CHAPTER IV

RESULTS AND DISCUSSION

4.1 Data inputs and model analysis

4.1.1 Land uses

Data on land uses in KKCNP was supported from Department of Land Development, the Royal Thai Survey Department, and the Royal Forest Department of Thailand. Historical maps with scales varying from 1:25000 and 1:50000, and historical works (RFD, 1994) were verified and discussed. Total area of 291,500 hectares (*Tot_area=291500*) has been classified into two types: disturbed and undisturbed sites, according to land-use management. Disturbed area covers approximately 14,500 hectares (*distb_area=14500*). This is believed to be caused from heavy forest concession and slash-and-burn cultivation by indigenous people live around and inside the boundary since the establishment of the park (RFD, 1994). Despite trying to move all of them out, but the rests still settle inside. A strategy to compromise is allowing people to live inside but they are required to remove to the new resettlement sites. This agreement can perceptibly reduce conflicts between forest managers and local people. Once, the resettlement zones are established, the sites cover approximately 4,000 hectares (27.58%) of all disturbed area. Inside resettlement zones, cultivation area of each household is defended. Cultivation area is classified as apart of disturbed sites, where cover roughly 10,500 hectares (72.42%). Undisturbed site or forest area covers roughly 277,000 hectares (95%) of the whole park area. Total forest area includes all types of forest ecosystems and forestland returned by reforestation process (Eqn. 1). Details of land uses in KKCNP are explained Table 4.1

$$forest\ area=Tot\_area-disturbed\_area+refores\_area \qquad \text{(Eqn. 1)}$$

Table 4.1 Details of land uses in KKCNP, classified as disturbed and undisturbed sites in Kaeng Krachan National Park.

Unit of measurement	Total park area	Undisturbed area	Disturbed area
square kilometer (sq. km)	2,915	2,770	145
square meter (sq. m)	$2.92x10^9$	$2.77x10^9$	$1.45x10^8$
hectare (ha)	$2.92x10^5$	277,000	14,500
rai	$1.82x10^6$	1,731,250	90,625
Percentage	100.00	95.03	4.97

4.1.2 Forest and tree distribution

Systematic Sampling Method following Krebs (1989) and Pielou (1995) was employed for sampling plot construction. Thirty temporary sampling plots were totally established. Fifteen temporary circular plots with radius of 15 m were constructed. Fifteen 1X1 m^2 plots were temporarily constructed inside of each circular plot. Data on tree and saplings and seedlings were collected. Details of study site and sampling plot sizes are shown in Table 4.2.

An average sampling plot area was approximately 706.85 square meters. Trees in each sampling plot were classified in five size-classes following their DBH sizes. Seedlings and saplings were excluded because of DBH size was less than 4.50 centimeters. However, they were incorporated as initial recruitment numbers at the beginning stage. Tree numbers and tree density of each size-classes were estimated.

Table 4.2 Details of park area and sampling plot size.

Unit of measurement	Total park area	Average sampling plot area	Total sampling plot area
square kilometer (sq. km)	2.92×10^{3}	7.07×10^{-4}	1.06×10^{-2}
square meter (sq. m)	2.92×10^{9}	7.07×10^{2}	1.06×10^{4}
hectare (ha)	2.92×10^{5}	7.07×10^{-2}	1.06
rai	1.82×10^{6}	4.42×10^{3}	6.63×10^{4}
Plot radius (m)		15	
Sampling plot number		30	
Remark		1 hectare = 6.25 rai	

Average tree density (Eqn. 2), total tree numbers (Eqn. 3) and forest state (Eqn. 4) were also estimated. Tree heights and aboveground biomass were estimated by application of DBH value to regression equations developed by Ogawa et al. (1965). Seedlings and saplings were also counted and set as initial input numbers at the beginning stage of tree growth.

tree numbers=zclass1+zclass2+zclass3+zclass4+zclass5 (Eqn. 2)

total tree density=(if tree_numbers>=tmax then tmax else tree_numbers) (Eqn. 3)

F_state=st1+st2+st3+str4+st5 (Eqn. 4)

The results showed that 1,015 tree individuals were totally recorded. Average tree density was approximately 957 Ind./ha and the highest tree density was in the first size-class (337 Ind./ha). The results suggested that tree density reduced while DBH size increased. Saplings and seedlings were extremely found in all sampling plots, approximately estimated 140,000 Ind./ha. Previous researches about forest biodiversity, forest structures and compositions conducted in several forest types in Thailand were reported (Boontawee, Plengklai, and Kao-sa-ard, 1995; Srikanha and Gajaseni, 2000). Unfortunately, official reports on tree characteristics in evergreen forests in Kaeng Krachan are absent except estimated tree density in moist and dry evergreen forest (RFD, 1994). This may be quarreled to specific types of model construction if specific issues on forest management are lead because lacking of historical data to compare. However, this prototype model was not attended to that of some specific cases. Based on the model objectives and available information, we compared our data with previous studies in evergreen forests by Visaratana (1983) and Vannaprasert (1985).

We found that, in general, average tree density in evergreen forests in Kaeng Krachan was higher than that of Visaratana (1983) and Vannaprasert (1985) studied in Sakerat research station and in Doi Pui, respectively. Surprising that this tree density is closely related to average tree numbers found in Tropical rain forest study by Kiratiprayoon (1986). However, when compared our results with previous observe by RFD (1994), average tree density in this study was more close to tree density in dry evergreen forest than in moist evergreen forest. Unfortunately, there were no records of saplings and seedlings in the previous researches mentioned above. Then numbers of seedlings and saplings at the beginning state were estimated roughly from our available data collected in field. Tree characteristics and relative tree density in KKCNP are described in Table 4.3.

Table 4.3 Total tree density classified by DBH size

Size-class	DBH (cm)	Total tree numbers (Ind.)	Average tree numbers (Ind./plot)	Tree density (Ind./ha)
0	< 4.5	Seedlings and saplings		140,000
1	4.5 - 10.0	357	24	337
2	10.1 - 20.0	341	23	322
3	20.1 - 40.0	169	11	159
4	40.1 - 60.0	84	6	79
5	> 60.0	64	4	60
Total		1,015	68	957

Another important factor determining forest characteristics was tree growth. Survival and mortality rates of trees in previous size-class can determine tree density of the adjacent one. Higher survival rate reasonably indicates higher tree numbers in the next size-class. The results indicated only 0.24 per cent of seedlings were transferred to be saplings in the first size-class. The highest survival rate (95.5 %) occurred in the first size-class ($4.50 \leq$ DBH ≤ 10.0 cm). Survival rates tend to decrease in trees groups with larger DBH size. Size-classes 2 and 3, survival rates were lower than 50 per cent (49.6% and 49.7%) then increased sharply in size-class 5 (76.2%). Trees with DBH > 60.0 cm showed rather high relative survival rate (80.0%). We used these values to construct the model and simulated it over the time span to estimate the possible tree density in the forest ecosystems in KKCNP. Table 4.4 depicts estimation of survival and mortality rates of trees in different size-classes.

Table 4.4 Survival and mortality rates of sampling trees in five size-classes.

Size-class	DBH (cm)	Tree density (Ind./ha)	Survival rate (%)	Mortality rate (%)
0	>4.5	140,000	0.24	99.76
1	4.5 – 10.0	337	95.5	4.5
2	10.1 – 20.0	322	49.6	50.4
3	20.1 - 40.0	159	49.7	50.3
4	40.1 - 60.0	79	76.2	23.8
5	> 60.0	60	80.0	20.0

Result of aboveground biomass is summarized in Table 4.5. Trees with DBH larger than 60.0 cm generated highest value of aboveground biomass (210.9 ton/ha), even the average density was rather low (60 Ind./ha). While trees in the first size-class generated very low aboveground biomass (6.128 ton/ha). Total aboveground biomass was calculated at 356.52 ton/ha. In simulation, aboveground biomass of the forest is also estimated (Eqn. 5). However, in this study biomass of seedlings and sapling was excluded.

*f_biomass=356.52*tree_numbers* (Eqn. 5)

Table 4.5 Calculation of aboveground biomass of trees in five size-classes.

Size-class	DBH (cm)	Total biomass (ton)	Average biomass (ton/plot)	Average biomass (ton/ha)
0	< 4.5	Seedlings and saplings		N/A.
1	4.5 - 10.0	6.45	0.43	6.13
2	10.1 - 20.0	29.56	1.97	27.88
3	20.1 - 40.0	52.35	3.50	49.37
4	40.1 - 60.0	66.0	4.40	62.27
5	> 60.0	223.59	14.97	210.88
	Total	378.01	25.20	356.52

N/A. = Information not available

4.1.3 Reforestation

Reforestation is a part of forest management scheme of Kaeng Krachan. The operation is usually set aside, and not concerned as a main project in management. Strength of this operation largely depends on the amount of total budget allocated. Possibility to establish the program can change every budget year depends on how much money to be supported and importance of the program (Kasetsart University, 1987; RFD, 1994). The operation mainly manipulates by replantation of seedlings or by seed distribution. Fast growing species such as *Acacia auriculaeformis* Cunn., *Eucalyptus* sp., and *Gmelina arborea* Roxb. are usually selected (F/FRED, 1994; RFD, 1994; Hossain, 1999). Seeds of selected species will be randomly distributed along the roadside or in some heavy disturbed area (RFD, 1994). Even reforestation by these methods can return forest area in short times, but, in term of ecological relationships, they would create side effects to some endemic species (Hossain, 1999). In addition, in long term, alteration of forest compositions or increase degradation of soil components might occur. Unfortunately, information and records about reforestation management in this area were not revealed. Therefore, some fixed values of parameters and variables were presumed to enable running simulation. Reforestation was determined by estimating numbers of trees survived and size of forestland returned. We assumed that only 2% of small trees in the first size-class (approximately 7 Ind./ha/year) survived every year by reforestation process (Eqn. 6).

While forestland recovered was assumed by 2% and 1% returned by human operation and natural regenerating process, respectively (Eqn. 7). Then, possible forest area returned was estimated at about 435 ha/yr. This was assumed to be happened by chances and the values were fixed throughout the simulation. Results were discussed in term of changes of land-use size and numbers of tree survived. This study aims to construct a prototype management model in terrestrial national park, thus, investigation of side effects or impacts on endemic species due to reforestation is excluded.

*reforestration=0.02*zclass1* (Eqn. 6)

refores_area=(nat_r+refor_r)*disturbed_area (Eqn.7)

Restoration and logging and logging largely depend on the amount of budget allocation into the program, level of forest worker employment, and responsibility of forest officers. Possibility and level of success can be changed sequentially every budget year depends on how much amount of money to be supported. Generally, restoration management mainly concentrated on re-plantation of small trees (seedlings and saplings) with DBH<4.50 centimeters or distribution of seeds on ground. Seeds of faster growth species such as *Eucalyptus sp.* or *Acacia auriculaeformis* Cunn. will be randomly distributed along the roadside or in some heavy disturbed area.

Even the main purpose of the program is to returned the forest area but, in term of ecological relationship, those species planted were not native species. In long term, they would create side effects such as alteration of forest compositions or degradation of soil components. This research assumed that restoration management by human occurred only by replanted of saplings or seedlings only. Survival of trees in the first size-class was proportional total numbers of seedlings and saplings recruited at the first stage. However, there was no evidence to support this issue was found of this specific site. Therefore, it was assumed only 0.2 percents of total numbers of seedlings and saplings recruited in the beginning stage were restored by human via restoration process.

4.1.4 Illegal logging

Illegal logging becomes an important problem in KKCNP since the early stage of the park establishment. It is evidenced that this problem occurs throughout the country, especially in terrestrial national parks (IUCN, 1978 and 1979). The delay of accomplishment in forest protection in Kaeng Krachan is believed to be a result of unable to provide enough numbers of officers to control uses of forest resources (RFD, 1994). Budget constraint has long been concerned to be a major cause of unsuccessfulness (IUCN, 1994 and 1999). Like reforestation, less numbers of illegal logging were recorded separately in details because this program is usually set as a small part in a more important program. Information of work employment and budget supports is also covered. According to this, initial input values were mainly estimated from data collection and from paper sources.

Intensity of illegal logging was described relating to existing numbers of stumps per unit area. We observed numbers and sizes of stumps found in fifteen temporary sampling plots and classified into 4 size-classes: size-class 1: DBH $\leq$ 20.0 cm; size-class 2: 20.1 $<$ DBH $\leq$ 40.0 cm; size-class 3: 40.1$<$ DBH $\leq$ 60.0 cm; size-class 4: DBH $\geq$ 60.0 cm. The result showed that illegal logging in Kaeng Krachan often occurred in tree groups with large DBH size (41.2%). Less numbers of stumps were found in small tree groups (DBH $<$ 60.0 cm) (details in Table 4.6). The result indicated that large tree groups have higher chance to be destroyed (by illegal logging). This also suggested that, if forest manager want to increase capability of illegal-logging control, there would be more suitable to manipulate with large tree than in small tree groups.

Table 4.6 Average numbers and sizes of stumps per unit area.

Stump diameter (cm)	Total no. of stump (no.)	Percentage (%)	Average no. of stump (no./plot)	Stump density (no./ha)
< 20.0	2	11.8	0.1	2
20.1-40.0	5	29.4	0.3	5
40.1-60.0	3	17.6	0.2	3
>60.0	7	41.2	0.4	7
Total	17	100.0	1.0	17

The relationships between ability to control and degree of illegal logging were made based on the assumption that when capability of logging control decrease, intensity of illegal logging will increase. Since intensity of illegal logging around this area apparently relates with existing numbers of forest staffs in the park (RFD, 1994), increasing numbers of forest officers per unit area may probably slow down the problem. Information of forest staff and employment were supported from the RFD and Kaeng Krachan Headquarter. Existing numbers of forest officers are approximated at 100 persons (year 1994) distributed to 15 forest protection units around the park. Increasing numbers of forest staffs from 100 to 300 persons is planned to achieve in a five-year strategy (RFD, 1994). According to this, one officer requires to take care at least 1000 hectares of forest area. Therefore, maximum numbers of staffs required is estimated as total amount of the park area divided by amount of forest area taken care by one officer. Illegal logging index was calculated as the subtraction value of maximum logging rate ($lgr\_max = 1$) and proportion of existing and required numbers of staffs in the park (Eqn. 8). Illegal logging rate will be close to zero when existing numbers of forest staffs is maximized (Eqn. 9). Logging, when interpret in term of unit area, the value was estimated by 1% of illegal logging index multiplied by total amount of existing forest area (Eqn.10). The interlinkages showed relationships among intensity of logging, tree numbers (DBH > 60 cm), and logging area. Model was simulated when numbers of forest staffs were changed.

l_rate=lgr_max(lgr_max-real_officer/re_officer)* (Eqn. 8)

*real_officer=(if n>=re_officer then re_officer*0.999 else n)* (Eqn. 9)

*logging_area=forest_area*l_rate*0.01* (Eqn. 10)

4.1.5 Wild elephants

Information of wild elephants was gathered unofficially by personal communications. None have reported about characteristics of elephants in Kaeng Krachan rather than about crop-raiding incidents (RFD, 1994 and 2002). Since elephant population in Kaeng Krachan increase rapidly in a short time period, the event have been claimed to affect characteristics of forest ecosystems in some ways. Previous observations were recognised by park officers and local people since 1998. Numbers of wild elephants living around the park were estimated ranging between 100 - 200 individuals. All are classified as a resident population group. In accordance with previous observations in Zimbabwe (Hoare, 1999) and in Kenya (Sitati et al., 2003), size of elephant groups in Kaeng Krachan ranged from 1-20 individuals.

Intensity of damage on seedlings and saplings relates directly to those elephants moving manners. Unfortunately, there were no previous records about this, but estimated sizes of their habitat and foraging area. They usually range cross and beyond the boundary of its present area in the south approximately more than 50000 hectares (18% of all park area). Less elephant groups move upward to the north, this maybe because this area is suitable for being their food sources. Thus, to estimate degree of disturbance by elephants on vegetation, damage rate per elephant group was estimated related to their habitat and foraging size, and plant density in different size-classes.

