

## Huai Kha Khaeng Forest Dynamics Plot, Thailand

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### Site Location, Administration, and Scientific Infrastructure

The Huai Kha Khaeng (HKK) Wildlife Sanctuary is a 278,000-ha reserve in the western part of Thailand. HKK is one of 17 Wildlife Sanctuaries and National Forests that together comprise Thailand's Western Forest Complex (WFC). The WFC covers an area of approximately 1,870,000 ha along the west-central portion of Thailand, making it the largest contiguous area of protected forest in continental southeast Asia. In recognition of their critical role in the conservation of the flora and fauna of continental southeast Asia, HKK and Tung-Yai Naresuan, a neighboring wildlife sanctuary, which together constitute the core of the WFC, were awarded UNESCO World Heritage Site status in 1991. The two sanctuaries form the largest area of protected land in the Indo-Burmese biogeographic region.

The 50-ha HKK Forest Dynamics Plot is located in the center of the northern half of the HKK Wildlife Sanctuary at the Khlong Phuu Research Station (fig. 27.1). The 50-ha HKK plot and associated research station are administered by the Royal Forest Department of Thailand. Facilities at the research station are limited due to the extremely remote location of the site. The research station can accommodate 6–8 visitors. It has no electricity, running water, laboratory, greenhouse, or computer facility. Less than 5 km from the 50-ha Forest Dynamics Plot is another, smaller (16-ha) Forest Dynamics Plot, located in mixed deciduous forest.

### Climate

Mean annual rainfall is 1476 mm, based on a 10-year average (1983–93) from a weather station approximately 4 km from the plot. The extent and severity of the dry season (less than 100 mm of precipitation a month) is variable; some years have sporadic rainfall during the dry season, others have little or no rain during the entire dry season. On average, though, there is a 6-month dry season lasting from November to April (table 27.1).

