Thai J. For. 10 : 139-155 (1991)   วารสารวนศาสตร์ 10 : 139-155 (2534)

ENVIRONMENTAL IMPACTS OF NATURAL FOREST MANAGEMENT IN THAILAND 1/

Nipon Tangtham 2/

บทคัดย่อ

ผลกระทบของการจัดการป่าไม้ธรรมชาติต่อสภาพแวดล้อมในประเทศไทย ในที่นี้ประเมินจากข้อมูลเท่าที่หาได้จากการวิจัยในอดีตของนักวิจัยของประเทศไทย และจากผลของการสัมมนาของนิสิตและคณาจารย์ในคณะวนศาสตร์ มหาวิทยาลัยเกษตรศาสตร์ รวมทั้งความคิดเห็นจากประสบการณ์ของผู้ศึกษาเอง กล่าวได้ว่างานศึกษาวิจัยโดยตรงในเรื่องนี้ของประเทศไทยมีค่อนข้างน้อย ส่วนใหญ่จะเป็นการศึกษาผลกระทบของการทำไร่เลื่อนลอย การเปลี่ยนสภาพป่าเพื่อทำไร่และการปลูกสร้างสวนป่า หรือการใช้ระบบวนเกษตร ต่อเรื่องของการพังทลายของดินและการเกิดน้ำไหลบ่าหน้าดิน ผลกระทบต่อความผันแปรของความหลากหลายทางนิเวศวิทยาก็มีน้อยและมีในช่วงเวลาสั้น อย่างไรก็ตามพอจะกล่าวเป็นนัยได้ว่า การทำไม้จากป่าธรรมชาติโดยวิธีเลือกตัด (selection cutting) นั้นจะมีผลกระทบต่อลักษณะทางนิเวศวิทยาและสภาพแวดล้อมน้อยที่สุด เมื่อเทียบกับการทำไร่เลื่อนลอยและการใช้ที่ดินเพื่อการเกษตรรูปแบบอื่น ๆ กล่าวคือ การทำไม้แบบเลือกตัดจะมีการสูญเสียหน้าดินเพียง ๐.๖ ตัน/เฮกตาร์/ปี ในขณะที่การทำการเกษตรแบบชาวบ้านจะมีการสูญเสียดินประมาณ ๑ ตัน/เฮกตาร์/ปี การเปลี่ยนป่าดงดิบชื้นทางภาคใต้เพื่อปลูกสวนยาง ซึ่งมีลักษณะคล้ายคลึงกับการตัดไม้ออกหมด และปลูกสร้างสวนป่าขึ้นมาใหม่ จะมีการสูญเสียหน้าดินประมาณ ๗ ตัน/เฮกตาร์/ปี ในปีแรกและจะลดลงใกล้เคียงกับสภาพธรรมชาติเดิม เมื่อขึ้นปีที่ ๓ อย่างไรก็ตามระบบเลือกตัดดังกล่าวมีปัญหาที่รัฐไม่สามารถป้องกันรักษาสภาพป่าจากการบุกรุกของราษฎรได้ ดังนั้นหากจะใช้วิธีการตัดหมด (clear cutting) แล้วปลูกสร้างสวนป่าใหม่ทันทีก็น่าจะแก้ปัญหาการบุกรุกได้ในระดับหนึ่ง จากการศึกษาข้อมูลผลกระทบของประเทศต่าง ๆ ที่ได้มีการศึกษาไว้บ้าง และจากการสัมมนาเห็นว่าระบบตัดหมด โดยกำหนดพื้นที่พอเหมาะพอดี เช่น ๘๐๐-๒,๐๐๐ ไร่ ดังเช่นที่ ออป. ดำเนินการอยู่ น่าจะประยุกต์ได้ในป่าหลายชนิดของประเทศไทย ยกเว้นบริเวณต้นน้ำลำธาร ลาดเขาสูงชัน และสองฝั่งลำน้ำ ซึ่งคาดว่าไม่น่าจะส่งผลกระทบด้านสิ่งแวดล้อมมากนัก

อย่างไรก็ตาม ในสถานการณ์ที่กระแสการเมือง และความต้องการทางสังคม ยังสวนทางกับนโยบายด้านการจัดการทรัพยากรและการอนุรักษ์สิ่งแวดล้อมที่ผ่านมา และที่เป็นอยู่ทุกวันนี้ คงจะเป็นการยากที่จะทำให้มีการจัดการป่าธรรมชาติที่ยั่งยืนได้ นอกเสียจากคนไทยจะตระหนักถึงความหายนะที่จะเกิดขึ้นทั้งในด้านสิ่งแวดล้อม และการดำเนินชีวิตสำหรับอนาคต.

ABSTRACT

Environmental impacts of natural forest management in Thailand were formulated through available information and discussion in various seminars. The quantitative evidence of this study is rather few. Only descriptive and semi-quantitative impacts were discussed

---

1/ Paper prepared for discussion in the Seminar on Natural Forest and Indigenous Tree Species : Management Principles and Silvicultural Options Friday 18, Jan. 1991, Royal Forest Department.

2/ Department of Conservation, Faculty of Forestry, Kasetsart University, Bangkok 10903.

in some current publications. It could be generally concluded that, timber harvesting by any silvicultural system ever used in the natural forest of Thailand produced less environmental impact in terms of soil and water deterioration than that caused by agronomic practices. Less than 0.5 ton/ha of sediment was found in the first year of logging operation under selection cutting in the western region. Converting moist evergreen forest in the south into para-rubber plantation, which is equivalent to reforestation after clearcutting, caused about 7 ton/ha/yr of soil loss. Since the selection cutting which has been applied in various types of forest in Thailand for almost century resulted in mutually destructive both the socio-economic and forest ecological systems, clearcutting system at optimal size ranging from 600-2,000 rais and immediatly reforested by suitable species is recommended for forest management in the future. Based on the past situation, however, it is not a matter of environmental consequences to judge whether the forest can be sustainably managed but the socio-political pressures which sofar received less attention to seriously resolve by the government. Without people's realization on the essential roles of forest on environment and their quality of life, the ideal sustainable management of natural forests in this country is hardly possible.