Damage ratio per elephant group was assumed to 3 vegetative size-classes: saplings and seedlings, trees in size-class 1, and tree in size-class 2. We assumed that 1-5% of saplings and seedlings (Eqn. 11), 3-5% of trees in size-class 1 (Eqn. 12), and 2-4% of trees in size-class 2 (Eqn. 13) were destroyed by elephants, respectively. Those depend on total numbers of elephants exist in the area. Trees with DBH > 20.0 cm were presumed having less chances to be destroyed (damage ratio = 0). Forest area raided by elephants was approximated by varying degree of disturbance between 0.1 to 0.3 per cent of the whole forest area (Eqn. 14). Reduction factor was applied by 5 per cent if elephant numbers were higher 100 individuals. Details of elephants are showed in Table 4.7.

*ele_damage=(if elephant<=100 then elephant/20*0.01 elseif elephant<=200 then elephant/20*0.02 else elephant/20*0.03)* (Eqn. 11)

*ele_dm1=(if elephant<=100 then elephant/20*0.03 elseif elephant<=200 then elephant/20*0.04 else elephant/20*0.05)* (Eqn. 12)

*ele_dm2=(if elephant<=100 then elephant/20*0.02 elseif elephant<=200 then elephant/20*0.03 else elephant/20*0.04)* (Eqn. 13)

ele_d=(if elephant<=100 then 0.001 elseif elephant<=300 then 0.002 else 0.003) (Eqn. 14)

Table 4.7 Details of elephants in Kaeng Krachan national park.

Size-class	DBH (cm)	Damage ratio per group
0	Saplings and seedlings	0.1
1	4.51 - 10.0	0.05
2	10.1 - 20.0	0.05
Approximated number of elephant (Individual)		100-200
Group sizes (Individuals)		1-20

4.1.6 Environmental conditions

Environmental condition is an important factor determining vegetative characteristics. In this study, annual precipitation was considered dealing with growth and survivals of plants in the forest. Relative amount of water in soil necessarily describe the availability of the water to the plants. In general, the amount of soil water that can be used by the plant varies, due to characteristics of the soil and of the plant itself (Tolk, 2003). Naturally, the amount of water available to the plant depends on the depth of the root zone. A plant with a deeper root zone will have more water available than a seedling or saplings with roots only 2 to 3 inches deep (Dorota and Forrest, 1993).

The idea of plant-and-water relationship was employed to construct the linkages between available soil water and growth of seedlings and trees in the forest. Amount of soil water available for plants was determined to be varied follows annual precipitation or rainfall levels in Kaeng Krachan. Apart of historical records from the year 1952 to 1985 were from RFD (1994) and recent data from the year 1985 to 1999 were supported from 16 meteorological subunits around Kaeng Krachan and Hua Hin districts. Average rainfall level of 12 months was graphically depicts in Figure 4.1. Minimum rainfall level occurred in January (8.25 mm) while maximum level occurred in October (208.94 mm). Available amount of water in soil was mimic to average rainfall levels of 12 months in a year and those were assumed as maximum availability of the water which the plants can use. Soil water indices were determined for survivals of trees in five size-classes: size-class 1: 0.15; size-class 2: 0.25; size-class 3: 0.30; size-class 4: 0.35; size-class 5: 0.40, respectively.

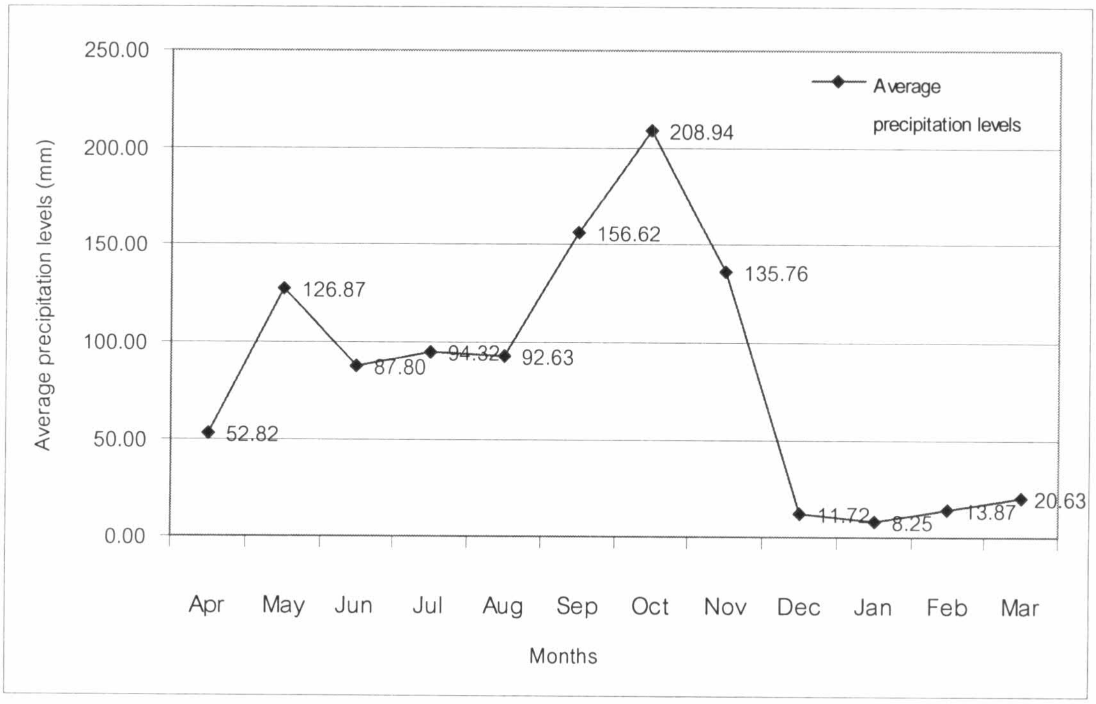

Figure 4.1 Average annual rainfall levels in Kang Krachan national park. The data was averaged from the year 1952 to 1999.

4.1.7 Community structure

Total number of population living in KKCNP could not be counted accurately. However, average numbers can be estimated by multiplying total number of households with average numbers of member per household which is equaled to 5 (RFD, 1994). Total numbers of households in KKCNP were estimated at 75 house holds. Therefore, total population size was approximated at 500 individuals.

Table 4.8 Population characteristics in KKCNP.

Characteristics		
Age (year)	Percent (%)	
<10.0	22.0	
10.0-20.0	35.0	
20.1-40.0	25.0	
40.1-60.0	10.0	
>60.0	8.0	
Total	100.0	
Total number of household	100	
Average household member (Individual)	5.0	
Approx. population size (Individual)	500	
	Sex ratio	
	Male	Female
Children (<10.0 years)	0.4	0.6
Adults(>10.0 years)	0.5	0.5
	Population size	
	Male	Female
Children (<10.0 years)	44	66
Adults(>10.0 years)	195	195

(Sources: RFD (1994) and personal interviews)

Table 4.8 shows population characteristics in Kaeng Krachan national park, observed 2000. Population was classified into two groups: children and adults. Children included people with age less than 10 years. This was approximated at 22 percent of the total population number (110 individuals). Adults included people with age older than 10 years. This was estimated at 78 percent of the whole population numbers (390 individuals).

Birth rate of infants was varied depending on amount of females and susceptibility to disease and water quality. Mortality also depended on water quality in KKCNP because water was a major influenced factor for living in that specific area.

This study, sex ratio in adult group, between male and female, was set to be equal to each other (50 percents) (males = 195 individuals and females = 195 individuals) . Sex ration in children was 40 percents for males (44 males) and 60 percents for females (66 females).

Settlement area in KKCNP is classified as disturbed site. Local community occupied totally 10,500 hectares for settlement and housing. Each household occupied at least 10 rai (31.6 hectares) (RFD, 1994). Socio-economic status of local residents is determined by agricultural cultivation (crop cultivation). Regarding community settlement and housing of those people, deforestation was estimated to increase by 1 percent every year due to increasing population size.

4.1.8 Agriculture

In agricultural processes were divided into 3 stages: cultivation or growing process, harvest, and storage and selling process.

4.1.8.1 Cultivation

Observation on crop cultivation was made in year 2000. Total crop cultivation area inside the park covered approximately 4,000 hectares. Even each household was limited to occupy only 10 rai (1.6 hectares). However, people cannot cultivate all the year round due to drought during summer or unable to cultivate because of infertility of land. Generally, only 2 to 10 rai (or 0.6-1.0 hectares) can be used for plantation.

Crop species cultivated in the area included banana, limes, pineapple, rice, jackfruit, mango, rice and some medicinal plants. Among those, banana, limes and pineapple were most often found. This might be because those species are easily to cultivate and kept in stores waiting for selling out in local market. Cropping system, in general, can be changed due to several reasons. For examples, if previous species generates rather low productivity or is unable to grow in the area. This also depended on local market situation. If the price of that species is very cheap, people then either stop or change crop species in next growing season.

For crop cultivation in Kaeng Krachan, local people are not allowed to use chemical fertilizers, pesticides or herbicides, which toxic substances are generated and contaminated into water and soil systems after applications (RFD, 1994). However, they can use all kinds of organic fertilizers instead of chemical fertilizers. From current observation in this study, people who cultivated mainly limes and banana applied approximately 200 kilograms of organic fertilizers per rai per year (or 1,250 kilograms/ha/year) (personal communication).

Chemical pesticides and herbicides are used to control insect pests or weed species sometime during cultivation period and when keeping raw products in storage. An average amount of pesticide and herbicide used were approximated at 5 times a year with concentration ratio of 50 milliliters of substances per 20 liters of water. This can be applied to total area approximately 0.5 rai (0.08 hectares). Suppose that each household occupied cultivated land for at least 1 hectare, total amount of pesticides or herbicides used can be calculated at about 3.125 liters per year.

Vegetation growth can also influence by several factors such as growth rate and life span of plant species. Also, amount of water in soil, types and amount of fertilizers and other chemical applications can affect growth patterns. During simulation, growth and crop production are determined following inputs such as rainfall levels, amount of fertilizers and season of plant growth.

4.1.8.2 Harvest process

Harvest of crop products occurred at the end of cultivation period. Total amount of raw products were limited by cultivation process and factors caused product losses. Crop productivity can be maintained during cultivation time to collected. This was assumed that 50 percents of total amount of vegetation. This was also depended on amount of soil water, fertilizer application.

Vegetative loss during cultivation time depends on level of pesticide application. Maximum productivity was assumed to be 100 kilograms/ rai/ year (or 625 kilograms/ hectare/ year). Loss process before harvest is assumed to be pressured concretely by animal raiding (raiding by wild elephants). This depends on numbers of elephants available in the area. Level of pest destruction was assumed to controlled by amount of pesticides. They came out from the core area and destroyed large amount of crop products in fields. This event always happened to pineapple farming around and inside the area. Therefore, number of elephants available in the area influence directly to amount of crop to be harvested. This study assumed products loss in this case that if elephant numbers is less than 200 individuals, product loss was approximated 3 percents of the whole amount. However, if number of elephants is higher than 200 individuals, maximum rate was limited at 5 percents of total amount of crop productions.

4.1.8.3 Storage

After harvest, crop yields were stored in storage places and waited for distribution. In general, crop yields were distributed in 3 ways: sell out in local market, natural discard, and loss by animal). Maximum crop yields kept in stored were estimated by total amount of crop products that harvested multiplied by total agricultural area. Selling rate at that time depended on local market situation, amount of products required by local market. Product sell-prices were limited due to crop demands and amount of crop yields in stores. This study assumed maximum local demands at 200 kilograms/day. Product discards was determined by season and amount of product loss during keeping in stores, which was determined by numbers of elephants. This was limited at 1 percent of all product yields in stores.

4.2 KM Model analysis

The choices of model components were selected from the discussion on information available and possibility to data collection and interpretation. The flows and linkages (both negative and positive contributions) among model components were designed, especially those contents which directly connect to the forestland in KKCNP were analyzed. The KM Model attempted to predict the likely consequences of current management operations in Kaeng Krachan. While running, the components are dependent on some possible, but not exclusive, environmental indicators. Figure 4.2 shows general components of Kaeng Krachan Management Model (KM Model) in forms of compartment-flow modeling diagram development. A complete list of the equations, parameters and variables in the model are given in Appendix C.

KM Model was assigned to simulate different scenarios. The user interface shows an explanation of an operation, a value of each run and some graphical displays of selected scenarios. We predicted the possible outcomes of management strategies in forest ecosystems by varying degree of disturbance, and potentiality and capability of supports over the time span of the model. Even Kaeng Krachan has been under the administrations of several government units, less number of researches and academic data are provided. Fundamental data in ecology are rarely found. Hence, initial values of parameters and variables in this prototype model are partially estimated by verifying of raw data collecting from various organizations around KKCNP. Secondary data on changes of land-use types and sizes were collected from various government units. Master Plan of KKCNP (1993-1998) (RFD, 1994) was reviewed. Types of forest ecosystems were classified and sizes of each were estimated. In Forest sub-model, forest state, tree distribution pattern, relative tree density as well as changes of forestland due to current management actions were calculated. While in Agriculture sub-model, changes between forest size and agricultural land, cropping system and selling process were estimated and discussed. Finally, Community sub-model pointed to characteristics of local people and community structure in the core area. Compartment-flow model diagram of Forest sub-model, Agriculture sub-model and Community sub-model are depicted in Figure 4.3, Figure 4.4 and Figure 4.5, respectively.

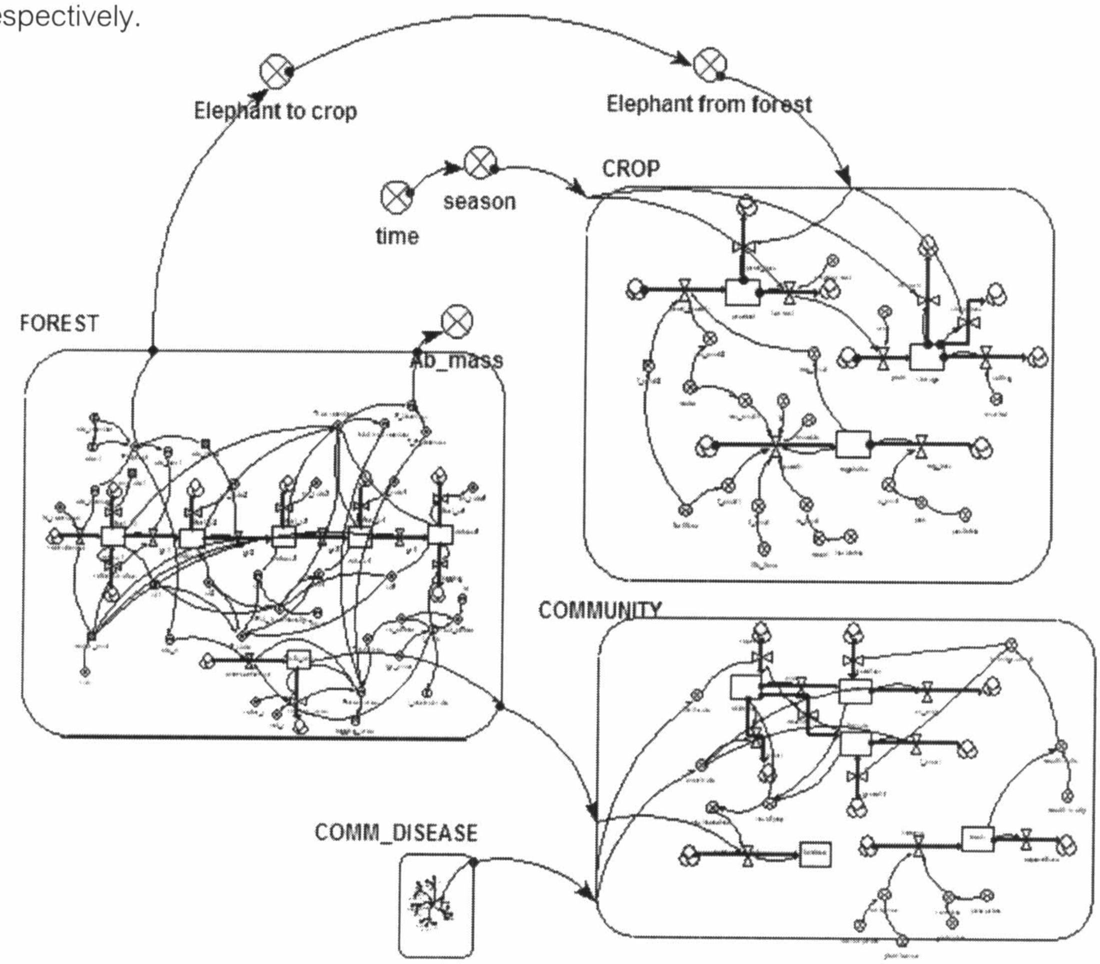

Figure 4.2 Kaeng Krachan Management Model (KM Model) in forms of compartment-flow model diagram development.