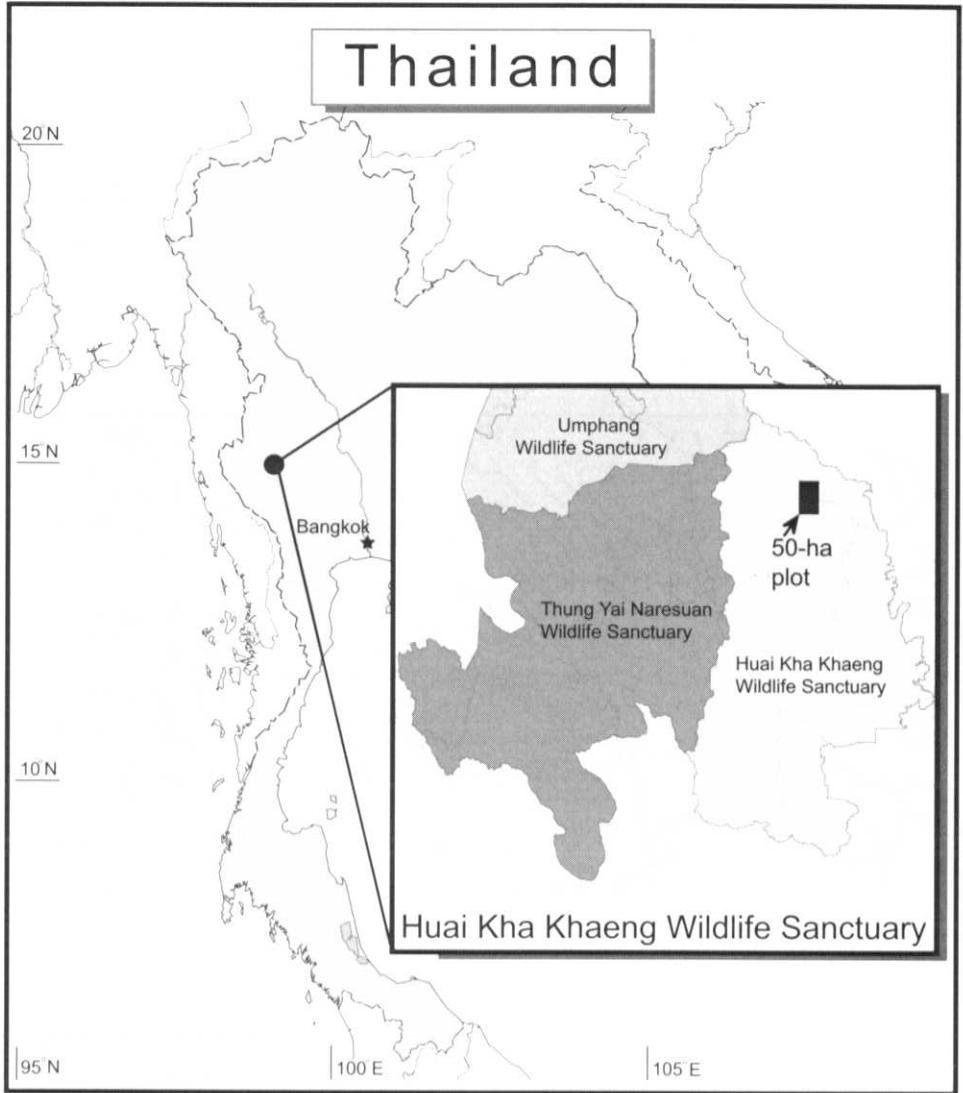


Fig. 27.1. Location of the 50-ha Huai Kha Khaeng Forest Dynamics Plot.

### Topography and Soil

The HKK plot is characterized by gently sloping terrain, punctuated by small areas with steep slopes (figs. 27.2 and 27.3). Altitude in the plot ranges between 549 and 638 m above sea level. A low hill bisects the long axis of the plot,

Table 27.1. HKK Climate Data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total/ Averages
Rain (mm)	6	30	39	82	226	120	123	155	278	360	47	10	1476
ADTMx (°C)	31.8	29.1	32.7	34.1	35.2	30.5	30.9	29.7	28.8	28.5	26.6	26.5	30.4
ADTMn (°C)	16.8	15.0	15.0	17.4	20.2	20.4	21.8	21.5	19.5	18.7	14.9	11.6	17.7
Q (W/m <sup>2</sup> )	174.8	209.6	213.4	223.7	195.9	162.4	155.7	136.8	160.8	145.0	142.5	146.3	172.2

Notes: Rainfall is an average of 1983–1993 readings at the Kapook Kapiang Ranger Station, which is approximately 4 km north of the HKK Forest Dynamics Plot. Average daily minimum and maximum temperatures (ADTM<sub>n</sub> and ADTM<sub>x</sub>) and solar radiation (Q) data are mean values from automated readings from 1992 to 1994. ADT = average daily temperature.

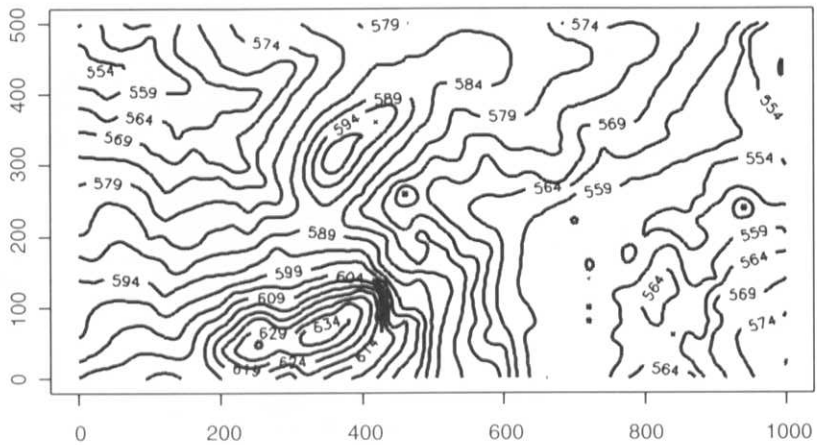


Fig. 27.2. Topographic map of the 50-ha Huai Kha Khaeng Forest Dynamics Plot with 5-m contour intervals.