INTRODUCTION

Environmental impact is a popular issue in the recent world situation. This is perhaps due to the world has lost tremendous natural resources and the consequent effects caused by unwise exploitation and spontaneous use have been accumulated and seriousely impaired not only the local but also the global biosphere. In the past when the large part of the earth was still covered with the forest, the impact of forest management even the deforestation on environmental degradation seemed to receive less attention. It is only in recent years that the effect of forest management, such as deforestation, silvicultural practices and reforestation on environment gained more attention in the developed and some developing countries.

In Thailand as well, although almost a hundred years that the Royal Forest Department was established and the selection cutting system has been employed for timber harvesting in various types of natural forest, the environmental impacts in terms of ecological, aesthetic value, meteorological, soil erosion and sedimentation have been ignored or received very few attention to investigate or monitor. Only the last two decades that impacts of shifting cultivation, which is not a system of timber management but is considered as a practice that degrades carrying capacity of the northern head-water source, have been studied. The counter measures for mitigating those harmful impacts have been also invented but mostly in forms of soil and water conservation in the shifting cultivated areas. Very few quantitative information concerning environmental impacts of forest management have been made available.

In this paper, information concerning the probable impacts of forest management in Thailand collected from available publication and through seminar discussion was formulated. The specific objectives are : (1) to describe, in general, the probable environmental impacts of forest management systems that have been applied to the natural forest of Thailand, (2) to compare the ecological and environmental impacts that could be possibly caused by selection and clear cutting system in the natural forest of Thailand and (3) to discuss in some aspects of environmental impacts of reforestation of the exotic species particularly Eucalyptus in Thailand.

In this context, the probable ecological and environmental impacts in terms of soil erosion and fertility degradation, changes in microclimate and hydro-ecological characteristics such as water balance, nutrient cycling and streamflow timing are attempted to formulate. Changes in flora and fauna including socio-economic will also be considered in the discussion.

AVAILABLE INFORMATION CONCERNING ENVIRONMENTAL IMPACTS OF SILVICULTURAL SYSTEMS IN THAILAND

2.1 Hypothetical Impacts

As mentioned earlier that very few information concerning this topic are made available by Thai foresters. Information presented herein is more likely to be the impact of forest conversion on soil and hydrology rather than the effect of natural forest management on environment. The effect of logging, road construction, swiddening and agroforestry will be attempted to formulate as much as possible.

The hypothetical impact of various cutting showed in the text of Principle Silviculture (Figure 1) was illustrated in the paper presented by Thaiutsa (1981). It was also described in general that clear cutting system causes more environmental impact in terms of surface soil temperature, overland flow and soil erosion than the seed-tree and selection cutting methods. The percentage of maximal ecological impacts is certainly occurred in higher degree in the clearcutting areas than those areas harvested by other systems.

2.2 Effect of Silvicultural Systems on Soil Properties

Investigation in Thailand by Thaiutsa et al (1976) indicated that among three systems namely: selection, alternative strip and clearcutting, the last one caused more impact on soil erodibility than the other two. The effect of the mentioned systems on the other soil properties was also illustrated in Figure 2. It was also mentioned by Thaiutsa (1981) that clearcutting method could induce more serious impact if followed by burning as usually practice in shifting cultivation by the hilltribes, and reforestation by the RFD and TIO (Timber Industry Organization) due to volaterization of plant natrients and damage of soil micro-organism. Sukwong et al (1976) suggested that coppice system is suitable for teak forest but fire must be protected after cutting. Besides help allevate soil erosion, coppice system can also reduce cost of reforestation operation.

2.3 Effect of Forest Conversion and Logging Operation

Investigation of soil and water losses from various types of land-use in the north indicated that erosion rate from the natural forest ranged from 0.02 tons/ha/yr in the hill-evergreen forest upto 8 ton/ha/yr in the sloping mixed deciduous forest. Converting forest on sloping areas into agricultural crops such as upland rice, corn, bean and sesame caused tremendous amount of soil erosion, i.e., ranging from 2 to 89 ton/ha/yr (Naprakob et al, 1976; Hurni, 1982; Inthapand and Boonchi, 1990; Suebsaen and Aneeksamphant, 1990). Ruangpanit (1971) pointed out based on his investigation that mountainous land in the north should have at least 70 percent of forest cover to maintain soil erosion in optimal level. However, agroforestry systems such as growing coffee tree in natural hill evergreen forest or even in abandoned shifting cultivated area produced insignificant soil