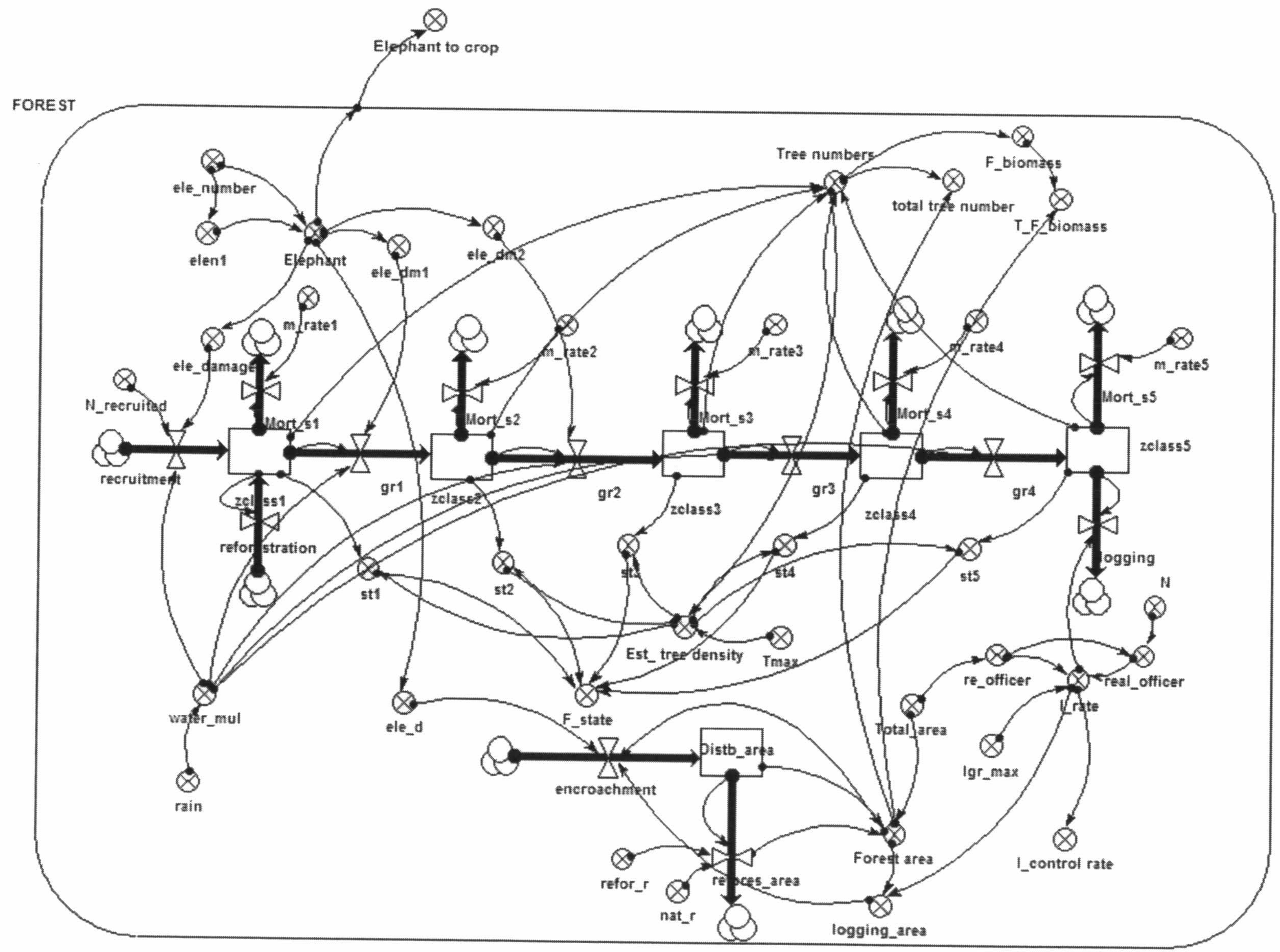

Figure 4.3 Forest compartment-flow sub-model diagram

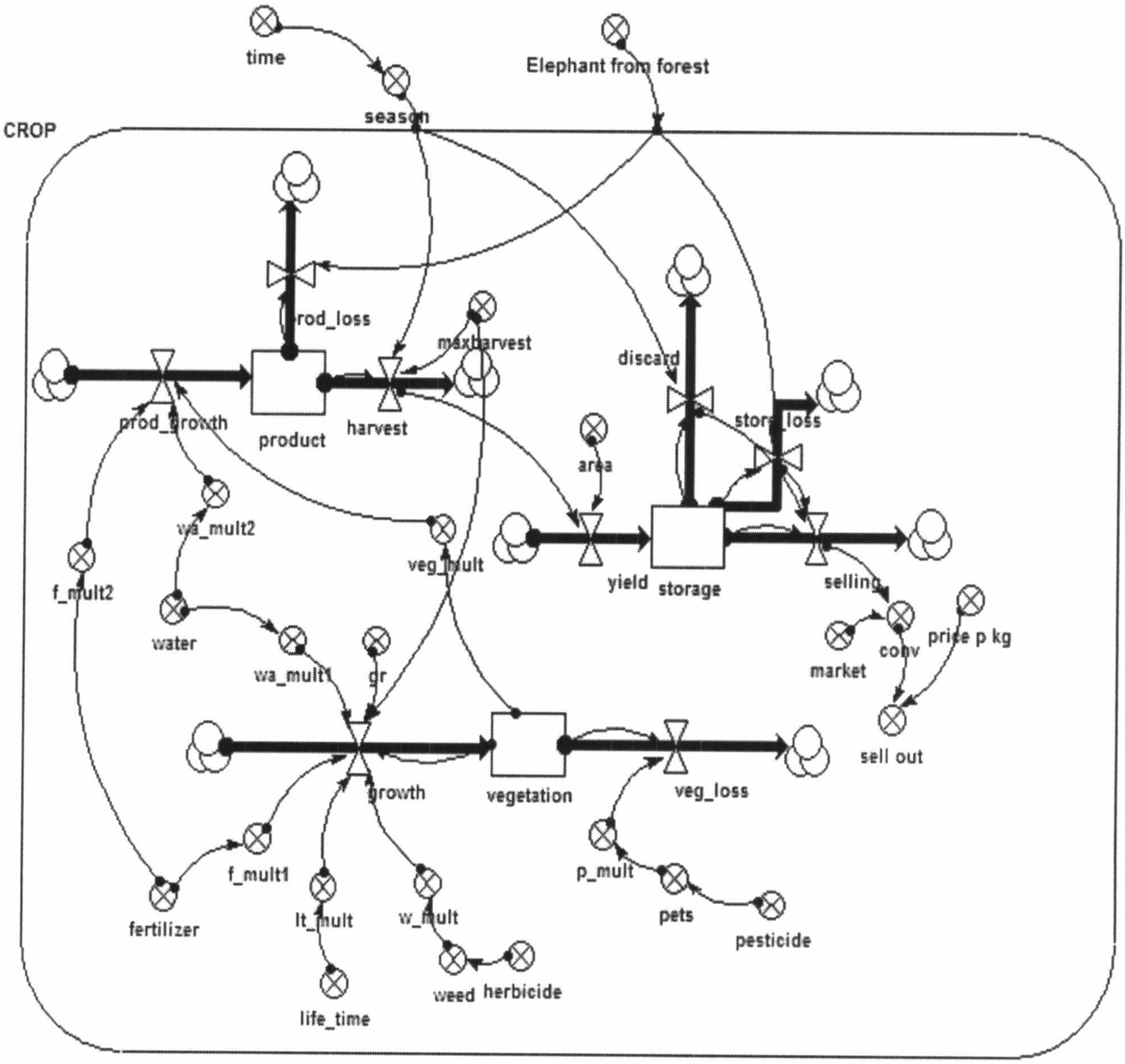

Figure 4.4 Agriculture compartment flow sub-model diagram

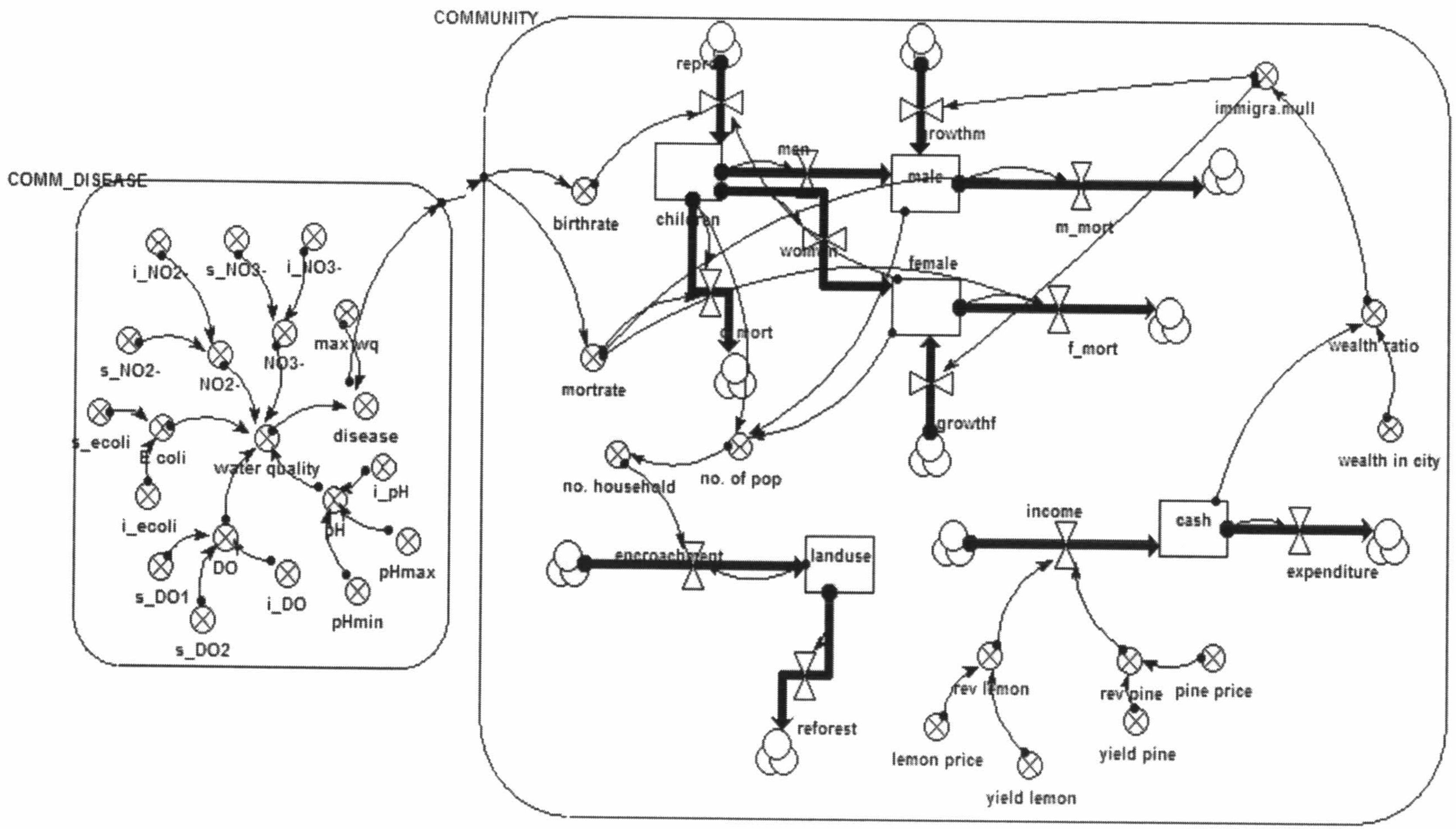

Figure 4.5 Community compartment flow sub-model diagram

4.3 Predications and scenario analysis

The KM Model aims to predict and simulate broad range of scenarios. Alternatively, a parameter can be reduced to zero, equations can be changed, or numerical values can be changed by keyboard inputs. Existing conditions of forest ecosystems under the current management strategy are determined and outcomes of each scenario can be presented either by graphical display or in tabulation. Future status of forest ecosystems in Kaeng Krachan is predicted in different aspects following present management conditions. The model is set to run from 2000-2050. We normally ran a 50-year scenario, with the year 2000 and 2050 being the first year and the last year of simulation.

4.3.1 Existing forest ecosystem and its condition

We have used the model to explore 22 scenarios that reflex a variety of natural and human-induced changes in Kaeng Krachan. The model began to run in 2000 and end in 2050. The results of the modelling process are summarised in Table 4.9.

By representing and analysing these figures, it cannot be over-emphasised that these scenarios extremely reflect the most appropriate levels for prediction. In turns, the results reflect what the model says will happen or what the situation tends to be. Some model parameters may need more efforts to adjust so that the model can predict more accurate results. The outputs may somehow raise a false sense of confidence to resource managers. However, there are merely distinctive results of the extent of consequences and predictions produced by the model to response a wide range of different management actions on forest ecosystem entities.

At the present condition of forest ecosystems in KKCNP, total tree density, total amount of forest area and disturbed area were estimated.

Table 4.9 Summary results of 22 scenarios

	Conditions							Model reults										
Scenario	Ele_number	Ele_damage	Ele_dm1	Ele_dm2	Ele_d	N	L_rate	Zclass1	Zclass5	Tree numbers	F_state	F_biomass	Encroachment	Distb_area	Forest area	Logging	Logging_area	Refores_area
1	50	.025	.075	.05	.001	100	.656	962	459	2975	1.700	1060955	1823	52220	240846	301	1582	1566
2	100	.048	.143	.095	.001	100	.656	1013	439	2975	1.703	1062410	1823	52220	240846	288	1582	1566
3	150	.1425	.285	.214	.002	100	.656	1089	371	2861	1.634	1020087	2018	57762	235470	243	1546	2017
4	200	.19	.38	.285	.002	100	.656	1181	335	2855	1.631	1077765	2017	57762	235470	220	1547	1733
5	300	.428	.713	.57	.002	100	.656	1738	175	2902	1.658	1034688	2018	57762	235470	115	1547	1733
6	350	.499	.831	.665	.003	100	.656	2473	126	3463	.562	1234500	2203	63114	230278	83	1512	1893
7	400	.57	.95	.76	.003	100	.656	5667	68	6340	.384	2260000	2203	63114	230278	44	1512	1893
8	450	.641	1.07	.885	.003	100	.656	$1.4x10^5$	-1261	$1.2x10^5$	0	$4.36x10^7$	2203	63114	230278	-828	1512	1893
9	100	.0475	.143	.095	.001	150	.485	1013	549	3089	1.766	1101603	1466	42249	250518	266	1216	1267
10	100	.0475	.143	.095	.001	200	.314	1013	732	3273	1.87	1166960	1079	31652	260796	229	819	950
11	100	.0475	.143	.095	.001	250	.142	1013	1099	3640	2.08	1297804	659	20386	271725	156	387	612
12	100	.0475	.143	.095	.001	275	.056	1013	1467	4008	2.29	1428821	434	14487	277447	83	157	435
13	100	.0475	.143	.095	.001	300	.001	1013	1872	4413	2.45	1573471	284	10562	281254	2	2.81	298
14	200	.19	.38	.285	.002	150	.485	1181	418	2938	1.679	1047628	1678	48135	244808	203	1188	1444
15	200	.19	.38	.285	.002	200	.314	1181	558	3078	1.76	1097427	1309	37908	254728	175	799	1137
16	200	.19	.38	.285	.002	250	.142	1181	838	3358	1.92	1197125	908	27039	265272	119	378	811
17	200	.19	.38	.285	.002	275	.056	1181	1118	3638	2.08	1296955	695	21348	270792	63	153	640
18	200	.19	.38	.285	.002	300	.001	1181	1424	3946	2.25	1407170	552	17546	274463	1	2.75	552
19	300	.428	.713	.57	.002	200	.314	1738	292	3019	1.725	1076376	1309	37908	254728	92	799	1137
20	300	.428	.713	.57	.002	300	.001	1738	746	3473	1.98	1238444	551	17563	274463	1	2.75	526
21	400	.57	.95	.76	.003	200	.314	5667	113	6385	.41	2276536	1527	43946	248872	35	781	1318
22	400	.57	.95	.76	.003	300	.001	5667	285	6558	.50	2338784	807	24316	267913	1	2.7	279

Table 4.10 Summary results of 9 scenarios.

