

## Natural Vegetation And Forests

### Natural Vegetation

Vegetation analysis is one of the basic analytical tools for developing an understanding of mountain environments. Vegetation is an overall expression of various environmental factors, which operate continually or in a cyclic fashion. It is well known that areas that are climatically similar will be characterized by similar plant forms. Therefore, observations on dominant vegetation and their response to human interaction would provide useful clues to identify environmentally homogeneous or heterogeneous areas. Identification of similar areas for similar treatments is basic to all management practices.

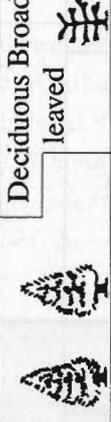
In the Himalaya, changes in vegetation type occur not only with respect to altitude, latitude, slope angle, slope aspect, and soils but also with respect to rainfall patterns. On the basis of vegetation maps, Dobremez (1976) has provided an interpretation of the ecology of various parts of Nepal. Alpine and sub-alpine zones along Nepal Himalaya and the tropical zone along the Terai and foot-hills show uniform pattern of vegetation distribution all along Nepal, from east to west. However, the intervening area lying between 1,000 m and 3,000 m (sub-tropical and temperate zones) exhibits a great degree of diversity. There is a pronounced difference in vegetation type between west, central and east Nepal (Fig. 7). Above all, this zone (1,000 m-3,000 m) is the principal area of human occupation and cultivation.

Challenges of mountain development lie largely in the biophysical diversity of mountains. Classification of differing ecological regions and providing them with appropriate names have, however, been caught in a complexity of differing opinions and concepts. One of the most simple and convenient methods for describing ecological conditions of a mountainous region is to define "life zones" in terms of temperature and elevation. With the change in altitude, we find a complete range of change from tropical to arctic conditions, and natural vegetation has become a useful tool to identify and delimit various zones. Dominant plants or vegetation types are generally employed as bioclimatic indicators. Various authors have attempted to define climatic zones in terms of altitude (fig. 8). In the Arun Basin, six zones have been identified and they are characterized in Table 3.