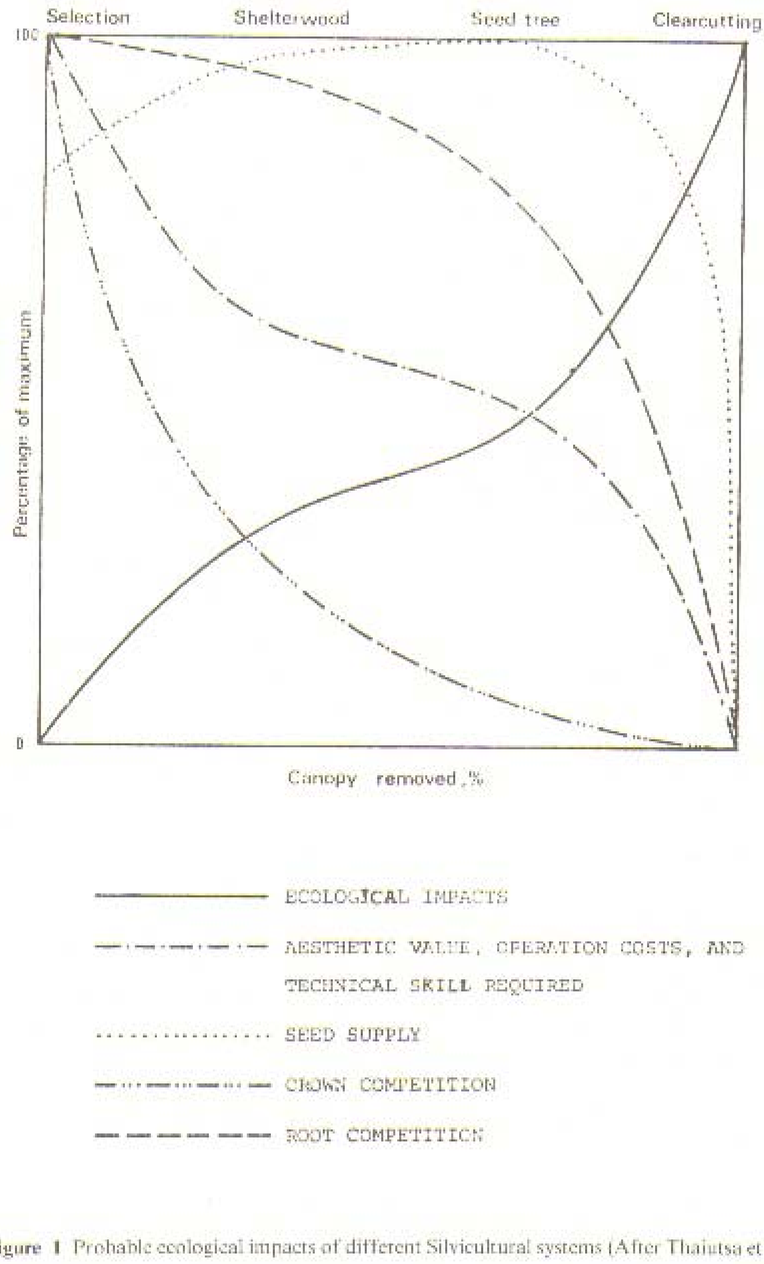

Figure 1 Probable ecological impacts of different Silvicultural systems (After Thaiutsa et.al. 1981)

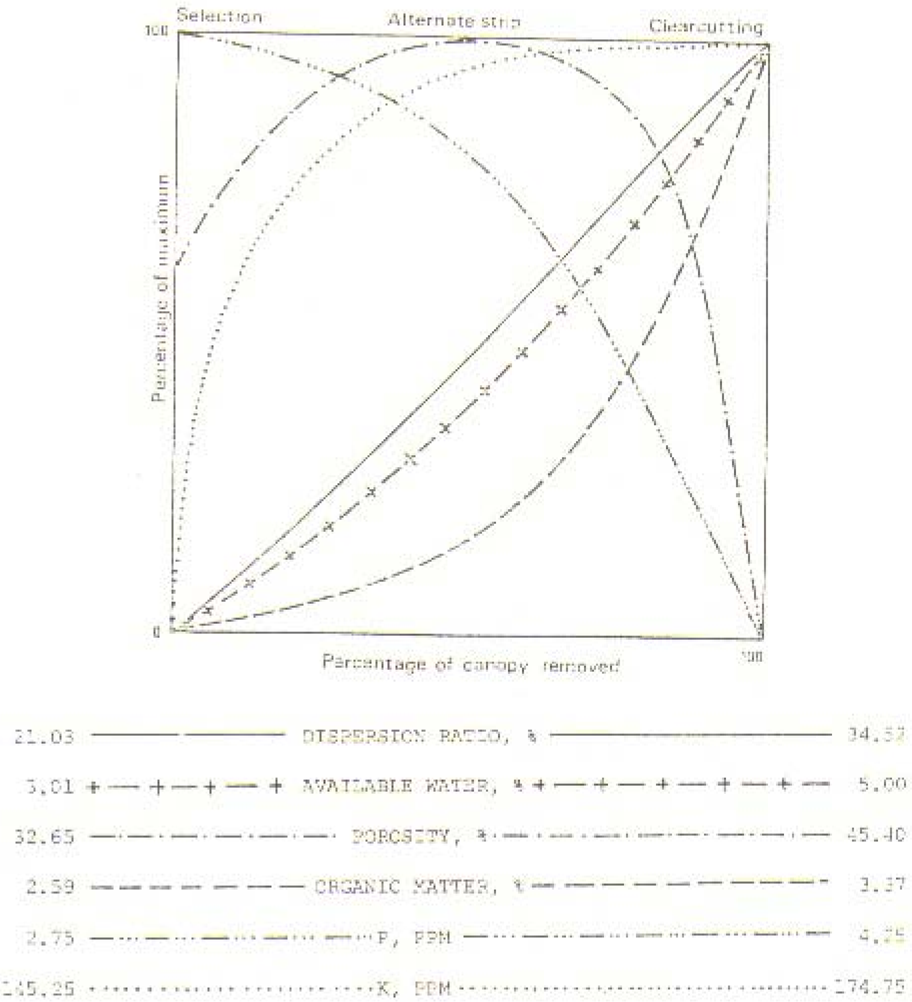

Figure 2. Impact of 3 different silvicultural systems on soil properties observed in natural teak forest. (After Thaiutsa et. al. 1981)

Table 1. Annual soil and water losses plots with different land use in the Phu Wiang Watershed

Treatment	(1988) Rainfall 1156 mm			(1989) Rainfall 785 mm		
	Soil Loss	Runoff		Soil Loss	Runoff	
	(ton/ha)	(mm)	% Rain	(ton/ha)	(mm)	% Rain
1. Bare soil	74.2	378	32.7	29.6	294	37.5
2. Cassava	13.4	365	31.6	14.9	204	26.0
3. Peanut	23.9	363	31.4	27.4	260	33.1
4. Cassava-Euc-4×4	7.4	357	30.9	16.1	234	29.8
5. Peanut-Euc-4×4	13.7	373	32.3	14.4	213	27.1
6. Cassava-Euc-2×8	14.1	378	32.7	13.9	251	32.0
7. Peanut-Euc-2×8	22.5	433	37.5	15.4	266	33.9
8. Cassava-Leu-4×4	18.3	309	26.7	10.1	200	25.5
9. Peanut-Leu-4×4	24.8	426	36.8	17.1	276	35.1
10. Cassava-Leu-2×8	16.9	425	36.7	14.7	216	27.5
11. Peanut-Leu-2×8	29.4	464	40.1	18.8	260	33.1
12. Euc-4×4	1.3	137	11.8	1.4	51	6.5
13. Leu-4×4	2.0	79	6.8	0.6	36	4.6
14. Euc-2×8	0.4	78	6.7	0.8	61	7.8
15. Leu-2×8	2.6	168	14.53	3.1	80	10.2

Source : Modified from Vannaprasert and Tongmee (1989)

erosion compared to that of natural forest. (Preechapanya, 1984).