Condition								Model results								
Case	Scenario	Elephant (Ind.)	N (person)	Ele_damage	Ele_dm1	Ele_dm2	L_rate	Zclass1 (Ind./ha)	Zclass5 (Ind./ha)	Tree density (Ind./ha)	Disturbed area (ha)	Forest area (ha)	Reforestation (ha)	Encroachment (ha)	Forest state	Forest biomass (ton/ha)
1	2	100	100	0.04	0.11	0.07	0.66	988	449	2975	52220.00	240846.00	1566.00	1823.00	1.70	1061682.50
				0.02	0.05	0.03	0.00	36	14	0	0.00	0.00	0.00	0.00	0.00	1028.84
2	4	200	100	0.17	0.33	0.25	0.66	1135	353	2858	57762.00	235470.00	1875.00	2017.50	1.63	1048926.00
				0.03	0.07	0.05	0.00	65	25	4	0.00	0.00	200.82	0.71	0.00	40784.50
3	7	400	100	0.50	0.83	0.67	0.66	3703	122	4621	60438.00	232874.00	1813.00	2110.50	1.02	1647344.00
				0.10	0.17	0.13	0.00	2778	76	2431	3784.44	3671.30	113.14	130.81	0.90	866426.42
4	10	100	200	0.05	0.14	0.10	0.49	1013	586	3124	41936.00	250821.00	1258.00	1451.00	1.79	1114685.00
				0.00	0.00	0.00	0.24	0	207	211	14543.77	14106.78	435.58	526.09	0.12	73928.01
5	15	200	200	0.19	0.38	0.29	0.49	1181	447	2967	47835.00	245099.00	1435.00	1663.00	1.70	1087596.00
				0.00	0.00	0.00	0.24	0	158	158	14038.90	13617.46	421.44	500.63	0.09	13903.13
6	21	400	200	0.50	0.83	0.67	0.31	3703	203	4702	40927.00	251800.00	1227.50	1418.00	1.07	1676456.00
				0.10	0.17	0.13	0.00	2778	127	2380	4269.51	4140.82	127.99	154.15	0.93	848641.27
7	13	100	300	0.05	0.14	0.10	0.07	1013	1486	4027	15474.00	276489.50	455.00	471.50	2.27	1435637.50
				0.00	0.00	0.00	0.10	0	547	547	6946.62	6738.02	222.03	265.17	0.26	194926.01
8	18	200	300	0.19	0.38	0.29	0.07	1181	1131	3652	22292.50	269867.50	681.50	730.00	2.09	1302147.50
				0.00	0.00	0.00	0.10	0	414	416	6712.56	6499.02	183.14	251.73	0.23	148524.24
9	22	400	300	0.50	0.83	0.67	0.00	3703	516	5016	20939.50	271188.00	402.50	679.00	1.24	1788614.00
				0.10	0.17	0.13	0.00	2778	326	2181	4775.09	4631.55	174.66	181.02	1.05	778057.88

We modelled and observed changes of nine interesting model components those are subjected to changes of forest protected areas and land use characteristics of Kaeng Krachan in future. The quantitative outputs of base scenarios (scenario 1-3) without any changes in current management actions are summarised in Table 4.9. Amongst those model outputs, some selected cases (case 1-9 in Table 4.10 or scenario 2, 4, 7, 100, 15, 21, 13, 18, and 22 in Table 4.9) were explained according to interesting policies or management actions. In Table 4.10, the mean is followed by the S.D. of each scenario and totally 9 selected variables were observed for outputs.

Graphical displays were drawn. Figure 4.6 is divided into 6 panels (A-F) to depict changes of 6 different model variables (components): average tree density, state of the forest, land encroachment, forest size, disturbed size, and estimated numbers of logged trees of size-class 6. A set of elephant population sizes was varied by 100, 150 and 200 individuals (*ele_number = 100, 150, and 200*) to separate the degree of elephant disturbance into 3 levels: light, moderate and heavy disturbance. At present condition, tree density increased rapidly during the first 10-years of analysis (Figure 4.6a). There were 12% (scenario 2) and 8.3% (scenario 4) of tree density increased and reach the maximum values varied between 2845 - 2975 Ind./ha in year 2010. Those indicate range and possibility of disturbance that would happen by elephant because we cannot estimate numbers of elephants present in the park exactly. The model based on the assumption that other human-induced activities such as agriculture, tourism or other recreation activities have no negative impacts on the forest ecosystems, which could be a subject for future discussion.

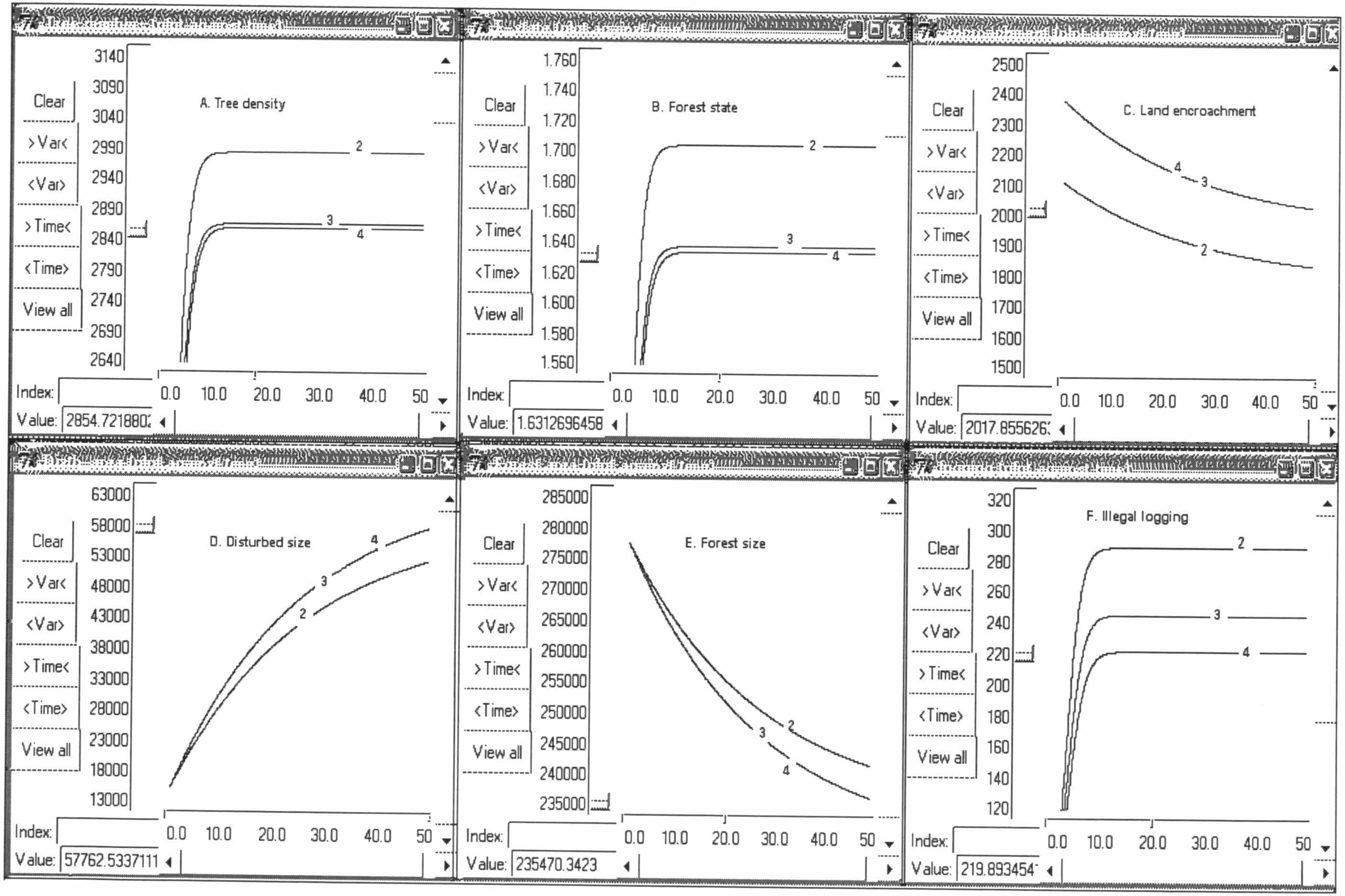

Figure 4.6 Panels A-F depict changes of 6 different model components (average tree density, state of the forest, land encroachment, forest size, disturbed size and estimated numbers of logged trees in size-class 6).

N.B Number presented on each line indicates scenario. In this graph, scenario 2, 3, and 4 are indicated.

When there have no negative effects from human to elephants and number of forest staffs equals to 100 persons (present staffs available in Kaeng Krachan national park), tree density in evergreen forest is averaged at 2,975 Ind./ha (scenario 1). Forest area decreased by 13.05% when compared with current forest size while total disturbed area increased by 260.16%. In fact, average tree density estimated by the model is rather high when compared with the previous, but unofficial, observation in moist and dry evergreen forest reported by Kaeng Krachan officers (RFD, 1994). Our result is also different from the results studied in dry and hill evergreen forests studied by Visaratana (1983) and Vannaprasert (1985), respectively. Belong to the forestland, reforestation can return secondary forest by 1,566 ha (0.70%) of total forest area 240,846.0 ha. Area returned by reforestation is proportional to total amount of disturbed size and occurred by both natural regeneration and replantation processes. When forest staffs are maintained at 100 persons, increasing elephant population destroyed large amount of forestland. This promoted natural regeneration and increased secondary forest relatively proportioned to total area raided by elephants (19.73%).

The modelling results also supported previous observation occurred in the low land forest in the eastern part of Thailand (RFD, 2002). There is critical to the forest when wild elephant population increases continuously. They destroyed large numbers of plant species in low land forest, and raided large amount of cultivated crops of local people as their food sources (RFD, 2002). In Kaeng Krachan, since human-elephant conflicts become increasingly significant, forest manager and local people should look for an appropriate way to reduce the conflicts those may happen in future. One possible way to solve this future problem is to keep wild elephants under the population control program and protect agricultural expansion that might invade habitats and foraging sites of wild elephants.

4.3.2 Elephant population changes

The quantitative values of interesting model variables (components) are shown in Table 4.9. Graphical displays are indicated in panels A-F of Figure 4.7. Figure 4.7a depicts results and status of forest ecosystems when number of wild elephants increased (scenario 2, 4, 5 and 7).

When elephant population size reaches a critical point (population number>300 Ind.), reforestation occurred at lower rate. In returns, deforestation occurred at the rate faster than that of reforestation and disturbed size was totally risen up by 3.3%. Estimated area encroached by elephant raiding and by illegal logging decreased by 13.19% (scenario 1). With relatively high tree density estimated by the model, forest state become a key indicator to imply general status of the forest in Kaeng Krachan. This is estimated by comparison of the estimated tree density with actual average tree density in evergreen forest (1750 Ind./ ha). In scenario 1, forest state was approximated at 1.70. This index value tends to decreases while elephant population size increases.

At moderate and heavy destructions by wild elephants (scenario 4 and 7), we compared the results with that occurred in scenario 1. It was found that negative effects were promoted to forest ecosystems by increasing land encroachment, total disturbed size by 9.62% and 1061%, respectively. Also, large number of trees in size-class 5 (DBH>60 cm) which indirectly indicate main structure of the forest, and total forest area declined by 72.8% and 2.23%, respectively.

In fact, increasing wild elephants created negative impacts to almost parts of forest ecosystem characteristics (based on the results of this study). Saplings, seedlings and small trees were primarily destroyed then resulted in declining of large trees in long term. With large number of small trees in future, this indicates that primary forest in Kaeng Krachan may face with bigger threat by this wild animal species. This may reduce ecosystem integrity and promote unsustainable manners to forest ecosystems.

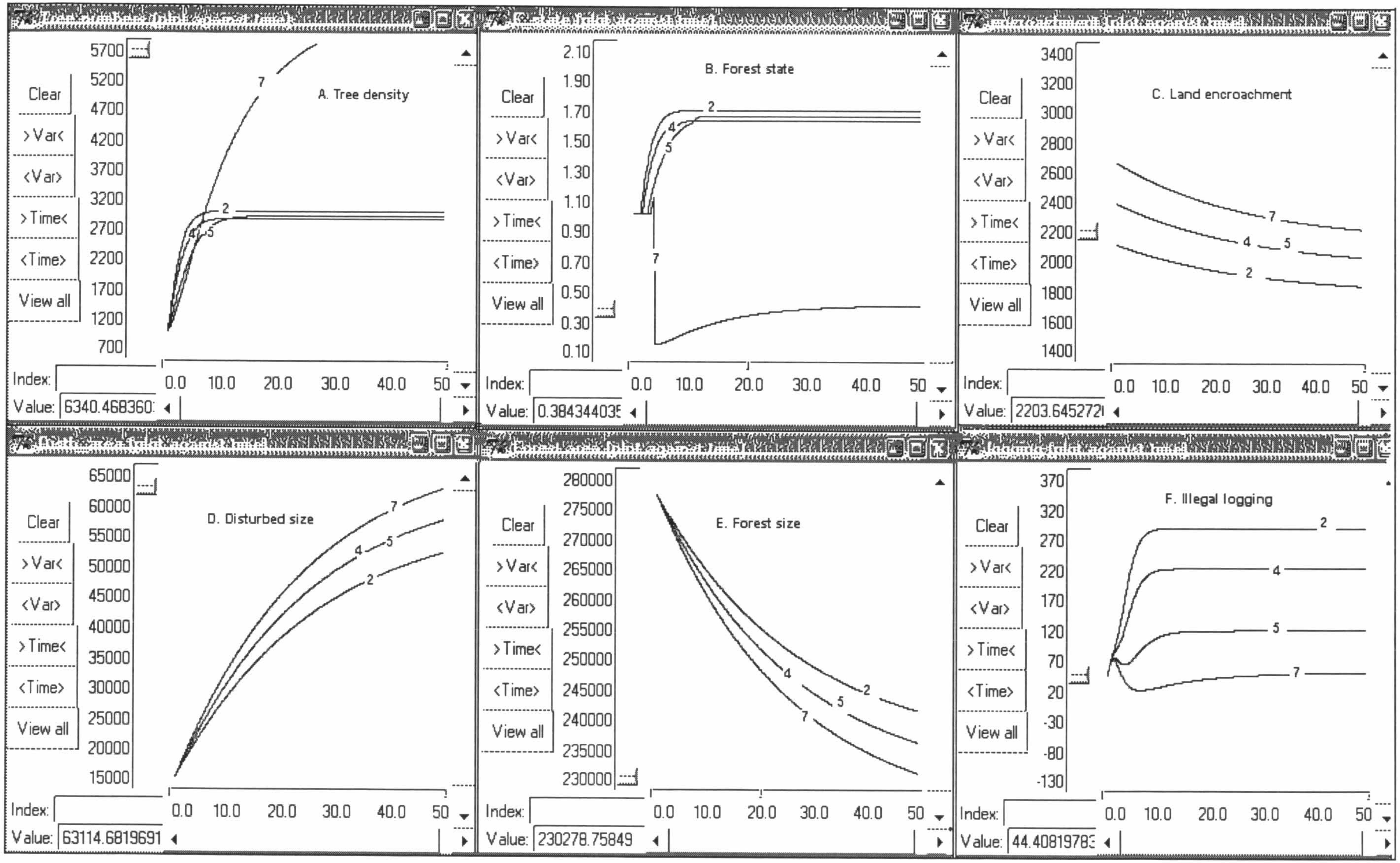

Figure 4.7 Panels A-F depict changes of 6 different model components when number of wild elephants increased: (average tree density, state of the forest, land encroachment, disturbed size, forest size, intensity of logging).