dividing the plot into a southwest-facing dry side and a north-facing mesic side (Bunyavejchewin et al. 1998). An ephemeral stream runs through the northernmost edge of the plot. The plot soils are pale yellow-grey siliceous, highly weathered Ultisol soils. Soil analyses from the nearby 16-ha plot indicate that the parent material is a residuum of granite porphyry. Soil textures are sandy loam in the surface horizon and sandy-clay loam in the subsurface horizon. Clay accumulates in the lower horizons, from 40 cm downward, due to leaching and weathering of granite in upper horizons. The soil pH is neutral to slightly acidic (5.2–6.8), increasing in acidity with depth (Lauprasert 1988). Litterfall was collected between

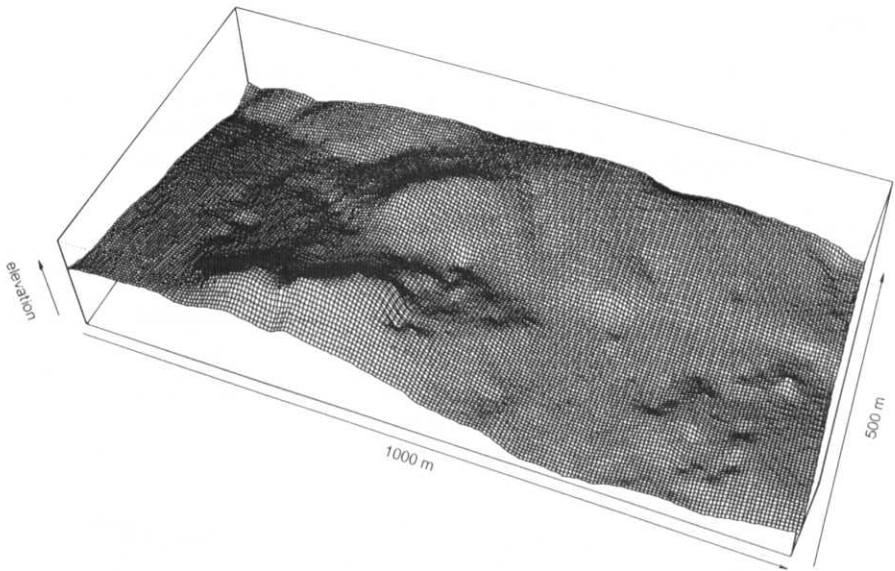


Fig. 27.3. Perspective map of the 50-ha Huai Kha Khaeng Forest Dynamics Plot.

February 1995 and January 1996 on three 1-ha plots. The mean litterfall rate for the plots was  $1085 \text{ g/m}^2/\text{year}$ .

### Forest Type and Characteristics

The HKK sanctuary includes a mosaic of several forest types including seasonal dry evergreen, mixed deciduous, and deciduous dipterocarp forests, as well as a small area of variably dry to mesic montane forests. The 50-ha HKK Forest Dynamics Plot is situated in an area of seasonal dry evergreen forest dominated by the emergent *Hopea odorata* (Dipterocarpaceae), various Annonaceae species, and mesic species such as *Acer oblongum* (Aceraceae). The forest has numerous species that are widely distributed throughout, and large isolated figs, *Ficus spp.* (strangling and free standing), which are some of the most conspicuous features of this forest type. The proportion of small trees (1–2 cm dbh) is low in comparison to that of the Malaysian lowland mixed dipterocarp forests. Species richness in the plot is relatively low, with a somewhat elevated proportion of rare species (those with fewer than five individuals in the plot). Canopy height ranges from 40 to 55 m, with occasional trees (mostly dipterocarps) more than 60 m tall. Data are not yet available for leaf area index or total aboveground biomass. For census data and rankings, see tables 27.2–27.7.

## Fauna

HKK contains at least 159 species of mammals (60 of which are bats) in 33 families, 379 species of birds in 46 families, 70 species of reptiles in 14 families, 17 species of amphibians in 6 families, and 52 species of fish in 15 families. The wildlife sanctuary has viable populations of elephant (*Elephas maximus*), tiger (*Panthera tigris*),

Table 27.2. HKK Plot Census History

Census	Dates	Number of Trees ( $\geq 1$ cm dbh)	Number of Species ( $\geq 1$ cm dbh)	Number of Trees ( $\geq 10$ cm dbh)	Number of Species ( $\geq 10$ cm dbh)
First	February 1992–August 1994	79,345	259	21,892	217
Second	January 1999–October 1999	72,509	251	21,875	214

Note: Two censuses have been completed, the next census is expected to begin in January 2004.