In northeastern region, Takahashi *et al* (1983) investigated that soil erosion occuring on bare soil of 27 percent slope was about 13 to 15 times greater than that observed from the nearby dry evergreen forest. Agroforestry systems combining two different tree species (*Eucalyptus camaldulensis* and *Leucaena leucocephala*) and two different spacings (2×8 and 4×4 metres) on 8-10% sloping land at Phu Wiang Watershed, Khon Kaen produced interesting results of soil and water losses as shown in Table 1. It was concluded by Vannaprasert and Tongmee (1989) that soil and water losses from Eucalyptus plantation was less than that from Leacaena but insignificantly different although plantation with 2×8m spacing showed greater amount of soil and water losses. Among agroforestry systems, combination of peanut with tree species lost more soil and water than that with cassava and again in 2×8m spacing than in 4×4m spacing. Combination between eucalyptus and crops, however, caused less soil erosion than that between leucaena and crops but almost equally loss of surface runoff.

When comparing 4 main combinations, i.e., reforestation, agricultural crop, agroforestry and bare land as control, there was no significant different in soil and water losses among agroforestry systems and monocrop cultivation but significant different in soil loss between reforestation area and other treatments. The minimum soil loss among treatments was found in reforested area (Table 2).

In western region, soil and water losses observed by runoff plots at Mae Khlong Watershed Research Station indicated quite low erosion rate (1 ton/ha/yr) with surface runoff less than 10 mm/yr in Dry Dipterocarp, Bamboo forest and in agro-forestry systems

Table 2. Average soil loss and runoff on plots among forest plantation cash crop, agroforestry and bare soil in 1988 and 1989

Treatment	1988		1989	
	soil loss (ton/ha)	runoff (mm)	soil loss (ton/ha)	runoff (mm)
Forest plantation	1.59	115.5	1.48	57.2
Cash crop	18.64	363.8	21.11	232.0
Agroforestry	18.55	395.6	15.06	239.7
Bare soil	74.17	377.7	29.64	294.5

Source : Vannaprasert and Tongmee (1989)

Table 3. Soil erosion and water losses from various types of land use at Mae Klong Watershed Research Station, Kanchanaburi

Land use Type	Annual Rainfall (mm)	Overland Slope (%)	Soil Erosion Kg/ha/yr	Surface Runoff mm/yr	Period of Records, Ref
Dry Dipterocarp Forest	1644	30	140	9.6	(1978-1984) :
Bamboo Forest (rate)	1644	30	70	8.1	Saengkuvang and Rouysung
Reforestation					nern, 1985
- D. alatus + corn	1644	30	263	8.6	
- D. alatus + rice	1644	30	102	9.4	
Agricultural Practices :					
Corn + Lemongrass strip	1355	20	274	25.9	Only in 1984; Donsakul
Corn + Lemongrass + terrace	1355	20	205	23.4	et al, 1985
Natural condition + weeding	1355	20	930	55.0	
Conventional corn	1355	20	356	33.3	
Agro-forestry Systems :					
A. indica + cutton	1355		3,930	89.4	Only in 1984; in print from
P. javanica + corn	1355		3,863	86.5	Mae Klong WS. Res. Stat.,
E. camaldulensis + cutton	1355		3,393	128.9	Kanchanaburi
E. Camaldulensis + corn	1355		3,222	124.4	
L. Leucocephala + corn	1355		2,627	86.0	
P. javanica + rice + cutton	1355		2,009	71.2	

Notes : D. alatus = Dipterocarpus alatus
E. camaldulensis = Eucalytus camaldulensis
L. Leucocephala = Lucaena leucocephala

of *Dipterocarpus alatus* – corn and *D. alatus* – rice. However, agroforestry systems which combined cutton, corn and upland rice in *Azadirachata indica, E. camaldulensis* and *L. leucocephala* caused top soil to be eroded at about 4 ton/ha with surface flow almost 100 mm/yr or about 10 time greater than that agroforestry in the natural forest (Table 2)

Preliminary investigation of sedimentation caused by logging operation in the natural forest to Mae Khlong Watershed Research Station was shown in Table 3. First year logging operation and logging road construction in small watershed produced downstream sedimentation about 21 and 22 ton/sq.km/yr meanwhile only 8 to 14 tons/sq.km/yr was observed in natural mixed decidous with bamboo forest and 8 yr old plantation.

In southern region where rainfall amount is higher than the others, only 0.22 to 1.05 ton/ha/yr of top soil was eroded from 30-35%, sloping area of tropical moist forest. The 5-yr average soil erosion observed in terraced and unterraced rubber and other native tree species (e.g., *Parkia speciosa*, and *Intsia palembanica)* ranged from 2.87 to 6.68 ton/ha/yr. Soil loss of terraced plantation seems to be very low or none after 3 year of planting. (Thainougul *et al.* 1981.)

2.4 Biodiversity of Undisturbed and Disturbed Forests

Regarding biodiversity study in undisturbed and disturbed natural forest in Thailand, very few investigation are relevant. Arksornkoae *et al.* (1977) found that while the 10 yr fire protected natural hill-evergreen forest consists of 34 plant species. There were 35, 37 and 52 species in the 2-yr old, 4-yr old burned and 4-yr old shifting cultivated area respectively. The 10-yr old shifting cultivated area had 29 species. Index of similarity between 10-yr old shifting area and 10 yr fire protected natural forest is about 0.25 indicating quite slow succession. This implies that it needs a long period of time to reach the climax stage to be hill evergreen-forest. It was also found that the castanopsis which is the dominant species in the hill-evergreen forest was slightly occured in the 2- and 4-year burned area. But higher number was found in 4 and 10 yr-unburned areas. Soil erosion occuring in these four sites observed by runoff plots showed the lowest amount in 4-yr old burned area (119 kg/ha) followed by 10-yr-unburned (125 kg/ha), 4-yr unburned (129 kg/ha) and 2-yr-old burned area (778 kg/ha) the maximum one. *Imperata cylindrica* (grass) played a vital role in protecting soil erosion in this shifting cultivated area.