Table 3 : BIOCLIMATIC ZONES IN ARUN BASIN

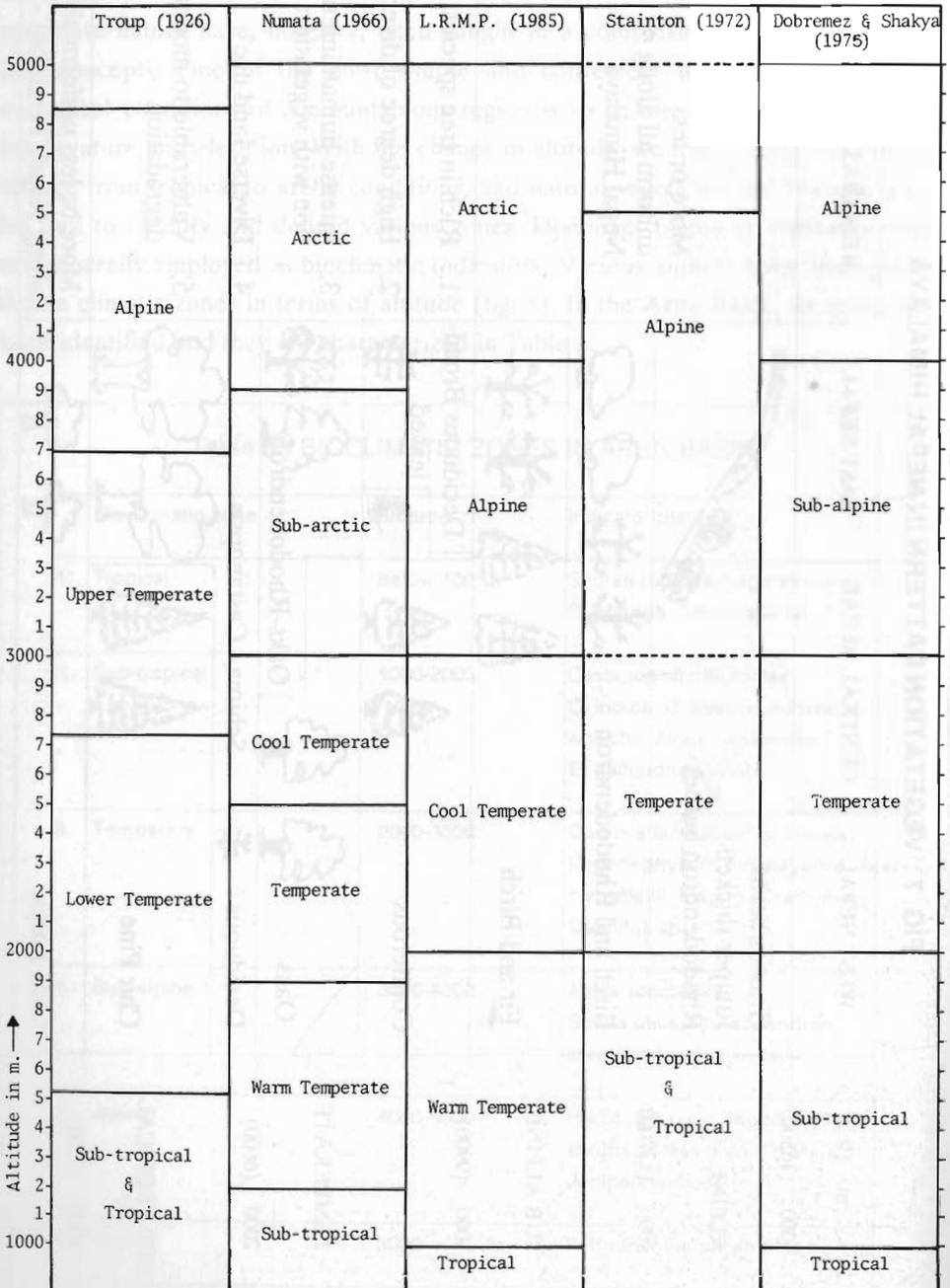
Bio-climatic zone	Altitude (m)	Indicator plants
1. Tropical	below 1000	<i>Shorea robusta</i> , <i>Lagerstroemia</i> , <i>Duabanga</i> , <i>Terminalia</i> sp.
2. Sub-tropical	1000-2000	<i>Castanopsis tribuloides</i> , <i>C. indica</i> , <i>C. hystrix</i> , <i>Schima</i> <i>wallichii</i> , <i>Alnus nepalensis</i> , <i>Engelhardtia spicata</i>
3. Temperate	2000-3000	<i>Quercus lamellosa</i> , <i>Q. lineata</i> , <i>Daphniphyllum himalayense</i> , <i>Acer</i> <i>campbellii</i> , <i>Magnolia campbellii</i> <i>Machilus</i> sp.
4. Sub-alpine	3000-4000	<i>Abies spectabilis</i> , <i>Betula utilis</i> , <i>Rhododendron</i> shrubland over 1 m tall.
5. Alpine	4000-5000	Herbs, grasses, <i>Rhododendron</i> shrubs of less than 0.5 m, <i>Juniperus indica</i>
6. Nival	5000 +	Permanent snow and ice

FIG. 7 : VEGETATION PATTERN IN NEPAL HIMALAYA

m. (ft.)	WEST NEPAL	CENTRAL NEPAL	EAST NEPAL	REMARKS
5000 (16500)	Grasses/herbs Juniper thickets Rhododendron bushes			More or less uniform all along Nepal Himalaya
4000 (13200)	Birch and Rhododendron			
SUB ALPINE	Fir and Birch			1. Rich in tree species 2. High degree of diversity
3000 (9900)	Coniferous		Deciduous Broad-leaved	
TEMPERATE	Oaks		Oaks-Rhododendron	3. Intense human interaction with vegetation 4. Diverse land use
2000 (6600)	Deciduous		Schima - Castanopsis	
SUB TROPICAL	Chir Pine			5. Vulnerable to mountain degradation
1000 (3300)	Saal Forest			

More or less uniform all along Nepal Terai/foot - hills.