Table 27.3. HKK Summary Tally

Size Class (cm dbh)	Average per Hectare						50-ha Plot					
	BA	N	S	G	F	H'	$\alpha$	S	G	F	H'	$\alpha$
$\geq 1$	31.2	1450	96	78	35	1.50	23.3	251	161	58	1.63	32.6
$\geq 10$	29.4	438	65	58	29	1.48	21.3	214	144	54	1.64	32.9
$\geq 30$	20.8	82	29	28	18	1.29	17.2	148	106	44	1.61	30.0
$\geq 60$	12.1	19	9	9	7	0.83	9.7	77	56	28	1.35	19.9

Notes: BA represents basal area in  $m^2$ , N is the number of individual trees, S is number of species, G is number of genera, F is number of families, H' is Shannon–Wiener diversity index using  $\log_{10}$ , and  $\alpha$  is Fisher's  $\alpha$ . Basal area includes all multiple stems for each individual. 186 individuals were not identified to species or morphospecies. Data are from the second census.

Table 27.4. HKK Rankings by Family

Rank	Family	Basal Area			% Trees			Family	Species
		( $m^2$ )	BA	%	Trees	%	Trees		
1	Dipterocarpaceae	317.2	21.2	3.8	Euphorbiaceae	15,643	21.6	Euphorbiaceae	32
2	Annonaceae	292.1	19.5	21.5	Annonaceae	15,542	21.5	Leguminosae	17
3	Lauraceae	110.3	7.4	5.3	Sapindaceae	8,552	11.8	Moraceae	17
4	Euphorbiaceae	100.9	6.7	21.6	Lauraceae	3,859	5.3	Sapindaceae	11
5	Sapindaceae	88.5	5.9	11.8	Rubiaceae	3,846	5.3	Lauraceae	10
6	Moraceae	73.8	4.9	0.2	Ebenaceae	3,432	4.7	Meliaceae	10
7	Datisceae	64.2	4.3	1.8	Dipterocarpaceae	2,718	3.8	Rubiaceae	10
8	Ebenaceae	59.6	4.0	4.7	Rutaceae	2,565	3.5	Annonaceae	9
9	Lythraceae	56.5	3.8	1.3	Leguminosae	2,240	3.1	Rutaceae	9
10	Meliaceae	49.5	3.3	2.2	Bignoniaceae	1,658	2.3	Lythraceae	8

Notes: The top 10 families for trees  $\geq 1$  cm dbh are ranked in terms of basal area, number of individual trees, and number of species, with the percentage of trees in the plot. Basal area is calculated from only the largest stem of multiple-stemmed individuals. Data are from the second census.

Table 27.5. HKK Rankings by Genus

Rank	Genus	Basal Area (m <sup>2</sup> )	% BA	% Trees	Genus	Trees	% Trees	Genus	Species
1	<i>Hopea</i> (Dipterocarpaceae)	154.8	10.3	0.4	<i>Croton</i> (Euphorbiaceae)	10,674	14.8	<i>Ficus</i> (Moraceae)	13
2	<i>Milium</i> (Annonaceae)	130.7	8.7	2.3	<i>Polyalthia</i> (Annonaceae)	5,583	7.7	<i>Lagerstroemia</i> (Lythraceae)	8
3	<i>Polyalthia</i> (Annonaceae)	82.4	5.5	7.7	<i>Dimocarpus</i> (Sapindaceae)	5,098	7.1	<i>Syzygium</i> (Myrtaceae)	7
4	<i>Ficus</i> (Moraceae)	72.0	4.8	0.1	<i>Orophea</i> (Annonaceae)	4,393	6.1	<i>Diospyros</i> (Ebenaceae)	6
5	<i>Dipterocarpus</i> (Dipterocarpaceae)	65.8	4.4	0.4	<i>Prismatomeris</i> (Rubiaceae)	3,441	4.8	<i>Aporosa</i> (Euphorbiaceae)	5
6	<i>Vatica</i> (Dipterocarpaceae)	65.7	4.4	2.7	<i>Diospyros</i> (Ebenaceae)	3,432	4.7	<i>Cassia</i> (Leguminosae)	4
7	<i>Tetrameles</i> (Datiaceae)	64.2	4.3	1.8	<i>Phoebe</i> (Lauraceae)	2,453	3.4	<i>Aglaia</i> (Meliaceae)	3
8	<i>Diospyros</i> (Ebenaceae)	59.6	4.0	4.7	<i>Baccaurea</i> (Euphorbiaceae)	2,137	3.0	<i>Albizia</i> (Leguminosae)	3
9	<i>Lagerstroemia</i> (Lythraceae)	56.5	3.8	1.3	<i>Arytera</i> (Sapindaceae)	2,033	2.8	<i>Casearia</i> (Flacourtiaceae)	3
10	<i>Neolitsea</i> (Lauraceae)	45.9	3.1	1.4	<i>Vatica</i> (Dipterocarpaceae)	1,937	2.7	<i>Grewia</i> (Tiliaceae)	3
								<i>Homalium</i> (Flacourtiaceae)	3
								<i>Litsea</i> (Lauraceae)	3
								<i>Mallotus</i> (Euphorbiaceae)	3
								<i>Polyalthia</i> (Annonaceae)	3
								<i>Vitex</i> (Labiatae)	3