N.B. Number presented on each line indicates scenario. In this graph, scenario 2, 5, 4,and 7 are indicated.

4.3.3 Increasing capability of forest protection and conservation

The model was also used to explore the consequences of the future protection and conservation plan in Kaeng Krachan. We set the light disturbance by elephants as base case study then varied capacity of forest protection and conservation by increasing number of forest staffs following the current management actions. Forest staffs were increased from 100 to 200 and 300 persons (maximum staff numbers that the park can provide). When we started to run with increasing staff numbers by 100% (from 100 to 200 persons), without any changes of other model components, averaged tree density increased by 4.76% (scenario 4) when compared with the result in scenario 1. Encroachment and total disturbed area decreased sharply by 20.46% and 19.69%, respectively. Total forest area slightly increased by 4.14%. However, forest state index was lower than that of the previous state by 5.26% increased. By this management procedure, the results of the model indicated that advantages to the forest and other ecosystem components are greater when compared with the results of simulation in scenario 1.

Under the limitation of budget allocation and time constraint, this management procedure may not satisfy the park manager with many reasons. One reason is maybe because of the forest and other ecosystem components are still under being destroyed. Even if the degradation to forest ecosystem occurs at slower rate, but in long term consideration, sustainability to both the forest itself and people, who uses the forest as their major food sources, may not occur.

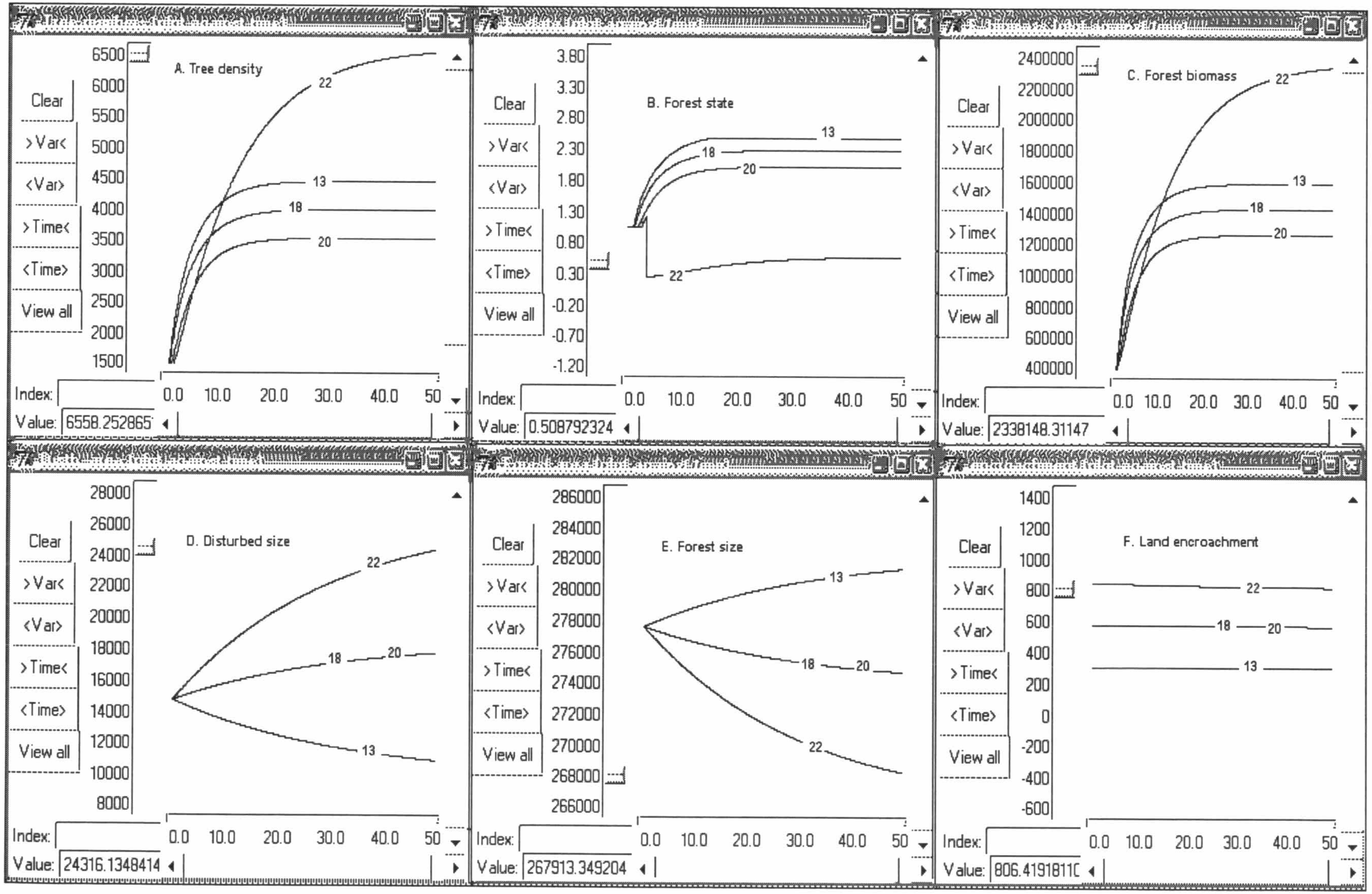

Figure 4.8 Panels A-F depict changes of 6 different model components (average tree density, state of the forest, forest biomass, disturbed size , forest size, and land encroachment).

N.B. Number presented on each line indicates scenario. In this graph, scenario 13, 18, 20,and 22 are indicated.

Another interesting scenario was also modelled and the results were observed (scenario 7). The action was increasing number of forest staffs from 100 to 300 persons in order to maximise the capacity to forest protection and conservation. It is clearly indicated that there were much differences in almost model components when compared the results of scenario 7 with the results of base case (scenario 1). Total forest area only declined by 0.18% when compared with total amount of present forestland in Kaeng Krachan. Also, total disturbed area increased by 6.72% while total land encroachment greatly reduced by 77.57%. We compared the forest state indices between scenario 1 and 4, and between scenario 1 and 7. The predictive index values clearly showed that there were extremely increased by 5.29 % and 33.53% when forest staffs were set at 200 and 300 persons, respectively. In general, we can infer that the management procedure in scenario 7 provides greater benefits to forest ecosystem when compared with other modelling results. In cases of heavy disturbance by elephants occurred, forest ecosystems still degraded even capability of forest protection increased (scenario 5,6,8 and 9).

4.3.4 Crop production

Cropping system and market process of people in KKCNP were observed. Simulation process induced initial values of vegetation by 6,250 kilograms per hectare per year. Amount of fertilizer was applied at 1,250 kilograms per hectare accompanied with 3.125 liters of herbicides and pesticides. And in this case, wild elephants were estimated at 100 individuals.

It was found that total amount of crop production long growing process did not extremely change although organic fertilization was applied as twice much as of the observed amount of fertilization currently used (100% increased) (Figure 4.9). The total crop production value was estimated at 26000 kilograms per year per household.

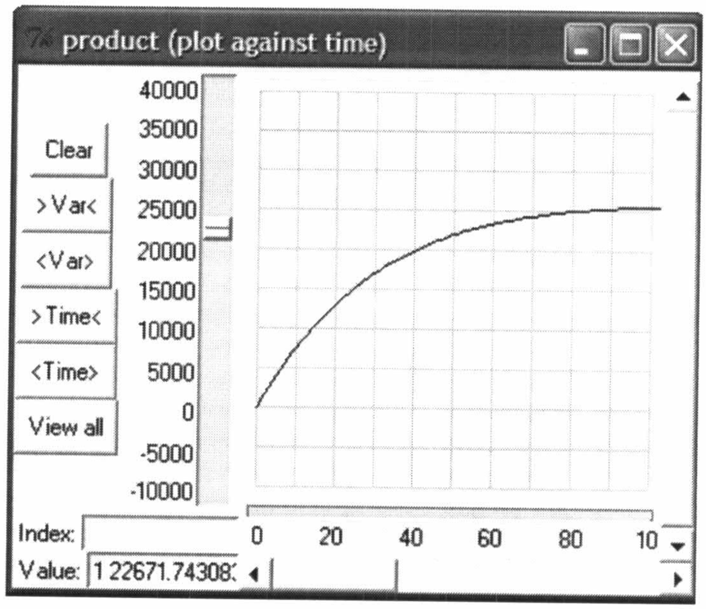

Figure 4.9 Estimated crop production values when 1250 kilograms and 2500 kilograms/ha/yr were applied.

When raw products were keeping in storage place and waiting for sell, less amount of them had lost. Figure 4.10 shows total estimated crop production value which are keeping for sell. This is an averaged production value of all households in Kaeng Krachan national park (250000 kilograms per year). When products were sold out in local market, estimated total incomes generated by crop production in this area is about 250000 THB per year (product price equal to 7 THB per kilogram).

Those estimated values were rather high and seemed to be over-estimation. However, this maybe true for some household that occupied cultivated area larger than one hectare and can invest for moderate to heavy fertilization inputs (1250 – 2500 kilograms per hectare per year). The calculation also depended on current crop price and place (where) to sell.

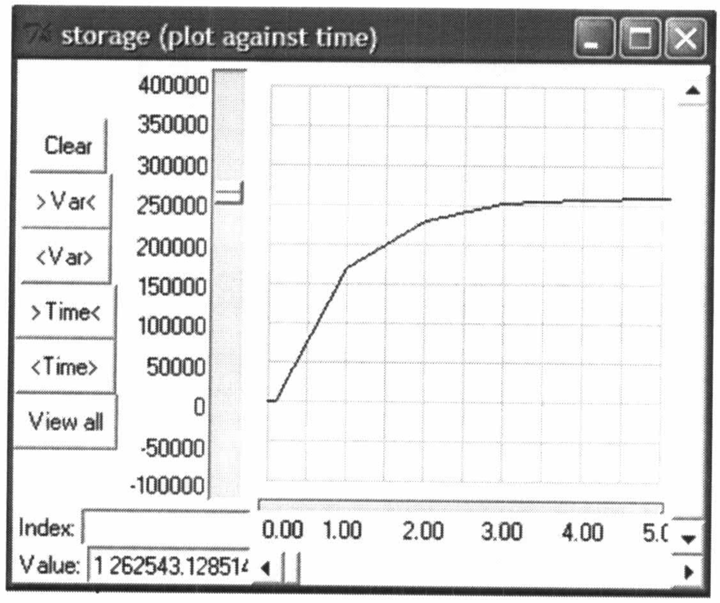

Figure 4.10 Total estimated crop production value keeping for sell.

The results suggested that total amount of crop production in Kaeng Krachan was not really depended on amount of fertilizer application in cultivation process. Within normal condition of fertilizers, pesticides or herbicides used at different stages of crop cultivation, crop production be maximized. Although increasing amount of fertilizers can increase crop production but less amount of products increased. The result may be useful when forest manager try to suggest local people to reduce amount of chemicals or fertilizers in cultivation process. This will help them to reduce expenditures. Also, contamination of inorganic matters in the water system and in soil may consequently decrease.

4.3.5 Community and population

Population structure and community characteristics were observed and predicted for the next 20 years. Normally, changes of water quality in KKCNP can affect growth and death of local people in this area. People usually use water in Kaeng Krachan reservoir in daily utilization and consumption. Therefore, people can get infection and results in declining in population numbers in long-term consideration. Level of disease infection was estimated when disease and contamination of toxic substances in water system increased.

From 500 villagers in the year 2000, with current condition, number of local residents dramatically increased to 16000 persons by year 2050 (Figure 4.11). However, even total number of population increase sharply but there was not much increase in total settlement area in side the park. Only 250 hectares (6.25%) were increased, or 0.125 hectare increased every year, for housing of new generation (Figure 4.12). This may result from regeneration process which can occur rather fast.

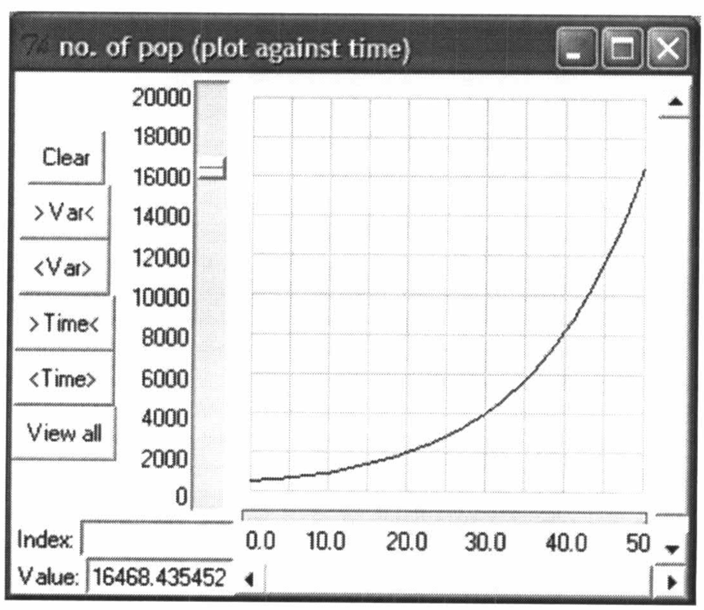

Figure 4.11 Predicted total number of local villagers in KKCNP by end of year 2050.

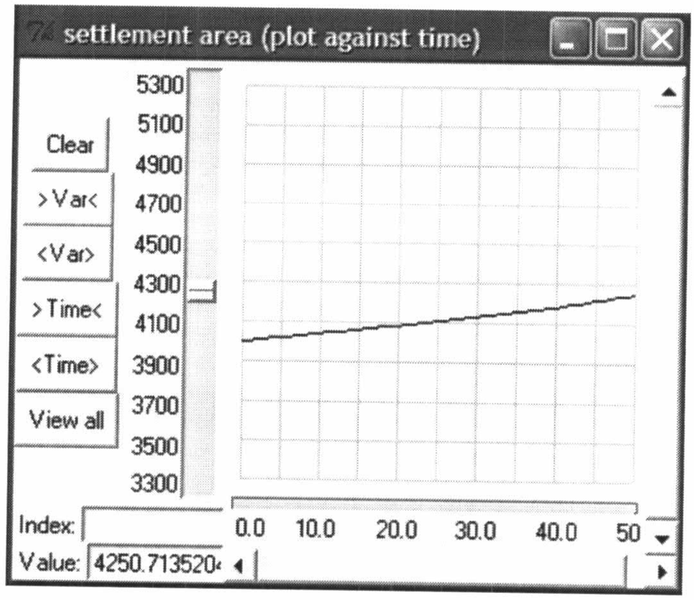

Figure 4.12 Total estimated settlement area in the next 50 years.