FIG. 8 BIOCLIMATIC (ALTITUDINAL) ZONATION PROPOSED BY VARIOUS AUTHORS. (E. NEPAL)



Forests bear a close relationship with the environment of an area. Figures on forest coverage in Nepal show considerable variation. The present work has relied more on LRMP figures and maps since they are based on data from a broad coverage with 1:50,000 stereo air photographs, combined with field work. Accordingly, the forest coverage (including shrubland) in the Arun Basin is estimated to fall near 2,538.6 km<sup>2</sup>, which is about 50.48% of the total area (vide Table 7). However, when shrubland is excluded the forest coverage is only 32.5 per cent (Table 4). This figure is not so encouraging as compared to the figure estimated for the whole of Nepal (42.7 per cent). Therefore, protection of forests should still be given high priority in the management of Arun Basin.

The classification of forest types and vegetation of Eastern Nepal (including the Arun Basin) has been attempted by many authors. Dobremez and Shakya (1975) identified 30 types of vegetation in Eastern Nepal. Ohsawa et al (1983) classified the Arun Valley into five zones as *Shorea* zone, *Schima-Castanopsis* zone, *Quercus* zone, *Acer* zone, and the *Abies* zone. These life zones may be used conveniently for describing natural vegetation and forests of the Arun Basin. Forest coverage by climatic zones is summarized in Table 4.



The Sabahaya khola, a Southern tributary of the Arun, is quiet when it nears the confluence. Impressive Saal forest (*Shorea robusta*) is seen in the valley

### A. Tropical zone (below 1,000 m)

Although the Himalaya does not lie strictly within the tropics, natural vegetation and climatic conditions more akin to tropical regions do prevail in areas lying below 1,000 m altitude. The occurrence of Dipterocarpus forest, supplemented with palms, cycads, tree ferns, bananas, etc., does characterize the tropical zone. Mean temperature for the coldest month does not drop below 18<sup>0</sup>C, and frost is totally absent. In most of the Arun Basin, the aspect of slopes does not exhibit any great influence on vegetation as one might expect in other parts of Nepal. *Shorea robusta*, "Sal", is the dominant tree of this zone, and the hill sal forests, which have developed on laterite slopes along river courses and along shaded gullies, give an impression that the Arun Basin is well maintained in this zone. The tropical area covers about 1,347 km<sup>2</sup>, i.e., 22.74 per cent of the total area covered by the three districts (Dhankuta, Bhojpur, and Sankhuwasabha). Forest coverage may be estimated to fall near 8.29 per cent in the tropical area (Table 4).

Table 4 : DISTRIBUTION OF LAND, FORESTS, AND PEOPLE  
BY BIOCLIMATIC ZONES

Climatic zone	Tropical (< 1km)	Sub-tropical (1-2km)	Temperate (2-3km)	Sub-alpine (3-4km)	Alpine (> 4km)	Total
1. Land Area in km <sup>2</sup> (Percentage)	1347.32 22.76%	1996.82 33.73%	1081.82 18.27%	596.43 9.62%	924.74 15.62%	5920 100%
2. Forest Area in km <sup>2</sup> (Percentage)	450.00 8.3%	494.2 9.00%	623.8 11.4%	211.90 3.8%	- -	1779.8 32.5%
3. Population Density per km <sup>2</sup>	11.53	133.44	46.74	8.20	-	73

Source :