Notes: The top 10 tree genera for trees  $\geq 1$  cm dbh are ranked by basal area, number of individual trees, and number of species with the percentage of trees in the plot. Basal area is calculated from only the largest stem of multiple-stemmed individuals. Data are from the second census.

leopard (*Panthera pardus*), and wild buffalo (*Bubalus arnee*). Mammal density and biomass have been estimated in a 50–70 km<sup>2</sup> area around the nearby Khao Nang Rum Wildlife Research Station for gaur (*Bos* spp.; 1.8 ind./km<sup>2</sup> and 810 kg/km<sup>2</sup>), sambar deer (*Cervus unicolor*; dry season: 1.9 ind./km<sup>2</sup> and 255 kg/km<sup>2</sup>; wet season: 4.2 ind./km<sup>2</sup> and 563 kg/km<sup>2</sup>), common muntjak (*Muntiacus muntjak*; 3.1 ind./km<sup>2</sup> and 65 kg/km<sup>2</sup>), lesser bamboo rat (*Cannomys badius*; 777.4 ind./km<sup>2</sup> and 257 kg/km<sup>2</sup>), common tree shrew (*Tupaia glis*; 24.1 ind./km<sup>2</sup> and 4.3 kg/km<sup>2</sup>), white-handed gibbon (*Hylobates lar*; 5.4 ind./km<sup>2</sup> and 21.6 kg/km<sup>2</sup>), and elephant (0.08 ind./km<sup>2</sup> and 167 kg/km<sup>2</sup>). In addition, A. Rabinowitz (personal communication) estimates that tiger density in KNR is 0.01 ind./km<sup>2</sup> and leopard density is 0.04 ind./km<sup>2</sup>. There are several endangered animals in the HKK Wildlife

Table 27.6. HKK Rankings by Species

Rank	Species	Number Trees	% Trees	Species	Basal Area (m <sup>2</sup> )	% BA	% Stems
1	<i>Croton oblongifolius</i> (Euphorbiaceae)	10,614	14.7	<i>Hopea odorata</i> (Dipterocarpaceae)	154.8	10.3	0.4
2	<i>Polyalthia viridis</i> (Annonaceae)	5249	7.3	<i>Saccopetalum lineatum</i> * (Annonaceae)	130.7	8.7	2.3
3	<i>Dimocarpus longan</i> (Sapindaceae)	5098	7.1	<i>Polyalthia viridis</i> (Annonaceae)	81.4	5.4	7.3
4	<i>Orophea polycarpa</i> (Annonaceae)	4393	6.1	<i>Vatica cinerea</i> (Dipterocarpaceae)	65.7	4.4	2.7
5	<i>Prismatomeris malayana</i> (Rubiaceae)	3441	4.8	<i>Tetrameles nudiflora</i> (Datisceae)	64.2	4.3	1.8
6	<i>Phoebe tavoyana</i> (Lauraceae)	2453	3.4	<i>Dipterocarpus alatus</i> (Dipterocarpaceae)	62.6	4.2	0.4
7	<i>Baccaurea ramiflora</i> (Euphorbiaceae)	2137	3.0	<i>Neolitsea obtusifolia</i> (Lauraceae)	45.9	3.1	1.4
8	<i>Arytera litoralis</i> (Sapindaceae)	2033	2.8	<i>Lagerstroemia tomentosa</i> (Lythraceae)	45.3	3.0	1.0
9	<i>Vatica cinerea</i> (Dipterocarpaceae)	1937	2.7	<i>Alphonsea ventricosa</i> (Annonaceae)	43.4	2.9	1.7
10	<i>Mitrephora thorelii</i> (Annonaceae)	1816	2.5	<i>Arytera litoralis</i> (Sapindaceae)	36.0	2.4	2.8