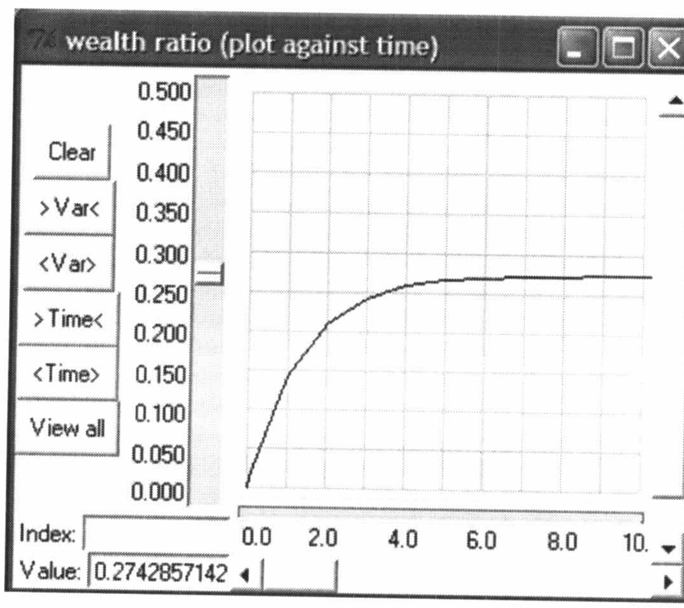

Figure 4.13 People' quality of life in Kaeng Krachan national park.

People' quality of life was observed and predicted (Figure 4.13). It was found that there was a little bit increase in people' quality and wealth. This value tended to increase rapidly in the early stage. However, after 6 year, or in year 2006, the values were rather stable until end of 2050.

Wealth of people may be a good indicator for resource manager and villagers in this park. People can not carry on other occupation in this site because it opposes to law and park regulation. Only crop cultivation can not bring enough well-beings and quality-of-life of people in this area. That may be the reason why now a day local people usually move downward and settle near Kaeng Krachan dam. Also, large number of people of this current generation usually go for work in Petchaburi city and other neighboring cities such as Hua Hin or Pran buri (personal communication).

4.4 Valuation of ecosystem benefits

4.4.1 Tourism and recreation

Growing tourism affects characteristics and management of Kaeng Krachan in several ways. Number of visitors come to KKCNP were first recorded in 1982 but the records are absent during 1991-1997 (RFD, 1994). The highest numbers of visitor occurred in 1998. There were more than 175,000 individuals. The records also show that from the early of December to mid of June, during rainy season, numbers of visitors is rather stable. This might be because of inconvenience in traveling. Increasing rate of numbers of visitor were estimated according to available data from Kaeng Krachan headquarter. There were 72.24%, 44.49% and 3.66% increase during the year 1997 – 2001, 1982 – 1990, and 1982 - 2001, respectively. However, we used average increasing value of 44.49% estimate possible number of tourists employing Logarithmic equations.

Important features of tourists and visitors who came and spent time in KKCNP are described as follows.

1. Visitors were classified into 2 groups: Thai, and Foreigner relating to nationality.
2. For Thais, visitors were identified as student and non-students groups. Student (main purpose is for education), and Non-student class (main purpose is for relaxation and leisure). Raw data is in Appendix C, Table C1.
3. Observation for time spending inside KKCNP, numbers of visitors staying overnight inside KKCNP camping area and visitors of one-day tour were recorded. Those were compared between Thais and Foreigners who came for traveling, not for education purpose. Raw data is in Appendix C, Table C2.
4. Total number of Thais visitors who came and spent overnight in KKCNP. Highest visitor numbers is more than 175,000 visitors in year 1998.

5. Fluctuation of visitors traveling to KKCNP in during 12 months were also observed. Increasing number of visitors started in early of December and still fluctuates at higher level until mid of June. This might be because of rainy season starts at the end of May, less convenience in traveling during rainy season.

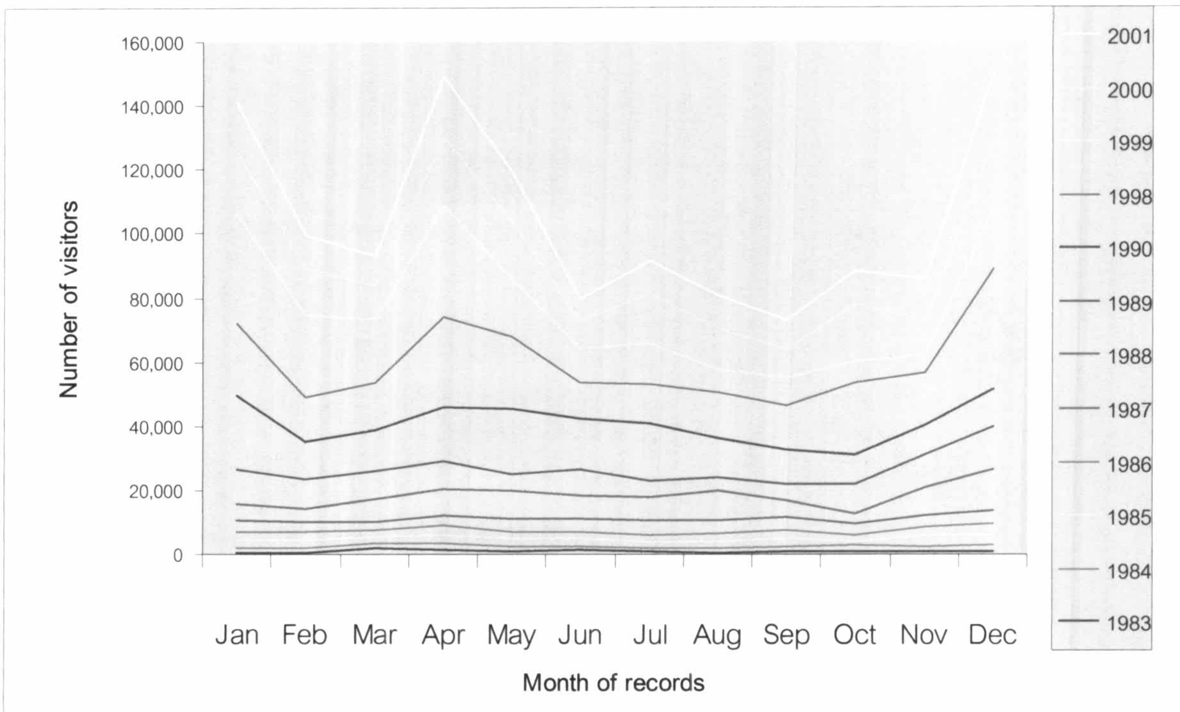

Figure 4.14 Number of visitors in KKCNP in each month.

Number of visitors in KKCNP was predicted by performing statistical analysis. Raw data in Table C5-C7, Appendix C were used to estimate increasing rates of visitors. Results were shown in Table 4.11.

Table 4.11 Estimated visitors' increasing rate.

Year	Increasing rate (percent)
1997s-2001s	3.66
1982s-1990s	72.24
1982s-2001s	44.49

The results showed that with R^2 value of 0.772, number of tourist in Kaeng Krachan may reach 2500,000 persons in the year 2010.

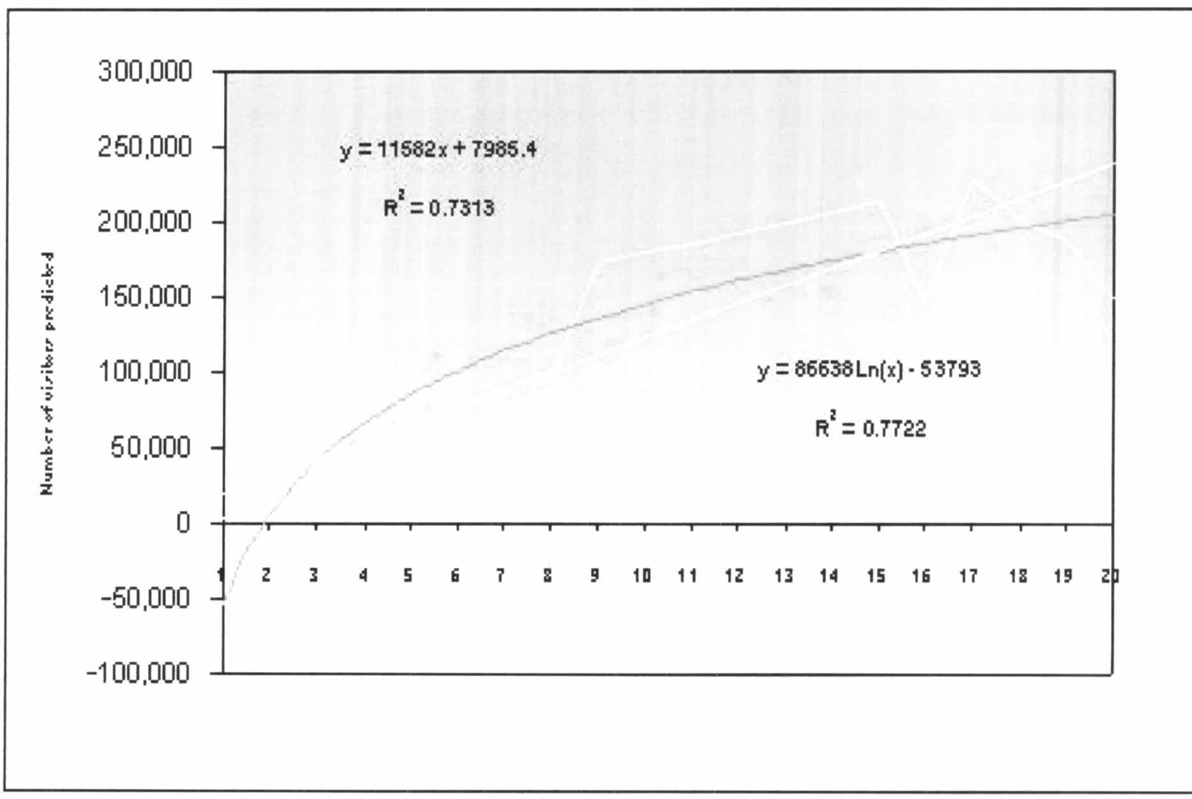

Figure 4.15 Predicted number of tourists in Kaeng Krachan National Park in 2010. With 44.49% increasing rate, employing Logarithmic equation ($R^2 =$ 0.772), number of tourists was estimated by 250,000 persons.

Estimation of equation for prediction of visitor numbers is shown in Figure 4.15. Two types of equations were generated: Logarithmic and Linear. Equations with R^2 values are in Table 4.12.

Table 4.12 Logarithmic and Linear equations and R^2 values for prediction of number of visitors.

Equation Description	R Squared value
Y = 11582X + 7985.4	0.7313
Y = 86638Ln(x) - 53793	0.7722

The results in Table 4.12 indicate that Logarithmic equation with higher R^2 value (0.7722) only explanatory X can be used to estimate number of visitors with more than 77% of confidence.

4.4.2 CVM analysis in estimation of WTP for new introduced recreational services.

4.4.2.1 Questionnaire analysis

One thousand sets of questionnaire distributed for data collection in three main visiting areas. Total numbers of visitors responded are 629 questionnaires, only 227 questionnaires (3 6.08%) of those were completed and used for analysis. Details are shown in Table 4.13.

Table 4.13 Response rates for surveys of three sampling areas in KKCNP.

Disposition of Surveys	KKCNP Headquarter	Panoen Thung and Ban Krang Campsite	Pa La au Waterfall	Total
Number of questionnaire	400	300	300.00	1000
Number of net potential respondents	272	165	192.00	629
Number of responses	117	62	48.00	227
Response rate (%)	43.01	37.58	25.00	36.08

Table 4.14 depicts details of respondents on WTP observation for new introduced recreational services. There are 87.7, 78.8 and 82.8 percents of respondents responded for Bus service, Home stay service, and Forest ranger service respectively. Those respondents reveal their opinion that they prefer and would be willing to pay for recreational use fees if new introduced recreational services are provided in KKCNP.

Table 4.14 Responses for WTP of new recreational services in KKCNP.

Service type	Responses from questionnaire		
	yes	no	total
Bus service	199	28	227
Home stay service	179	48	227
Forest ranger service	188	39	227

4.4.2.2 Factor Analysis

Nineteen socioeconomic variables were selected (Table 4.15), and these were standardized to adjudge value of mean ($\mu = 0$) an variance ($\delta^2 = 1$) before testing correlation among selected variables using Pearson Correlation (*r*).

Table 4.15 Results of FA. Related variables were grouped and extracted by PCA.

Common Factor	Related variables	Eigenvalue	% of Variance	Cumulative %
Fac1_1	INC, AGE, MAR, OCC	2.570	13.524	13.524
Fac2_1	PERSON, T_MATE, I_SEEK	2.107	11.089	24.613
Fac3_1	T_ASES, ASES	1.949	10.260	34.873
Fac4_1	TEXPENSE, EDU,REG_CODE	1.566	8.240	43.113
Fac5_1	T_WAY, TR_DAY	1.552	8.168	51.281
Fac6_1	SEX, PURPOSE	1.338	7.040	58.321
Fac7_1	K_DEST	1.312	6.907	65.288
Fac8_1	REASON, ECOTRS	1.241	6.533	71.761

Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO and Bartlett's Test) (Appendix C). KMO and Bartlett's Test generates value higher than 0.5. This indicates that set of selected variables is suitable for analyzing by FA. The result of hypothesis testing for their shows that Approximately Chai-Square value equals to 137.883, with degree of freedom values 171. Level of significance is equal zero. Null hypothesis (H_0) is refused. This means that all selected socioeconomic variables are related to each other.

Commonalties of 19 selected variables resulted from PCA extraction method are demonstrated in Table C9, Appendix C. Commonalties indicate that proportional variation of selected variables can be explained by new common factor. In this study, commonalties are higher than zero, this means that all selected variables can be explained by new factors extracted in Table C10, Appendix C.

From nineteen selected variables concerning having effects on WTP question are extracted and related variables are grouped. New eight factors are described in Table 4.15 with their Eigenvalues explained. More details are demonstrated in Table C10, Appendix C.

Eigenvalue indicates that how much variations of old variables of a new factor can be explained by each new factors (*Fac1_1* to *Fac8_1*). Results also indicate that Common Factor (*Fac1_1* to *Fac8_1*) can totally explain variation of all previous selected variables (19 variables, Table 4.16) by 71.76 percents.

Table 4.16 Selected variables for Factor Analysis.

Variables	Description
REG_CODE	Distance between KKCNP and visitor place
SEX	Sex of resplendence
MAR	Marital status
AGE	Age of despondence
EDU	Educational level
OCC	Occupation
INC	Income level
ASES	Previous access time (yes/no)
T_ASES	Number of previous access time
T_MATE	Types of travel mate
PERSON	Number of travel mate
TR_DAY	Days spend at KKCNP
TEXPENSE	Total expenditure along this trip to KKCNP
K_DEST	Destination (yes/no)
PURPOSE	Purpose of visit
T_WAY	Transportation type
I_SEEK	Information seeking before traveling (yes/no)
ECOTRS	Knowledge on ecotourism
REASON	Reason for estimation of service charge

Loading Factors of new component of *Fac1_1* to *Fac8_1* are shown in Table C11, Appendix C.

Factor scores of cases (respondents) responded for each of three services: Bus service, Home stay service, Forest ranger service are calculated and results are used for Logistic Regression Analysis (LRA) in next steps.

Then WTP function of each visitor is a function of new common factor and can be described as in equation 4.1.

$$WTP_i = F(Fac_{1\_1}, Fac_{2\_1}, \ldots, Fac_{8\_1}) \qquad (4.1)$$

4.4.2.3 Logistic Regression Analysis

Logit response functions for WTP of new recreational services are predicted. In this case, numbers of independent variables are fixed at 8 variables (*Fac1_1* to *Fac8_1*) for every case response (Table 4.17).

Table 4.17 Loading factor of components of new factor extracted.

Common Factor	Loading factors or coefficient values of factor component
Fac1_1	+ 0.810*INC* + 0.805*AGE* + 0.637*MAR* + 0.615*OCC*
Fac2_1	+ 0.870*PERSON* + 0.800*T_MATE* - 0.601*I_SEEK*
Fac3_1	+0.892*T_ASES* +0.884*ASES*
Fac4_1	+0.648*TEXPENSE* +0.615*EDU* + 0.523*REG_CODE*
Fac5_1	+0.823*T_WAY* +0.655*TR_DAY*
Fac6_1	+0.854*SEX* -0.609*PURPOSE*
Fac7_1	+0.833*K_DEST*
Fac8_1	+0.775*REASON* +0.514*ECOTRS*

A WTP for Bus service

Factor scores of all cases (visitors) are used as input variables to predict probability that answers that visitor responses will be "YES". This means that respondents prefer this service and are willing to pay for recreational use fees. This estimate based on visitor's answer and factor scores analyzed in FA section.