1. Based on contour maps of three districts - Dhankuta, Bhoj-pur, and Sankhuwasabha
2. Based on LRMP maps no. 72 M/1 to 72 M/8. Total 8 maps covering 5470 km<sup>2</sup>.
3. Point-by-point population map (1981 census), updated to 1987

## B. Sub-tropical Zone (1,000-2,000m)

This zone is characterized by the occurrence of *Schima wallichii*, the "Chilaune" tree. The Area of this zone amounts to 1,997 km<sup>2</sup>, of which only 9 per cent is under forest cover. Population density of 145 person per km<sup>2</sup> in Dhankuta, 127 person per km<sup>2</sup> in Bhojpur, and 37.2 person per km<sup>2</sup> in Sankhuwasabha (Central Bureau of Statistics, 1986) refers mostly to this zone. Most of the terrain with less than 40° slope is terraced. Spring thunderstorms followed by monsoon rains allow intensive agricultural practices.

Of the 30 vegetation types of eastern Nepal (Dobremez and Shakya 1975), six types are represented in this zone. However, four major types of forests will be discussed here.

### (a) *Schima* -- *Castanopsis* forest

The Arun Basin is a country of *Castanopsis*, i.e., chestnut trees. Trees of *Schima wallichii* form forests with *Castanopsis indica* at lower levels below 1,500 m, and with *C. tribuloides* at the upper levels of 1,500-2,000 m. *Schima* forest develops on all aspects of the slope, unlike in central Nepal where it is limited to northern aspects only. Undisturbed forests attain a canopy height of 25 m, while disturbed forests have heavily lopped trees hardly reaching to 10 m. A number of shrubs and trees, like *Engelhardtia spicata*, *Callicarpa arborea*, *Rhus javanicus*, *Osbeckia stellata*, *Mallotus philippinensis*, get associated with *Schima* when forests are used by villagers. Forest floors have a dense undergrowth of *Nephrolepis* fern on drier habitats, and of *Eupatorium* on wet ravines and gullies.

*Schima wallichii* has a good capacity for self-regeneration and hence it may be employed as an afforestation species. Ohsawa (1983) observed abandoned paddy terraces being replaced by *Schima* after some 70 years, and the trees have attained a height of 21 m. The rate of growth comes to some 0.3 m per year. In Kathmandu, in the forest at Nagarjun, Kanai et al (1975) observed that the chir pine forest was gradually replaced by *Schima wallichii* on north-facing slopes.

#### b) *Semi-evergreen Hill Forest*

Water courses and steep slopes indicate a very mixed type of broad-leaved forest, with some *Schima wallichii* and *Castanopsis* trees mixed largely with a number of other trees like *Betula ulnoides*, *Choerospondias axillaris*, *Saurauja napaulensis*, *Cedrela toona*, and *Talauma hodgsonii*. A large number of epiphytic orchids (*Coelogyne*, *Cymbidium*, *Dendrobium*, *Bulbophyllum*, *Erica*) and climbers occur in such forests. Ohsawa (1983) listed 16 species of climbers from this zone alone. Such forests provide a valuable source of indigenous genetic material for fruit, fodder, bamboo, and grass.

#### c) *Alnus nepalensis Forest*

It has a wide range of altitudinal distribution from 1,000m to 2,500 m. In the sub-tropical zone, are found rapid colonizer trees on unstable slopes, fresh landslides, and wet ravines. This species can colonize abandoned slopes in about five years time, attaining 8 m height. It has often to compete with *Eupatorium adenophorum* at seedling stage but later both grow well in mutual association. It is a favourite tree for villagers due to its straight poles, fodder leaves, and firewood. In natural succession, *Alnus* forests give way to *Schima - Castanopsis* after the slope has stabilized. Strips of *Alnus* forests along streams and gullies provide an excellent habitat for the cultivation of cardamom.