\*Genus *Saccopetalum* now changed to *Milusa* according to Mabberley (1997).

Notes: The top 10 tree species for trees  $\geq 1$  cm dbh are ranked by number of trees and basal area. The percentage of the total population is also shown. Basal area is calculated from only the largest stem of multiple-stemmed individuals. Data are from the second census.

Table 27.7. HKK Tree Demographic Dynamics

Size Class (cm dbh)	Growth Rate (mm/yr)	Mortality Rate (%/yr)	Recruitment Rate (%/yr)	BA Losses (m <sup>2</sup> /ha/yr)	BA Gains (m <sup>2</sup> /ha/yr)
	93–99	93–99	93–99	93–99	93–99
1–9.9	1.84	4.84	5.70	0.06	0.13
10–29.9	2.50	1.89	2.63	0.17	0.31
$\geq 30$	3.13	1.92	1.85	0.35	0.31

Note: Basal area is calculated from only the largest stem of multiple-stemmed individuals.

Sanctuary, including the clouded leopard (*Neofelis nebulosa*), white-winged duck (*Cairina scutulata*), and green peafowl (*Pavo muticus*) (Srikosamatara 1993).

### Natural Disturbances

Low-intensity surface fires are an important natural disturbance in the HKK area, and affect all size classes of trees. During the dry season, deciduous dipterocarp and mixed deciduous forests are particularly prone to forest fires. They support

thick understories dominated by grass and bamboo, respectively, which can be extremely dry and flammable. The effect of fire on forest composition is debatable, but there is concern that the fires are increasing the extent of deciduous dipterocarp forest and decreasing the extent of evergreen forest. Widespread fires occur approximately every 3–10 years. In 1991 and 1998, fire swept through the Forest Dynamics Plot. In 1992, a small portion of the southeast corner of the plot was burned.

Windthrows and elephants are responsible for numerous treefalls and tree damage in the plot. Wild pigs cause small-scale damage to the vegetation by digging into the ground and affecting seedling recruitment.

### Human Disturbance

Continental southeast Asia has been populated for at least 10,000 years. Historical population densities in the region of the WFC are unknown. In recent decades there has been considerable population growth, which has led to widespread land conversion for agriculture. Many of the fires that occur in the HKK forest are set by people living in the area. The hunting of animals for food and the extraction of timber and nontimber products (mushrooms, fruits, medicinal plants, honey, and game) are illegal and laws preventing these activities have been enforced with a fair degree of vigilance since 1972, the year HKK was gazetted as a wildlife sanctuary. However, some poaching continues at irregular intervals. Logging within HKK, which was primarily focused on trees over 100-cm girth, was halted upon establishment of the sanctuary; however, logging in the National Forest to the north of HKK, which is within about 5 km of the Forest Dynamics Plot, continued until the late 1980s. The plot itself is located in a block of forest that has never been logged. The distance from the plot to the nearest forest edge varies by direction. The nearest area of nonforest is approximately 20 km to the east and includes the outlying fields of local villages. Forests extend at least 40–50 km to the north, south, and west.

### Plot Size and Location

The HKK is a 50-ha, 500 × 1000 m plot; its long axis lies north-south. The northwest corner of the plot is located at 15°37'58.4"N and 99°12'34.1"E. The southeast corner is 15°37'54.7"N and 99°13'28.2"E.

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