Table 4.18 Response of WTP for Bus service.

Service type	Number of despondence	Number of despondence with information	Service charging system	Case response	Percentage
Bus service	216	197	Lump sum	51	25.9
			Real charge	146	74.1

Case responses with WTP on Bus service is shown in Table 4.18. There are 197 visitors who are responded with "yes" and 28 visitors responded with "no", from total 227 respondents. Logit Model test for Goodness of Fit is shown in Table 4.19.

Table 4.19 Logit Model test for Goodness of Fit.

Cox & Snell R Square	0.140
Nagelkerke R Square	0.265
-2 Log likelihood	135.474
Chi-square	19.771
Sig.	0.011

Cox & Snell R-Square and Nagelkerke R-Square value 0.140 and 0.265, respectively. These Psuedo R-Squared is using for explanation of variation in logistic regression model.

For Nagelkerke R-Square equals to 0.265, this indicates that at least 26.5% of model variation can be explained by Logit response model.

Chi-square is 19.771 with 0.01 of significance value, this indicates that Null hypothesis (H_0) is refused. There is none of coefficient values of input variables is equal to zero.

Percentage correct for model predication is shown in Table C14 compared with values in Table C12 in Appendix C. Real case responded with "yes" is 199 visitors (100%), and 197 visitors (99%) is predicted from Logit response function. Overall percentage for correct prediction is 90.7%.

Logistic beta coefficient (b_0, b_1,....,b_8) are demonstrated in Table C15 in Appendix C. Logistic response function can be drawn as shown is equation 4.2

$$\text{Log}(WTP_{bus}) = 2.595-0.273Fac_{1\_1}+0.2\,Fac_{2\_1}-0.529Fac_{3\_1} +0.713Fac_{4\_1}+0.740Fac_{5\_1}-0.571Fac_{6\_1} +0.126Fac_{7\_1}-0.523Fac_{8\_1} \quad (4.2)$$

Casewise list for exclusion number of visitors in estimation of WTP values, charge system and estimation of recreation use frees is shown in Table C16 in Appendix C.

Total 197 case response predicted by logistic regression model is selected to estimate charge system (Table 4.20). Charge systems are divided into two types: lump sum and real charge. Cases responses for bus charging systems are shown in Table 4.21 and Table 4.22. Details of case response for WTP for Bus service are listed in Table C17 to Table C20 in Appendix C.

Table 4.20 Comparison of WTP responses before and after analyzed with Logistic Regression Analysis (LRA).

Service type	Real case responses			Case predicted by LRA			
	Yes	no	Total	yes	no	Total	Overall percent
Bus service	199	28	227	197	19	216	90.7
Home stay service	179	48	227	173	34	207	82.4
Forest ranger service	188	39	227	186	22	208	89.4

Table 4.21 WTP for Bus service by lump sum charging system.

Service charge value (THB/trip)	Case response	percentage	Cumulative percent
600	28	54.9	54.9
700	11	21.6	76.5
800	7	13.7	90.2
1000	1	2.0	92.2
Other	4	7.8	100.0
Total	51	100.0	

Table 4.22 WTP for Bus service by real charge charging system.

Service charge value (THB/person/trip)	Case response	Percentage	Cumulative percent
50	49	33.6	33.6
100	46	31.5	65.1
150	20	13.7	78.8
200	14	9.6	88.4
250	3	2.1	90.4
Other	14	9.6	100.0
Total	146	100.0	

B WTP for Home stay service

Case responses with WTP on Home stay service is previously shown in Table 4.23. There are 179 visitors who are responded with "yes" and 48 visitors responded with "no", from total 227 respondents. Logit Model test for Goodness of Fit is shown in Table 4.24.

Table 4.23 Response of WTP for Home stay service.

Service type	Number of despondence	Number of despondence with information	Service charging system	Case response	Percentage
Home stay service	207	173	Lump sum	168	97.1
			Other system	5	2.9

Table 4.24 Logit Model test for Goodness of Fit.

Cox & Snell R Square	0.135
Nagelkerke R Square	0.209
-2 Log likelihood	201.396
Chi-square	27.388
Sig.	0.001

Cox & Snell R-Square and Nagelkerke R-Square value 0.135 and 0.209, respectively. These Psuedo R-Squared is using for explanation of variation in logistic regression model. For Nagelkerke R-Square equals to 0.209, this indicates that at least 20.9% of model variation can be explained by Logit response model.

Chi-square is 27.388 with 0.001 of significance value, this indicates that Null hypothesis (H_0) is refused. There is none of coefficient values of input variables is equal to zero.

Percentage correct for model predication is shown in Table C23 compared with values in Table C21 in Appendix C. Real case responded with "yes" is 179 visitors (100%), and 173 visitors (96.6%) is predicted from Logit response function. Overall percentage for correct prediction is 82.4%.

Logistic beta coefficient (b_0, b_1,....,b_8) are demonstrated in Table C24 in Appendix C.

Logistic response function can be drawn as shown is equation 4.3.

$$\text{Log (WTP}_{H}) = 1.658+0.135Fac_{1\_1}+0.375Fac_{2\_1}-0.124Fac_{3\_1} +0.100Fac_{4\_1}+1.062Fac_{5\_1}-0.253Fac_{6\_1} -0.133Fac_{7\_1}-0.358Fac_{8\_1} \quad (4.3)$$

Casewise list for exclusion number of visitors in estimation of WTP values, charge system and estimation of recreation use frees is shown in Table C25 in Appendix C.

Total 173 case response predicted by logistic regression model is selected to estimate charge system (Table 4.25). Charge systems are divided into two types: lump sum and other system (Table 4.26). Details of case response for WTP for Bus service are listed in Table C26 to Table C28 in Appendix C.

Table 4.25 Comparison of WTP responses before and after analyzed with Logistic Regression Analysis (LRA).

Service type	Real case responses			Case predicted by LRA			
	Yes	no	Total	Yes	no	Total	Overall percent
Bus service	199	28	227	197	19	216	90.7
Home stay service	179	48	227	173	34	207	82.4
Forest ranger service	188	39	227	186	22	208	89.4

Table 4.26 WTP for Home stay service by lump sum charge system

Service charge value (THB/person/trip)	Case response	percentage	Cumulative percent
100	57	33.9	33.9
150	51	30.4	64.3
200	28	16.7	81.0
250	16	9.5	90.5
300	11	6.5	97.0
other	5	3.0	100.0
total	168	100.0	

C WTP for Forest ranger service

Case responses with WTP on Forest ranger service is shown in Table 4.26. There are 188 visitors who are responded with "yes" and 39 visitors responded with "no", from total 227 respondents. Logit Model test for Goodness of Fit is shown in Table 4.27.

Table 4.26 Response of WTP for Forest ranger service

Service type	Number of despondence	Number of despondence with information	Service charging system	Case response	Percentage
Forest ranger Service	208	186	Lump sum	181	97.3
			Other system	5	2.7

Table 4.27 Logit Model test for Goodness of Fit

Cox & Snell R Square	0.178
Nagelkerke R Square	0.296
-2 Log likelihood	163.771
Chi-square	12.694
Sig.	0.123

Cox & Snell R-Square and Nagelkerke R-Square value 0.178 and 0.296, respectively. These Psuedo R-Squared is using for explanation of variation in logistic regression model. For Nagelkerke R-Square equals to 0.296, this indicates that at least 29.6% of model variation can be explained by Logit response model.

Chi-square is 12.694 with 0.123 of significance value. This indicates that Null hypothesis (H_0) is accepted. There is none of coefficient values of input variables is not equal to zero. However, this study still analyzed data in next section because of Nagelkerke R-Square value is rather high, therefore this set of data can be used.

Percentage correct for model predication is shown in Table C30 compared with values in Table C28 in Appendix C. Real case responded with "yes" is 188 visitors (100%), and 186 visitors (98.9%) is predicted from Logit response function. Overall percentage for correct prediction is 89.4%.

Logistic beta coefficient (b_0, b_1,....,b_8) are demonstrated in Table C31 in Appendix C. Logistic response function can be drawn as shown is equation 4.5.

$$\text{Log}(WTP_F) = 2.290 - 0.218Fac_{1\_1} + 0.277Fac_{2\_1} + 0.262Fac_{3\_1} + 0.310Fac_{4\_1} + 1.529Fac_{5\_1} - 0.651Fac_{6\_1} - 0.427Fac_{7\_1} - 0.393Fac_{8\_1} \quad (4.4)$$

Casewise list for exclusion number of visitors in estimation of WTP values, charge system and estimation of recreation use frees is shown in Table C32 in Appendix C.

Total 186 case response predicted by logistic regression model is selected to estimate charge system (Table 4.29). Charge systems are divided into two types: lump sum and other system. Table 4.30 indicates numbers of visitors who preferred lumsum charging system. Details of case response for WTP for Forest ranger are listed in Table C33 to Table C35 in Appendix C.

Table 4.29 Comparison of WTP responses before and after analyzed with Logistic Regression Analysis (LRA).

Service type	Real case responses			Case predicted by LRA			
	Yes	No	Total	yes	No	Total	Overall percent
Bus service	199	28	227	197	19	216	90.7
Home stay service	179	48	227	173	34	207	82.4
Forest ranger service	188	39	227	186	22	208	89.4

Table 4.30 WTP for Forest ranger service by lump sum charge system

Service charge value (THB/person/trip)	Case response	percentage	Cumulative percent
100	57	33.9	33.9
150	51	30.4	64.3
200	28	16.7	81.0
250	16	9.5	90.5
300	11	6.5	97.0
other	5	3.0	100.0
total	168	100.0	

In calculation of demands for each service, average number of visitors in KKCNP in 2001s is about 200,000 visitors. Therefore, average number of visitors per year willing to pay for each service can be calculated as shown in Table 4.31.

Table 4.31 Calculation of demands of each service type.

Service	$\%N_{Y_i}$	Predicted number of visitor	Demands for service type (THB)
Bus service (lump sum system)	23.9	47,800	28,680,000
Bus service (real charge system)	67.0	13,400	6,700,000
Home stay service	33.9	67,800	6,780,000
Forest range service	60.7	121,540	24,308,000

4.4.3 Kaeng Krachan site value: TCM Analysis

Results of TCM analysis are described in this section. Zip code collected in questionnaire is used for divided visitor into 5 zones following distance between KCNP and visitors' place of origins. Number of visits recorded from visitors is calculated for each zone. Estimated zone population is estimated from average percentage numbers of visitors recorded.

Visits per 1000 visitors are estimated and this is found that total numbers of visits per year in KKCNP is about 9,276 times per 1000 visitors (Table 4.32).

Table 4.32 Calculation of visits per one thousand visitors (Vi/1000) of each concentric ring zones.

Zone (Zi)	Distance (Radius: km)	Total Visits/Year Type II	Estimated Zone Population	Visits/1000 Type II
1	0-200	419,383	172,687	2,429
2	201-400	27,313	20,264	1,348
3	401-600	6,167	1,762	3,500
4	601-800	3,524	3,524	1,000
5	801-1000	1,762	1,762	1,000
Total		458,150	200,000	9,276

Travel cost of each zone is calculated. The results are shown in Table 4.33 and relation between visits/1000 and total travel cost are predicted to set up Trip Generating Function (TGF) or Travel Cost Regression (Figure 4.16). Table 4.34 shows relation between visitation rate and travel cost.

Table 4.33 Complete travel cost from each zone following assumption.

Zone (Zi)	Average Round-trip Travel Distance (Km)	Average Round-trip Travel Time (hr) (60 km/hr)	Distance times Cost (Fuel Cost 16 THB/l) (3.0 THB/km)	Travel Time times Cost (Full Wage Rate 150 THB/day) (18.75 THB/hr)	Total Travel Cost (THB/Trip) TC5
1	200	3.33	600.00	62.50	1,137.89
2	400	6.67	1,200.00	125.00	1,933.70
3	600	10.00	1,800.00	187.50	2,237.50
4	800	13.33	2,400.00	250.00	3,200.00
5	1000	16.67	3,000.00	312.50	3,362.50

Table 4.34 Run regression to establish functional relationship between visitation rate and travel cost.

Zone (Zi)	Distance (Radius: km)	Visits/1000 Type II	Total Travel Cost (THB/Trip) TC5
1	0-200	2,429	1,137.89
2	201-400	1,348	1,933.70
3	401-600	3,500	2,237.50
4	601-800	1,000	3,200.00
5	801-1000	1,000	3,362.50

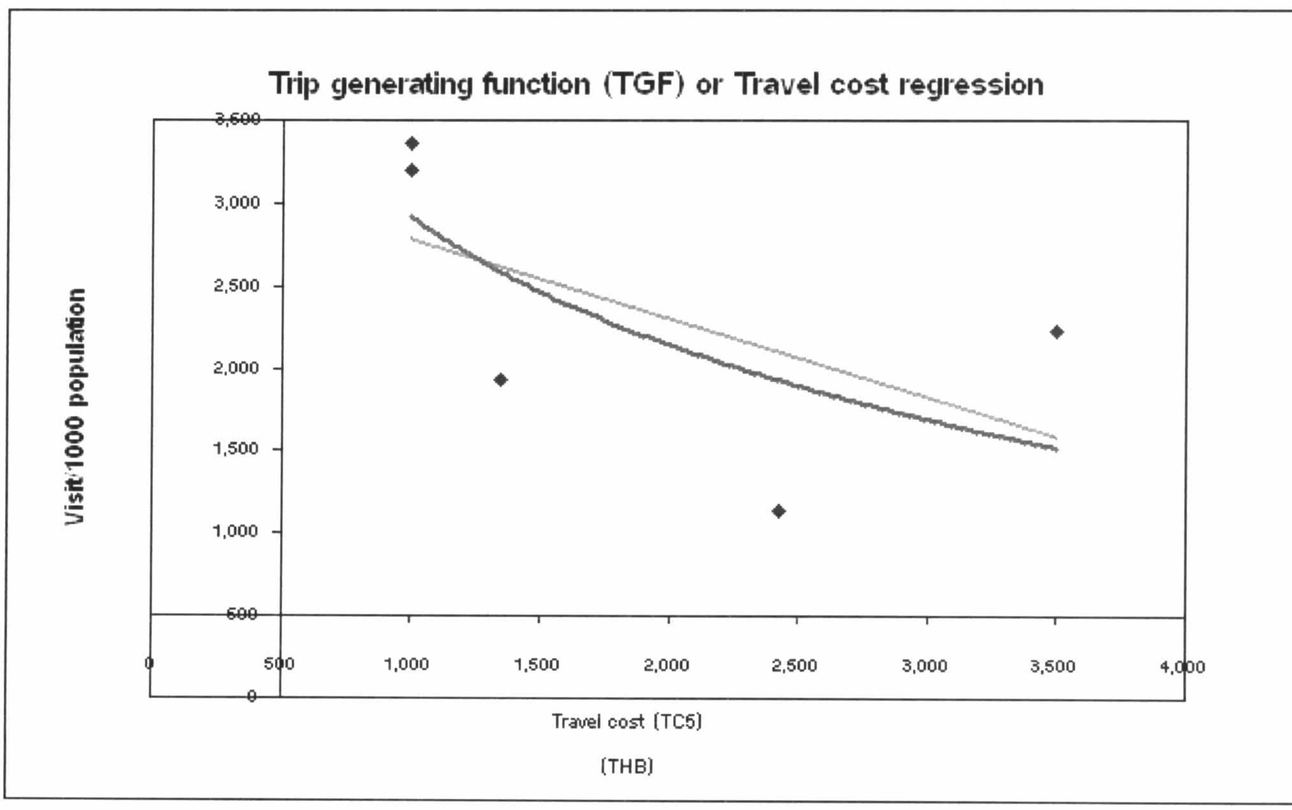

Figure 4.16 TGF demand function compared between linear and Semi-log (dependent) forms.