SELECTION VS CLEARCUTTING : THE ENVIRONMENTAL IMPACT ASPECT

3.1 Brief Background on the Application of Selection Cutting System in Thailand

According to Korvanich (1980), selection cutting system has been applied in the natural forest of Thailand since 1896, i.e., almost a century ago. Before this, this system was employed in timber harvesting in natural

Table 4. Sediment transportation from natural forest and managed forested watershed of Mae Klong Watershed Research Station, Kanchanabruti[1/]

Watershed Treatment	Drainage Area, sq.km	Annual Flow[2/]	Annual Sediment Yield ton/sq.km/yr	Period of Record
- Mixed Deciduous mixed with Baboo Forest	0.63	-	8.28469	1987-88
- 8-yr old Plantation with Natural Forest	0.56	-	14.31722	
- Logging Road Construction	0.19	-	21.86552	
- First Year Logging Operation	0.13	-	21.06504	

Souces : [1/] Data in preparing for publication : Mae Klong Watershed Res. Stat. (1989)
[2/] In computing by the metioned Research Station.

forest of India and Burma by Sir Brandis, the British Forester. It was accepted to be the suitable method for that particular places and time because there were numerous of mature and unproductive trees in those forests in which they should be harvested for uitilzation and, at the sametime, to open the space for the smaller trees to increase their growth.

Since the population in Thailand at that time was so small and the need of land for farming and living was not much, selection cutting seemed to be well applicable to those natural forests. Furthermore, the timbers were selected strictly according to rule and regulation, the natural forest was thus kept in good condition along those periods of time. Only the past two decades when the rural social condition has been changed due to increasing population and extra needs for better quality of life. People needed more land for their survival meanwhile the selection system was employed wrongly for solving the higher cost of living by both the government officials and the concessionaires. Good seed-trees had been exploited and left only those worse quality mother trees without thinking of the principles of natural regeneration. This led to the worse and worse condition of the existed natural forests to continuously keep their regeneration. The nearby farmers also took a chance using the logging roads to access into those exploited forests and settled their. They gradually utilized those forest lands for farming by slash and burn just for balancing their cost of living but finally took over as their permanent ownerships. This is why there are recently several patches of disturbed and unproductive natural forests in all regions of the country. This situation seems to be very difficult to control and becomes more and more serious problem to the government.

3.2 Why Clearcutting System is Needed?

Although the decision made for selecting the selection cutting system was primarily based on the facts as previousely mentioned together with the assumption that it would cause little disturbance to ecological and environmental conditions, and meanwhile, forests themselves could naturally regenerate in nearly close to original condition, the consequent situation was not what we expected. The existing forest areas, historical rate of forest destruction and the continuous invasion of people after the forest has been exploited were the evidences indicating the failure of selection cutting system in Thailand in all aspects. Commercial species and the whole ecosystems have been lost before the next management plans have been developed and implemented. More importantly and less popularly known, the environmental transformations in tropical region have rarely been successful for people's quality of life. Nevertheless, environmental transformation-typically from abundant virgin-forest to agricultural crops using slash and burn techniques and then back to unproductive secondary forest is a trully serious problem. Interactions among socio-cultural system, economic system and the ecosystem have usually been mutually destructive.

It was then agree among many foresters and the high authority-decision makers that selection cutting system that have been continuously operated for many years should be abolished, and clearcutting system with artifical reforestation should be introduced. It is, thus, a main purpose of this section to discuss in more detail about the applicability of clearcutting in each type of forests in Thailand.

In order to obtain the conclusions

and to formulate practical criteria for determining clearcutting applicability, the environmental and ecological impacts in terms of soil deterioration, divegence of microclimate, alteration in hydro-ecological balance, losses of flora and fauna and the changes in socio-economic, that could probably occur during and after operation were reviewed from various sources of information. Because this report is requested as a summary, only qualitative impacts can be briefly mentioned herein. Applicability of the system was mainly evaluated basing on degree of those observed and/or simulated impacts, economic returns and the real situation forcing from socio-political pressures.

3.3 Concluding Remarks on the Possible Impacts and System Applicability

Much of the information on the ecological and environmental impacts were drawn from papers presented in the seminar edited by Tangtham (1981). Many ideas dealing with the proposed criteria and recommendations were accumulated through discussions among numerous people participated in the Seminar. Conclusions can be briefly summarized as follows:-

3.3.1 Dry-Dipterocarp Forest

Theoretically speaking, clearcutting method seems not to be applicable to dry-dipterocarp forest. Soil erosion and loss of nutrients by leaching could be the most serious impacts during and following logging operation. Imblance of hydro-ecological phenomena was another consequence. Clearcutting with artificial reforestation could be possibly done but economic returns would be low. Slow rate of regeneration and plant succession steming from the change of microclimate and soil deterioration seem to be the most serious consequences. The most applicable silvicultural method recommended for this type of forest should be, therefore, clearcutting with coppice since most species in this forest can easily sprout. Also, this method is assure to be more sustainable regeneration. However, those exotic evergreen-species which can resist dry climate and low fertility of soil such as *E. camaldulensis* should be tried as reforestation or enrichment planting.

3.3.2 Mixed Deciduous Without Teak

It could be mentioned that this type to forest has the highest rate of destruction due to its fertile soil as well as its gentle slope of bottom land. Its distribution is also another factor affecting the destruction rate. Large area of this type in the Pasak River Basin, for example, has been converted into agricultural crops which was so far created numerous flash floods along and downstream areas. Clearcutting method in large scale would, in some degree, cause the hydro-ecological-balance to be altered. Streamflow would increase due to decreasing in evapotranspiration but flow timing would be shortened as well as water qualities would be degraded. Some flora and fauna would be disappeared or decreased since their habitats were suddently changed. These mentioned impacts except the lost of flora and fauna, however, would substantially recovery because of rapid rate of plant succession supported by tropical monsoon.

From the silviculture point of view, it could be possible that clearcutting method is appropriate for mixed deciduous with teak but the size and topographic position must be partly taken into consideration. Clear-cutting system should be banned for this forest type located at ridge top and on the head-watershed areas. In gentle sloping areas where clearcutting could be applied, small-discontinous patches are recommended so that environmental impacts could be mitigated as well as to maintain its regeneration.

3.3.3 Mixed Deciduous With Teak

The revision of impact studies implied that clearcutting method with coppice system could be applicable to undisturbed natural mixed deciduous with teak. In areas where natural regeneration was poor, clearcutting with artificial reforestation could be more appropriate. However, it should be avoided for the forest occupying on upland and hillslope of the head watershed. Fire protection must be seriously taken in action, at least one year before and after timber harvesting, in order to promote natural regeneration and plant succession.

It might be possible that clearcutting could help promote more rapid succession of legume which is usually very abundant in this types of forest. If it is true, this would be an advantage of clearcutting system in the mixed deciduous with teak. Because soil condition could be substantially improved by ways of nitrogen fixing and litter decomposition. This belief, however, needed to be studied in more details.