#### d) *Castanopsis tribuloides Forest*

*Castanopsis tribuloides*, in its undisturbed natural state, forms a closed canopy of monospecific forest with very tall trees of 25-30 m. Such forests are largely limited to inaccessible areas due to large distances from villages. The process of burning down the forest for extending cultivable land is diminishing this type of forest at altitudes of about 2,000 m.

#### e) *Other forest types*

Pure forests of *Rhododendron arboreum* are to be seen on drier south-facing slopes. The grandeur of this flower is best observed on the Milke Danda during April and May. Although it is the National Flower of Nepal, people hardly spare it

from burning and lopping. At times it is mixed with oak trees. Water streams are scarce in *Rhododendron* forests.

*Pinus roxburghii*, which is so important in western and central Nepal as an afforestation tree, is rather scarce in the Arun Basin. It develops in areas with less than 1,000 mm of rainfall per year and with high radiation on south-facing slopes. *Pinus roxburghii* is generally replaced by *Schima wallichii* in natural succession.

*Lagerstroemia parviflora*, a small tree of 3-5 m or rather a shrub, occurs in highly degraded and rocky slopes in southern Arun. Moist slopes with rich soil conditions, however, favour the *Albizia mollis* tree. Occurrence of this tree suggests that tea cultivation would be promising in the sub-tropical side valleys of the Arun.

The sub-tropical zone has over 1,600 species of plants. About 60 species of them are being currently used as fodder trees. Besides, some rare and endangered species, such as *Talauma hodgsonii*, *Cythea spinulosa*, *Podocarpus nerifolius*, *Quercus fenestratus*, and *Gnetum montanum*, are surviving a precarious existence in narrow gullies and gorges in the Arun Basin.



The Milke-danda ridge, which separates the Arun Watershed from the Tamur, is rich in rhododendrons. Grassy slopes are interspersed with rhododendron forests

### C. Temperate zone (2,000 m-3,000 m)

This zone lies just beyond the altitudinal limit of general agricultural/cereal cultivation. Winter is pronounced with frost and some snow. Mean annual temperatures vary between 8<sup>0</sup>C and 15<sup>0</sup>C. The ground generally remains overshadowed with clouds during the growing seasons. This becomes the main limiting factor for crop cultivation. However, floristic diversity, with over 1,400 species of plants, makes it an important area of genetic resources. At about 2,000 m altitude, forests of Arun are subjected to double pressure of grazing, i.e., from highland livestock (yaks and yak-hybrids, sheep) and from lowland livestock (buffaloes, cows/goats). Over 40 different types of trees and shrubs are used as fodder plants.

Dobremez and Shakya (1975) have identified 10 types of vegetation in the temperate zone of eastern Nepal and they could well be grouped into two categories.

#### a) Lower Temperate Mixed Broad-leaved forest

Forests of *Schima-Castanopsis* gradually pass into an oak-laurel forest, with a number of Magnoliaceae plants. Humid conditions are conspicuously expressed in terms of rich moss flora, epiphytic orchids, and vines. Forest floors have moss-carpeted rocks and fern infested ravines. The first canopy of trees (*Quercus lamellosa*) grows to a height of 35 m or 40 m, while the second storey of lauraceous trees and magnolias remain at 12-15 m in height. Disturbances due to human pressure promote the growth of bamboos on drier steep slopes (>40<sup>0</sup>) while, on gentler slopes, big-leaved shrubs and trees such as *Mallotus nepalensis*, *Ehretia macrophylla* and *Leucocephalum canum* form a secondary vegetation. Plants of good economic value, such as *Lycopodium clavatum* (medicinal), *Daphne sp.* (paper plant), *Girardinia diversifolia* (fibre plant), may be promoted by partial disturbances of temperate forests of the Arun Basin. Ravines and shaded slopes are generally occupied by *Ahus nepalensis* at lower levels and *Daphniphyllum himalaica* at higher altitudes. Both trees grow well in association with cardamom.