Table 4.35 describes summary of Semi-log dependent function model of TGF demand function in Figure 4.16.

Table 4.35 Summary output for Semi-log (dependent) model.

Regression statistics	
Pearson r	-0.677
P-Value	0.104
R-Square	0.459
Beta 0	8.373
T-sig.	0.001
Beta 1	-4.12E-04
T-sig.	0.209
F-sig.	0.209

Travel cost regression between vitis/1000 and total cost of travel is shown in equation 4.5.

$$\ln(V/1000) = 8.373 - 0.0004119*TC \qquad (4.5)$$

Trace of demands curve for trip to KKNCP is also calculated as shown in Figure 4.17. These can be done by supposing that visitor come to KKCNP will spend their extra money for recreational activities in KKNCP at least 200 THB per person.

Consumer surplus for trip site is estimated. The results show that CS per visit is about 2,428 THB per trip. Annual recreational benefits of KKCNP is about 1,271 million THB, or US$29.58 million in 2002s.

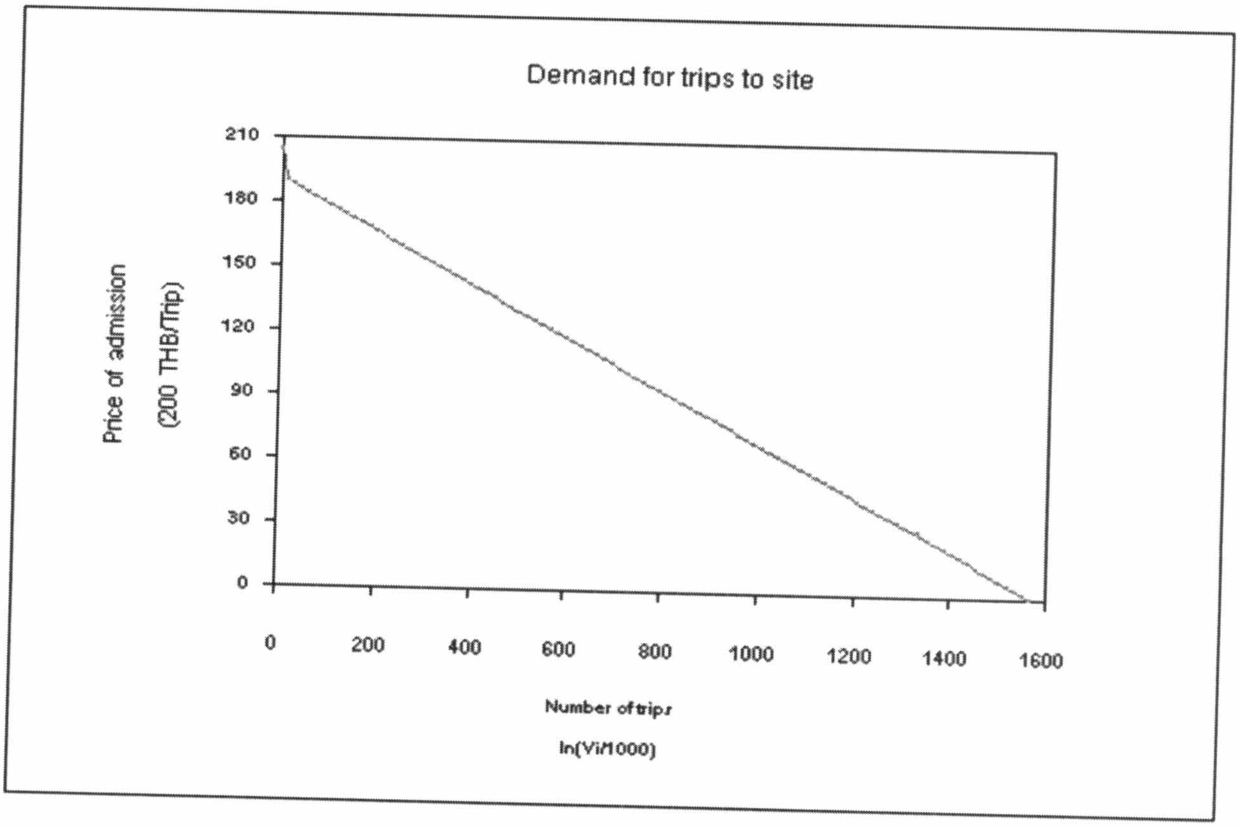

Figure 4.17 Demand curve for trip to site.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

In this research, a conceptual framework of forest protected area and ecosystem management and a prototype management model of Kaeng Krachan national park were developed employing the concepts of ecosystem management and systems thinking and hierarchical organization. Almost influencing factors related to forest resources and ecosystem's entities in Kaeng Krachan were identified. A process-based thought of development was employed to constructed a Kaeng Krachan Management Model (KM Model). Purposes of the model possibly suggest all stakeholders such as forest managers, local people and others who have important roles involving not only resource utilization but also resource protection and conservation on available forest resources. It is focusing on the possible ways of optimizing profits while conserving ecosystem structures and integrity for future sustainability.

5.1.1 KM Model conclusion

5.1.1.1 Existing condition

From current components of Kaeng Krachan national park, existing condition of the park were explored. The results of model are summarized in Table 5.1.

At present forest characteristics, number of wild elephants and numbers of local people are set at 100-200 individuals and 100 households, respectively. Averaged used agricultural areas are 0.6 to 1.0 hectares per household with approximated amount of fertilizers equals to 1250 kilograms per hectare and about 3.125 liter per hectare of pesticide and herbicide applications. Reforestation rate and illegal logging rate are fixed as constant values, equal to 0.02 and 0.01, respectively. While number of forest staffs are 100 persons. In a 50-years running simulation, with current conditions of scenario 1 (Table 5.1), forest ecosystems in Kaeng Krachan was moderately degraded when compared to the results of scenario 7 as worst case analysis. The results showed that, in general, forest structures were not extremely altered by elephant raiding. However, when compare the results of existing condition with the results of scenario 13 as best case analysis, heavier forest degradation could occur to forest ecosystems and other ecosystem entities in Kaeng Krachan.

Although elephant population size reaches at 400 individuals, tree density barely changes in its components in the next 50-year run time simulation. One possible reason why there are slightly changes on forest composition is due to high regeneration rate and large numbers of seedlings and saplings possibly survive in the area. However, in long-term consideration, over-exploitation and over-harvested collection on ecosystem goods and services may reduce forest ecosystem fragility and unhealthy.

Reserved sites such as national park has long been developed with various methods to liberate the conflicts amongst resource users. Several types of management actions are initiated for better situation. However, some problems still occurred because of inability to control degree of disturbance from both internal and external factors.

For crop cultivation and plantation system, the results revealed situation on fertilizer application in KKCNP. Based on the model simulation if local people want to increase crop production, they can increase amount of fertilizer and herbicide before harvest, during growth process. However, even large amount of fertilizers, pesticide and herbicide application is up to 100 percent increase, only limited amount of crop productivity can increase. This indicates that when forest managers would like to motivate people for moving out or reducing of chemicals or fertilizer application, they can provide the adequate information of negative impacts of overused of all chemicals to local community in this area. This might sound reasonable and better way of sharing knowledges for sustainable livelihood in the national park.

For community and population structure, changing population size due to present sex ratio with specific growth rate, community and size of population are not extremely changed. This result also indicated that little forest cover change in Kaeng Krachan is very little due to this increasing population size. However, in some cases, increase in mortality rate according to poor water quality of water system in Kaeng Krachan dam may reduce effect quality of life of people in this area. However, increasing population may induce deforestation because of increasing the needs of resource utilization such as residential area, etc.

Table 5.1 Summary results of KM Model analysis

Existing condition (Scenario 1)	Results
1. Total park area (291,500 hectares)	Forest area decreases by 13.05 percent
2. .Agriculture areas (10,500 hectares)	Secondary forest increases 0.70 percent
3. Settlement area (4,000 hectares)	Forest area raided by elephants 19.73 percent
4. Forest area (277,000 hectares)	Maximum tree density 2,845 - 2,975 Ind./ha
5. Reforestation (2 percent)	Forest index 1.70
6. Wild elephants (100-200 individuals)	Maximum production ≃250,000 kilograms per year
7. Illegal logging (1 percent)	Settlement area increases 6.25 percent
8. People and community (≃100 households)	
9. Agriculture area (≃0.6-1.0 ha/hh)	
10. Organic fertilizers (≃1250 kg/ha)	
11. Pesticides and herbicides (≃3.125 litre/ha)	
12. Forest staffs (100 persons)	
Worst case (Scenario 7)	**Expected results**
6. Wild elephants (300-400 individuals)	Forest area declines 72.8 percent
12. Forest staffs (100 persons)	Total disturbed size rises up 9.62 percent
Cases 1-5 and cases 7-11, the conditions are not changed	Average tree density 1750 Ind./ ha
	Forest index 1.02
Best case (Scenario 13)	**Expected results**
6. Wild elephants (100-200 individuals)	Total forest area increases 0.18 percent
12. Forest staffs (300 persons)	Total disturbed area increases 6.72 percent
Cases 1-5 and cases 7-11, the conditions are not changed	Land encroachment reduces 77.57 percent
	Forest index 2.27

For worst case analysis (scenario 7), number of wild elephants changes from 100 to maximize at 400 individuals. While number of forest staffs are fixed at 100 persons. Other components' values are not changed from the values of existing conditions.

For best case analysis (scenario 13), number of wild elephants are fixed at 100 to 200 individuals while number of forest staffs are varied from 100 to maximize at 300 persons. Other components' values are not changed from the values of existing conditions.

5.1.1.2 Future condition

Under a 50-years running simulation period, the expected results indicated in Table 5.1, under three scenarios as existing condition, worst case and best case scenarios.

The results show that forest area will decrease by 13.05, 72.8 and 0.18 percent in existing, worst case and best case scenarios, respectively. Forest index indicates much different in values (1.70, 1.02 and 2.27). At best case analysis, forest index shows highest value. This happens only when number of forest staffs maximize at 300 persons.

When capability of logging control and of forest protection were increased (illegal logging-control rate and numbers of forest workers increased), forest area were still being encroached. This result indicated that cause of deforestation in Kaeng Krachan should occur by other factors such as land conversion for agricultural practices, with faster and higher degradation rate. In order to maximize the capability of forest protection and conservation, increasing number of forest staffs can be done in appropriate manner. Now a day, in almost protected areas, lacks of budget supports from government for worker employment. Large amount of budgets was allocated into tourism development and infrastructure development programs while budgets supported to forest protection and conservation program was reduced or prolonged. Future effects may encounter the forest in several ways.

5.1.2 Resources valuation in Kaeng Krachan

5.1.2.2 Recreational management

The results of natural resources analyzed can be concluded that if new recreational services are established, KKCNP can increase their own park revenues at least 839,732 US$ per year or 1,328,176 US$ per year. This will happen when Bus service from Kaeng Krachan headquarter to Panoen Thung and Ban Krang campsite and Forest-ranger service are provided, respectively.

The findings suggested that recreational development in KKCNP, if possible, needed more opportunity to promote and induce some new services. Such as Bus and Forest-ranger services, these new programs (based on the results of this study) can be promoted to facilitate visitors who don't have their own cars. Improvement of transportation system inside Kaeng Krachan national park may induce some difficulties to park managers, however, this may be done appropriately if environmental impact assessment of this activity is studied by forest resources managers.

5.1.2.3 Site valuation

Results of Travel Cost Method Analysis demonstrate that KKCNP generated rather high economic benefits. Consumer surplus for trip site estimated per visit was approximated at 2,428 THB per trip. Annual recreational benefit of Kaeng Krachan national park was calculated at 1,271 million THB (or US$29.58 million) in 2002s.

5.1.3 Recommendation

From the results in this study, current management plan of Kaeng Krachan national park would be recommended that more effective and possible management in future. Figure 5.1 indicates that forest manager can separate ecosystem components and divided into two main categories (forest goods and services). While local people and local community both living inside and surrounding national park can be joined in management program. There are several kinds of activities to recommended based on various perspectives. However, in this study suggestions proposes as additional parts from Kaeng Krachan current management actions, as follows.

1. Important forest management program such as reforestation should be done separately instead of embedding in a large management program. This will help forest manager determine both advantages and disadvantages of this practice directly that may be very useful for justification of this program in future management scheme.

2. Effects of wild elephants on changing forest pattern in this study roughly estimated based on the artificial assumption of elephant characteristics. Therefore, this study strongly recommended that information of wild elephant species should be studied and provided to publics. Because of wild elephants in this area play important roles to both forest structure and composition, as well as to local population. Kaeng Krachan national park should take the responsibility on this as soon as possible.

3. Kaeng Krachan national park should induce ecotourism management by involving participation of local people in management scheme. In this case, some possible and important recreational activities such as Bus service, Home stay service and Forest ranger service, as proposed in this research, can be promoted. Because of those activities provide direct benefits to the sites and to local people, therefore, less possibility that those activities will be rejected by Thais people

The findings of economic evaluation in this study revealed only for domestic recreation. In term of resource allocation, if the park wants to increase their own revenues, possible and useful tourism management plan for this specific size can be organized and induced. If possible, researcher hope that Bus service between KKCNP headquarter and interesting visiting points (not only at Panoen Thung and Ban Krang campsites), and home stay service should be promoted.

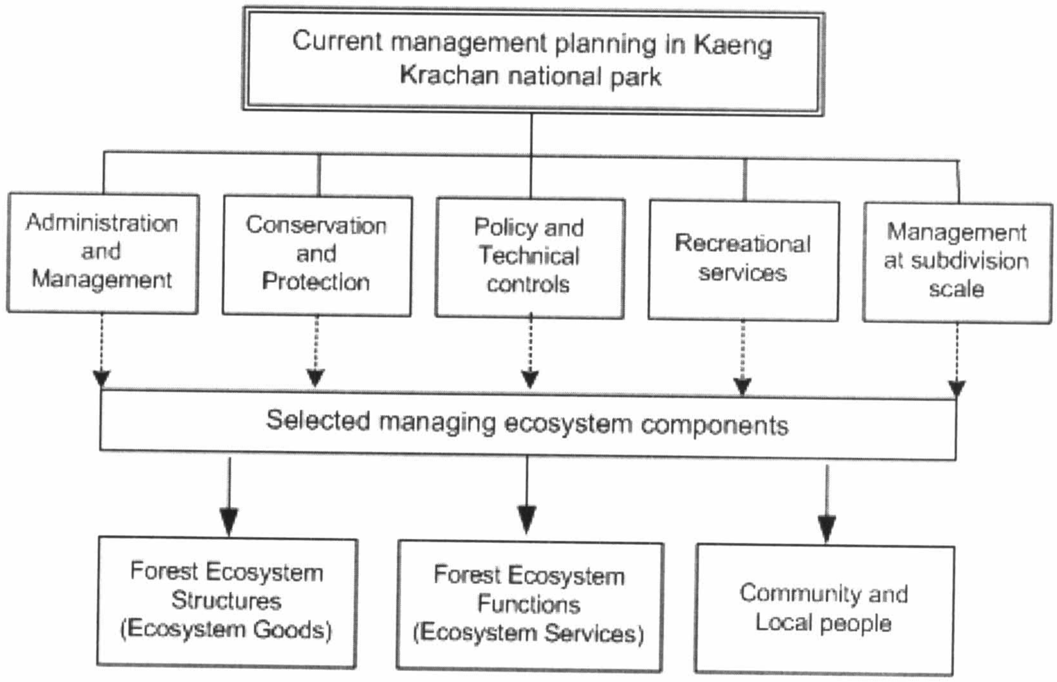

Figure 5.1 Proposed management scheme for Kaeng Krachan national park.

However, if those activities were introduced to the place, management plan must be done under more specific regulations and within specific limitations. This means that new introduced activities would not, at least, destroy the goods and natural features of the park. For examples, if the internal transportation system is set up, the infrastructure development inside KKCNP to support this system should not increase depressed atmospheric conditions to all stakeholders such as increasing in road construction inside the area. And regulation of establishment for such activities must base on agreement between park officials and local people, not only from officials' opinions.