3.3.4 Tropical Rain Forest

Previous works on the impacts of clearcutting on ecological and environmental conditions indicated that soil erosion and nutrient losses seemed to be the serious problems that could occur during and following timber harvesting due to high intensity and amount of rainfall. Degree of another forms of impact depends upon topographic position and the steepness of slope. Result of clearcutting system in Malaysia indicated insignificant change of flow quantity and timing due to longer period of rainy season. Clearcutting also help promote light demander trees to rapidly cover the ground which later increase efficiency of soil erosion control. However, some wildlife species could be extincted or migrated as well as the decrease of soil fauna. Based on the problem faced when selection cutting was employed, clear-cutting system seems to be better applicable. Reforestation, however, must be immediately initiated following logging operation. Recommended species should be those which naturally grown in this type of forest, i.e., *Dipterocarpus* spp., *Hopea* spp. Some fast-growing species such as *Leacana leucocephala*, *Eucallyptus camadulensis* etc., could be introduced, but environmental impacts for this region should be carefully checked.

3.3.5 Dry-Evergreen Forest

Results of previous investigation indicated that there could have tremendous ecological and environmental impact following clearcutting operation in the dry-evergreen forest. However, considering the failure of selection cutting system which has been used for almost a century, and the rapid decreasing dry-evergreen forest area due to increasing population and political pressure, it seems to be unavoidable that clearcutting method is urgently needed. It was recommended that small plot of 650-2,000 rai (625 rai = 1 ha) be suitable for mitigating ecosystem impairment. At the same time, reforestation of native species and other fast-growing species must be followed immediately after logging operation so that cleared areas could be saved from people invasion.

3.3.6 Hill-Evergreen Forest

It has been known that most of hill-evergreen forest occupies on the high-elevational mountainous lands where its catchment drains water through the central plain of Thailand by four main tributaries namely : Ping, Wang, Yom and Nan. Research on highland watershed management revealed that the dense undisturbed hill-evergreen forest can supply water regularly to the streams not less than 50 percent of total annual rainfall or about 1.3 MCM/sq.km. The physiographic features of those mountainous areas also indicated that environmental mainpulation, such as marked reduction of vegetative cover or severe disturbance of soil surface condition, would lead not only to greatly increase movement of surface and lateral flow, but also accelerated of soil and nutrient losses. In addition, benefit cost ratio analysis showed that very small was usually obtained. This is because there are few good quality commercial timbers. Logging operation is also costly due to rugged terrain and need high technology of road construction to reduce soil erosion.

From the standpoint of watershed managment and silvicultural consideration, clearcutting method should be banned from this type of forest. Morover, it should be preserved permanently as the protective areas, since it seems to be the only proper form of land use for the steep mountainous regions to keep the desirable hydro-ecological balance and the stability of their environmental conditions.

3.3.7 Pine Forest

Silvicultural and environmental impact consideration indicated that timber harvesting in the pine forest in Thailand by clearcutting method is possible for those having pure stand composition. But it must be done with highly cautiuos due to mainly occupy on the hill slopes and ridge-tops. Alternative strip clearcutting technique was recommended for large area of pure stands. Group clearcutting was considered to be more suitable for the discontinuous stands situated on mountainous lands.

The mentioned recommendation, however, was made according to silvicultural theories and the consequence of environmental disturbance. In practice there would be some problems since most of pine forests in Thailand are not pure stand. If the clearcutting method is permitted, other species consisting of about 60 percent of total timber must be harvested. The regulation for this type of forest, therefore, should take this issues into consideration.

3.3.8 Mangrove Forest

Since 1968, a system called clear felling in alternative strips has been introduced to the mangrove forest throughout the country. The impacts of two cutting methods-strip clearing and strip system with seed trees on vegetation and soil characteristics were reported. There were on significant difference in plant species, density, diversity, and natural regeneration following timber harvesting among the systems. A minor exception was true for seedling diversity and density of new crops. It can be, therefore, said that clearcutting method with alternative is suitably applicable for mangrove forest. Studies on impacts of the system and mining operation in this forest type as well as in upland watershed are very few and should be urgently carried out.

3.4 Criteria for Determining Clearcutting Applicability

Proposed criteria presented here were made through discussion with numerous participated in the class of seminar organized by Department of Conservation and Department of Silviculture in 1981. There must be, of course, some different ideas from other foresters and environmentalist. Comments on the previous conclusion and the following criteria, therefore, are definitely needed.

The following are criteria that one should consider before making a decision in applying clearcutting method in any type of forest in Thailand:-

1. Productive forest areas and protective forest areas must be clearly separated according to its topographic position and its function in protecting and maintaining ecosystem. There will be no any timber harvesting in those area classified as protective forest. This criterion has been applied in classifying the forest in watershed areas into WSC1 (Protection forest) and WSC2 (Commercial forest).

2. For those areas classified as productive or commercial forest, decision on clearcutting applicability should be made on the bases of:

1) Unique characteristic of some forest type especially dry-evergreen forest which may be absolutely transformed by clearcutting system.

2) Socio-economic needs and political pressures.

3) Tools and machines for harvesting and logging operation including labors.

4) Environmental and ecological impacts.

5) Existing real-life situation, e.g., needs of land for farming and the nation's stability.

3.5 Size of Clearcutting Area

An area of 650-2,000 rai has been applied for clearcutting with artificial regeneration in many types of forest by the Forest Industrial Organization. The size, however, designated basing on facilities and labors available. It was seldom be based on ecological and environmental impacts. It was not recommended as an optimal size yet. The standard size, however, must be different among forest types, topographic positions and economic factors. There are still much argument among academic people and those working in the governmental agencies and other organizations. It was, as this moment, recommended that experiments on appropriate size for clearcutting in each type of forest be ugently carried out so that it can be practically applied throughout the country.

PROBABLE IMPACTS OF REFORESTATION AND AGROFORESTRY SYSTEMS ON ECOLOGICAL AND ENVIRONMENTAL CONDITION

4.1 General Information on Environmental Impacts

Rencelty a controversy has grown among watershed scientists, foresters, policy makers and even farmers on the adverse effects of reforestation with fast growing exotic species, such as Eucalyptus, on soil fertility and soil moisture regime. Eucalyptus species which are recently popular for watershed rehabilitation and as commercial tree in the north and in the northeast have been blamed as an evil that causes soil deterioration and water shortage.