#### b) Upper Temperate Mixed Broad-leaved forest

At about 2,400 m or 2,500 m, the temperate forest is conspicuously enriched with a number of deciduous trees. Among the most important ones are the gigantic

maple trees (*Acer campbellii*) and *Magnolia campbellii*, reaching 25 to 40 m in height. A number of other trees, such as *Sorbus cuspidata*, the Himalayan bean, *Tetracentron sinense*, a primitive flowering plant which is restricted to eastern Himalayas, *Prunus nepalensis*, and *Pentapanax sp.* and so on, are frequently encountered. The low altitude birch (*Betula cylindrostachya*) and the high altitude birch (*B. utilis*) interpenetrate in this zone. In addition, a large number of smaller trees and shrubs belonging to evergreen broad-leaved categories occur as a second layer. Some of the important ones are *Osmanthus suavis*, *Ilex dipyrena*, *Corylus ferox*, *Symplocos sp.*, and some laurels like *Lindera sp.*, and *Litsea sp.* On some drier places, *Lyonia ovalifolia* and *Rhododendron arboreum* form patches of forests. Towards the head of river valleys, *Tsuga dumosa*, the Himalayan hemlock, occurs in isolated stands on drier slopes.

This zone is also good for bamboos when natural vegetation gets disturbed. In wetter areas, disturbed grounds are covered with rambling raspberries (*Rubus sp.*). This zone has been identified as cool-temperate deciduous broad-leaved forests by Ohsawa et al (1973). Their occurrence in the Iswa valley and the Kashwa valley adds a remarkable feature to the forest ecology in the Arun Basin.

Cattle breeding activities and pasture management in the *Acer* zone is of considerable significance. Flat pieces of land and gentle slopes are cleared to establish 'Goths' and they are used mainly during the summer and the monsoon.

#### **D. Sub-alpine Zone (3,000-4,000 m)**

This zone is characterized by the occurrence of silver fir (*Abies spectabilis*), all along Nepal Himalayas. This zone essentially falls between the tree-line and the upper limit of cereal cultivation. Winter is severe and snowfall is heavy enough to knock down branches and trees. Drizzling rain and enveloping clouds become a regular feature during the monsoon period.

Patches of *Abies* forest develop on alluvial fans, as well as on moraine deposits. They are rather shallow rooted, and one often sees quite a few fallen trees in a fir forest. At lower elevations towards 3,000 m, fir trees give away to dense thickets of bamboos when the forest is destroyed by fire or by other hazards like landslides. At higher elevations about 4,000 m, especially in moraine valleys, patches of fir forests

are seen among the shrubland of willows and rhododendrons. Open grasslands of the sub-alpine zone are principal areas of animal husbandry. Gentle slopes of sub-alpine valleys above 3,200 m have generally a sweep of rhododendron thickets, with a tangling mass of gnarled stems and a blanket of green leaves and flowering branches. Species commonly found here are *Rhododendron campanulatum*, *Rh. wallichii*, *Rh. campylocarpum*, *Rh. wightii*, *Rh. fulgens*, etc. Stainton (1972) classifies this type of vegetation as "moist alpine scrub".

The sub-alpine zone in the Arun Basin is very rich in birch forest (*Betula utilis*) which has often a number of other deciduous trees like *Acer* spp., *Sorbus* spp., *Virburnum* spp. etc. At places, this deciduous forest of birch is supplemented by evergreen coniferous species like *Tsuga dumosa* and *Abies spectabilis*. *Tsuga dumosa* sometimes forms a pretty forest, with *Rh. hodgsonii* and *Rh. barbatum* as undergrowth on drier ridges.

The sub-alpine zone is also a rich source of medicinal herbs, which are collected by shepherds for selling in nearby markets. Commercially important medicinal herbs are listed in Appendix I.

