) Climate mitigation (Temperature, humidity, precipitation)
Biology	Plants, animals, ecosystem

5.6.2. Current environment

Forests are a symbol of nature. The existence of healthy forests indicate a healthy environment. And the existence of deteriorated forests indicates a deteriorated environment. As was already mentioned, forests in the study area suffered serious damage as a result of fires and excessive grazing. Due to this, there has been a worsening of the environment, which was also referred to earlier.

5.6.3. The effect of forest management on future environment

The forest management plan for this study area is that healthy broad-leaved trees in stands having good composition be maintained as they are, and that stands that have been ravaged be returned to their original broad-leaved state. Accordingly, if this plan is implemented, the forest situation will gradually improve. Along with this, the environment will also improve. An outline of each item is given as follows:

- Soil erosion and Zambesi River clay turbidity

Due to the reddish soil along the banks of the Zambesi River, slight soil erosion causes the water to be cloudy. Along with this, water turbidity is gradually increasing. But if there is improvement in the forest situation, this will be terminated.

- Function of soil watershed cultivation

In this area, the infiltration capacity is not pronounced, but a part of the soil surface is leached so a pan is formed along with leaching. Thus, the watershed cultivation function decreases. But if the forest situation should improve, deterioration in this function will be terminated.

- Water quality preservation by soil

Currently, there is no deterioration in moisture preservation, so if the forest situation improves, the function will become even more secure. Regarding the use of land for cultivation, suggestions have been put forth on behalf of intensive farming, but if this proceeds, problems may arise from the excessive use of fertilizer. The amount used determines whether there will be pollution.

- Wild-life preservation

The natural growth of plant and animal life is closely related to the forest ecosystem, so that forest improvement results in the restoration of plant and animal life. However, in the case of wild animals, depending on the situation, other approaches must be considered because of the threat to human life.

- Atmosphere preservation

Improvement of the forest means an increase in the growing stock, and it also means an increase in the fixed volume of carbonic acid gas. It also helps to slow down global warming , and it results in fewer forest fires. Also, less pollution can be expected.

- Climate mitigation

When both the forest area and the volume of stock increases, it means that evapotranspiration also increases, so that the humidity rises, the atmospheric currents become strong and the frequency increases. Thus the amount of precipitation will rise. Depending on the evapotranspiration and shade of the tree canopy, temperature mitigation is maintained.

- Creation of firewood and charcoal forests in alluvial terrace belts

This should help in the successive use of healthy shifting cultivation. Moreover, the supply of firewood to residents would be stabilised.

6. TECHNOLOGY TRANSFER

In cooperation with our counterparts in Zambia, we conducted comprehensive outdoor surveys covering Phases II and III. On each occasion, field survey technology was transferred by providing the parties concerned with explanations on the purposes and specific means of the survey, as well as the reason for employing such means, and by letting them experience the actual measurement and entry of the results obtained.

In addition, at certain times and days in Zambia, we gave lectures and provided opportunities to practice the techniques related to the contents of the Progress Reports (1, 2) and Interim Report to be prepared.

We also instructed forestry engineers in Zambia on basic theories, since we noted that they themselves may conduct similar surveys some day for their future forest management plans in places other than the current survey area, based on the technologies transferred to them for this survey.

Transferred technologies included the following:

- Preparation of volume and yield tables:
  - Pipe models and their applications
  - Practice and utilisation of stem analyses
  - Significance of and method of deciding shape factors
  - Significance of preparing yield tables for resource management
  - Preparation of various volume tables and grasping of growth; method of analysis for preparing yield tables
- Preparation of Forest Inventory Book:
  - Relation between photograph interpretation and calculation of stand volumes
  - Measurement of tree heights with aerial photographs
  - Method of preparing Forest Inventory Book
- Preparation of land use and vegetation maps:
  - Classification of land use and vegetation; method of preparing drawings
- Collection of survey data:
  - Significance and utilisation of stand survey plot data
- Forest survey methods:
  - Characteristics of various methods of forest surveys; significance and interpretation of Belt Transect Method
- Soil survey methods:
  - Soil survey practice and soil classification
  - Method of preparing soil maps
- Topographic surveys:
  - Classification of topography and its relation with natural/conservational characteristics
- Social economic surveys:
  - Establishment of survey items and method of hearing

- Techniques of land-condition surveys:
  - Method of grasping the relation between land-conditions and natural/conservational characteristics
- Techniques of forest management plans:
  - Techniques of forest resources management (calculation of allowable cutting, etc.)
  - Clarification of natural site functions and techniques of site classification
  - Analysis of actual conditions and countermeasure techniques in forest operation methods
  - Analysis of environmental factors and sampling techniques
- Others
  - Techniques associated with this survey

Additionally, a training program for counterparts was held in Japan (from 20 November to 23 December, 1994). During this period, technology transfers were conducted with respect to general technologies associated with Japan's formulation of forest management plans and its forest management practices. Technology transfers were conducted through the cooperation of the Forestry Agency, Hokkaido Forestry Research Institute, Forest Owners' Cooperative in Shimokawa Town, Forestry and Forest Products Research Institute, Nagoya Branch of Regional Forestry Office, Gero District Forestry Office, Kyoto District Forest Office, Kiyomizu Temple, Fukuoka Prefectural Forest and Forestry Technology Center, and Kyushu University.

Moreover, training was given to our counterpart from Zambia during the period 29 August to 6 October, 1995, so that he might be smoothly accepted in Japan. As a step for toward training, in group training on forest management plans (sponsored by the Japan International Cooperation Agency), general technologies needed to formulate forest management plans as well as those on associated institutions were transferred. Technological information on the present forest management situation abroad was also transferred to one another through interchanges and discussions with the trainees from countries world-wide.

Further, the techniques on preparing the draft final report were exchanged through discussions with counterparts and seminars.

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