Regarding environmental consequences of planting Eucalyptus, five main conclusions were recently made by Florence (1986):

1) The remarkably wide range of genetic material in Eucalyptus has not been edequately trapped in species introduction programs.

2) With careful husbandry, Eucalyptus is capable of producing wood at a lower nutrient cost than many other fast-growing tree species.

3) Some observed effects of Eucalyptus on the soil condition might be attributed to strong competition for water and nutrients rather than to a direct toxic influence on the soil.

4) Where trees replace grasslands or a low natural vegetation, a reduction in water yield from the catchment should be expected; where Eucalyptus are planted,

high rates of wood production will be matched by high rates of water uses, but whether the water use efficiency declines to any appreciable degree under some environmental conditions cannot be determined from the available evidence.

5) In drier regions, particularly, it may be necessary to determine the eucalypt species and patterns of land use which will best meet the objectives of land management and avoid undue social conflict.

4.2 Environmental Impact Investigation in Thailand

In Thailand, researchers of the Thailand Institute of Scientific and Technological Research (TISTR) (Ungvichian et al, 1986) concluded as follows:

(1) Compared with other broad-leaf and dense canopy trees, atmospheric humidity is lower and temperature higher in Eucalypt plantations. But compared with bare soil or idle land, eucalypts improve the microclimate.

(2) Eucalypt plantations are less efficient in soil erosion control on sloping land. This can be alleviated by making terraces, but this s more costly.

(3) As a fast-growing tree, it consumes much more water than most other species to produce biomass. The rate of water consumption of eucalypt reaches a peak at 4-6 years' age. At this stage it can create water shortage conditions to the area where soil moisture is so limited and consequently competes for water use with nearby species.

(4) Loss of plant nutrients in eucalypt plantations could be more or less the same as in plantations of other species that have the same harvesting techniques. Nutrient loss might be greater if all parts of the tree are removed from the area and no fertilizer is returned to the soil.

(5) It was supported that toxics from eucalypt leaves can stunt other vegetation nearby, especially in areas of low rainfall due to inadequate water to wash out the toxic.

(6) As tree component in an agroforestry system, it would allow intercropping possibly only one to two years. After this period, production of the intercrop will be strongly reduced and uneconomical. This situation could be happening to any agroforestry system having fast-growing trees in combination, but the case of eucalyptus seem to be less suitable. The reason for this is that the rate or organic matter and plant nutrients returning to the soil are less and decompose slower than for leguminous species.

In contrast to the conclusion summarized by TISTR, Suvanaphinantha (1984), who studied recent Thai and other countries' researches dealing with the possible impacts of *Eucalyptus*, especially *E. camaldulensis*, on soil, water and hydrology, forest fire, allelopathy, and weed hazard, concluded that the beneficial effects of planting *E. camaldulensis* in Thailand, particularly on deteriorated or problem soils, overweight the possible adverse effects. There are no grounds for believing that it is a site deteriorator. Suitable provenances of *E. camaldulensis* can be planted in Thailand without fear or site deterioration.

Regarding plant nutrient consumption, although Eucalyptus can uptake as much as that absorbed by agricultural crops such as corn and cassava, it can produce more biomass than other tree species (such as *Leucaena leucocephala, Acacia auriculaeformis* and *Peltophorum pterocarpum)* with the same amount of nutrient (Petmark, 1989).

4.3 Concluding Remarks on Eucalyptus Reforestation

A comprehensive discussion on the problems and considerations dealing with Eucalyptus species in Thailand can be found in Sono (1986). The concluding remarks are more or less the same as those stated by Suvanphinantha (1984).

Taking the effect of eucalypt plantations on water consumption into consideration, even though most of water uptake by eucalypts is for producing biomass and transpiration, it seems eucalyptus use more water than the other fast-growing species. Also a strong competition for nutrients might be attributed to eucalypts. If this behavior is true for Thailand condition, it might be then worse for the Northeast where soil is usually shallow and low in fertility and water is normally short in supply during the dry season.

Meanwhile, other fast-growing species, such as leguminous trees combined with some cash crops which can improve soil fertility and moisture storage, might be considered as more suitable in terms of water yield contribution. Decision making on planting eucalyptus as agroforestry system or for reforestation in the North and Northeast should be therefore based not only on the social popularity and economic return but also on environmental degradation. This could be supported by a conclusion made by Poore and Fries (1985) that eucalyptus should not be planted, especially on a large scale, without a careful and intelligent assessement of the social and economic consequences, and an attempt to balance advantages against disadvantages.

In case of ecology, this will be assisted by an understanding of the results of the fundamental research on water, nutrients, etc. It was also suggested by Poore and Fries (1985) that short-term ad hoc research on a particular site may be of some help in making local decisions, but the results of such research must not be extrapolated to other different circumstances nor must unwarranted generalizations be made from it.

CONCLUSION

The quantitative evidence of environmental impact of natural forest management either in forms of timber harvesting method or reforestation in Thailand is rather few because less attention has been given since the selection cutting and reforestation has been intiated. Only descriptive and semi-quantitative impacts were discussed in some currently available information. In general, timber harvasting by any silvicultural systems ever used in Thailand produced less environmental impacts in terms of soil and water deterioration than those caused by agronomic practices such as corn, cassava and upland rice especially on the mountainous areas. Less than 0.5 ton/ha of sediment was found in first year logging operation area in western region of the country. Converting moist evergreen forest in the south into para-rubber plantation, which is equivalent to reforestation after clearcutting, indicated only 7 ton/ha/yr of soil loss under normal rainfall condition. Clearcutting system at optimal size is thus expected to be applicable for maintaining ecological and environmental deterioration in some forest types. Forest on the ridgetops and bottom land along the streams should be, however, kept as buffer zone or could be selectively harvested with high caution. From the ecological and environmental impacts point of view, reforestation either by native or exotic species in those deforested and/or clearcut areas should be put in high priority of forest policy implementation. As matter of fact, those areas which were classificed as watershed class 1 and 2, which were recommended for forest management purpose, could be employed as the starting point to implement. Based on the past situation, however, it is not a matter of environmental consequences of timber harvesting or reforestation technique to judge whether the forest can be sustainable managed but the socio-political presures, which sofar receieved less intention to resolve by the government, will be a big constraint for forest management in Thailand. Unless the Thai people could realize the essential role of forest on their survival both in terms of environment and stability of their ways of life, a little hope could be possibly seen for the ideal sustainable management of natural or even artificial forests in this country.

REFERENCES

Aksornkoae, S., S. Boonyawat and P. Dhamanondha. 1977 Plant succession in relation to sediment in different area after shifting cultivation at Doi Pui, Chiangmai. Kog-Ma Watershed Res. Bul., No. 31, Faculty of Forestry, Kasetsart University, Bangkok (in Thai with English summary).

Donsakul, K.,P., Saengkuvong and S. Rouysungnern. 1985. Sediment yields and surface runoff form agricultural areas at Mae Klong Watershed Res. Sta., Karnchanaburi. Res. Pap. No 6, Div. of Watershed Management, RFD (in Thai).

Florence, R.G. 1986. Cultural problems of eucalyptus exotics. Commonw. For. Rev. 65 (2), pp. 141-163.

Hurni, H. 1982. Soil erosion in Huai Tung Chao-Northern Thailand: Concerns and Constraints. Mountain Research and Development 2 (2) : 141-156.

Inthapand, P. and S. Boonchee. 1990. The study of conservation cropping systems on the highland of Northern Thailand. Paper presented in the Seminar on Farming Systems for Soil and Water Conservation on the Highland of Northern Thailand. DLD-TGHD, Chiang Mai. (in Thai)

Korvanich, A. 1980. Consideration on Forestry in Thailand. Paper presented on the Occasion of 84 YR. Anniversary of the Royal Forest Department. (in Thai)

Naprakob, B., P. Larbudomlert and T. Wachirajutipong. 1976. Sediment from shifting cultivated areas at Doi Chaing Dao Watershed Experiment Station. Chiang Mai. Paper presented in 1976 Annual National Forestry Seminar, RFD, pp. 109-118 (in Thai)

Petmark, P. Some ecological effect of eucalyptus plantation in agricultural area. Division of Silviculture, Royal Forest Department (in Thai)

Poore, M.E.D and C. Fries. 1985. The ecological effects of eucalyptus. FAO Forestry Paper 59. FAO, Rome, 87 pp.

Preechapanya, P., 1984. Soil and water losses from agroforestry systems: A case study of coffee plantation in hill-evergreen forest at Doi Pui, Chiang Mai, M.S. Thesis, Kasetsart University (in Thai with English abstract).

Reynolds, E.R.C. and P.J. Wood. 1977. Natural versus man-made forests as buffers against environmental deterioration. Forest Ecol. 1 : 83-96.

Ruangpanit, N. 1971. Effect of crown cover density of Hill-evergreen forest on soil and water loses. Kog-Ma Res. Bull. No. 7, Fac of Forestry, Kasetsart Unive., 25 p.

Saengkuvong, P. and S. Rouysungnern. 1985. Sediment yield and surface runoff from sample plots of various land uses at Mae Khlong Watershed Research

Stat., Res. Pa. No. 4, Res. Sec., Div. of Watershed Management, RFD (in Thai)

Sono, P. 1986 Problems and consideration concerning Eucalyptus in Thailand. Office of Private Reforestation and Extension, RFD, Ministry of Agriculture and Cooperatives, 75 pp. (in Thai)

Suebsaen, N. and C. Aneeksamphant. 1990. A Study on effect of land and crop management of steepland erosion. Paper presented in the Seminar on Farming Systems for Soil and Water Conservation of the Highlands of Northern Thailand. DLD-TGHD, Chiang Mai. (in Thai)

Sukwong, S., V. Charoenphaiboon, B. Thaiutsa, T. Kaewlaid and W. Suvanapinant. 1976. Natural regeneration of teak forest after clear cutting. Kasetsart J. No. 9. Kasetsart Univ., pp. 55-67. (in Thai)

Suvanaphinanth, W. 1984. Possible impacts of **Eucaluptus camaldulensis** Dehnn. on sites. Tech. Pap. No. 55, Dept. of Silviculture, Fac. of Forestry, Kasetsart Univ., Bangkok, 21 pp. (in Thai with English Abstract)

Takahashi, T., K. Nogahori, C. Mangkolsawat and M. Losirikul. 1983. Runoff and soil loss. In: SHIFTING CULTIVATION - An Experiment at Nam phrom, Northeastern Thailand, and Its Implication for Upland Farming in the Monsoon Tropics (Chapt. 5). Ed. K. Kyuma and C. Pairintra, Tokyo Univ. of Agric., pp. 84-109.

Tangtham, N. (editor) 1981. Probable Ecological and Environmental Impact of Clearcutting System in Various Types of Forest in Thailand. Watershed Monograph. Dept. of Cons., Fac. of Forestry, Kasetsart Univ., Bangkok (in Thai with English summary)

Thainoogul, W. and Other 13 Authors. 1981. A comparative study of soil erosion effected by rubber and other plant covers. Progressive Report for 1981 : No.. 20-09-09-04-20-02. Agricultural Technical Dept, Ministry of Agriculture and Cooperatives, 25 pp. (in Thai)

Thaiutsa, B., W. Suvanapinant, W. Gatepraneed and S. Sukwong. 1976. Effect of silvicultural system application on soil properties in teak forest. Forest Res. Bul No. 39. Fac. of Forestry, Kasetsart Univ., 28 p. (in Thai)

Thaiutsa, B. 1981. Consideration in selecting silvicultural system. In : Probable Ecological and Environmental Impacts of Clearcutting System in Various Types of Forest in Thailand. Watershed Monograph No. 3 (Ed. Nipon Tangtham) Dept. of Con., Fac. of Forestry, Kasetsart Univ., pp. 1-1 to 1-14. (in thai)

Ungvichian, I., K. Yantasartra, P. Boomklinkhoson and P. Buranasilapin. 1986. Problems and effects of eucalyptus on environment. Div. of Agric. Industry, Inst. of Science and Technology Research of Thailand, Bangkok, 12 pp. (in Thai)

Vannaprasert, M. and U. Tongmee. 1989. Soil and water losses on plots with different land uses in the Phu Wiang Watershed. Integrated Development of the Phu Wiang Watershed Project, Khon Kaen. (in Thai)