The sub-alpine zone of the Arun Basin is remarkably different from adjoining Dudhkosi valley where there is a preponderance of *Quercus semecarpifolia* and *Tsuga dumosa* in the *Abies* zone (Yoda 1967), and is also different from its eastern adjoining Tamur valley where *Lithocarpus pachyphylla* and *Tsuga dumosa* are very pronounced in the forest flora. The Arun valley, which lies between the Dudhkosi valley and the Tamur valley, has a more humid environment as is shown by the preponderance of *Rhododendrons* and deciduous trees.

#### E. Alpine zone (4,000 - 5,000 m)

This zone represents a treeless country, with vast stretches of shrublands interspersed by rocky slopes and grassy meadows. The floristic richness of this zone, in terms of colourful flowers and medicinal herbs, is quite remarkable. About 450 species of flowering plants have been recorded from this zone. Pasture lands of alpine valleys become a crowded place during the monsoon season due to sheep and yak grazing on the one hand and, mountaineering teams on the other. Large areas of



Saldima Valley shows a transect of alpine and sub-alpine vegetation on its slopes. The birch forest, the fir forest and rhododendron shrubland are seen in a row of succession

shrubland (*Rhododendrons*, *Junipers*) are cleared by people collecting firewood. One load of firewood would need about 25 m<sup>2</sup> of shrubland clearance.

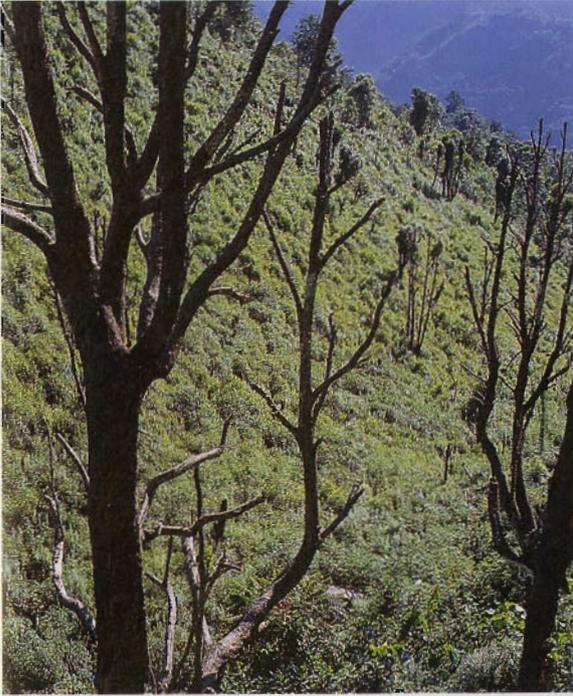
The lower part of the alpine zone in the Arun Basin is generally covered by a thick blanket of "moist alpine scrub" (Stainton 1972), which is composed of about half a dozen *Rhododendron* species (*Rh. campanulatum*, *Rh. campylocarpum*, *Rh. fulgens*, *Rh. nivale*, *Rh. wallichii*, *Rh. wightii*). This vegetation is characterized by a tangled mass of interwoven gnarled stems, which create a safe refuge for alpine birds and small mammals. It can hold large amounts of snow as reservoirs of water for downstream valleys.

The grasslands of the alpine zone have 90 per cent ground coverage, and generally consist of four important grass species, i.e., *Carex* sp., *Calamogrostis* sp., *Agrotis micrantha*, *Festuca leptogonum*, with a large number of flowering plants like *Primula* sp., *Androsace* sp., *Potentilla* sp., *Gentiana* sp., and so on. Heavily grazed grasslands soon get converted into colourful carpets of *Primula* sp., *Potentilla* sp, etc. It is not known if such colourful alpine meadows of flowering plants would revert back to grasslands. However it has been observed that burning and clearing of shrublands (*Rhododendron* and *Juniperus*) give rise to grasslands suitable for grazing. The Arun Basin does not have a steppe zone of cushion vegetation with thorny plants like *Caragana* sp., and *Astragalus* sp.

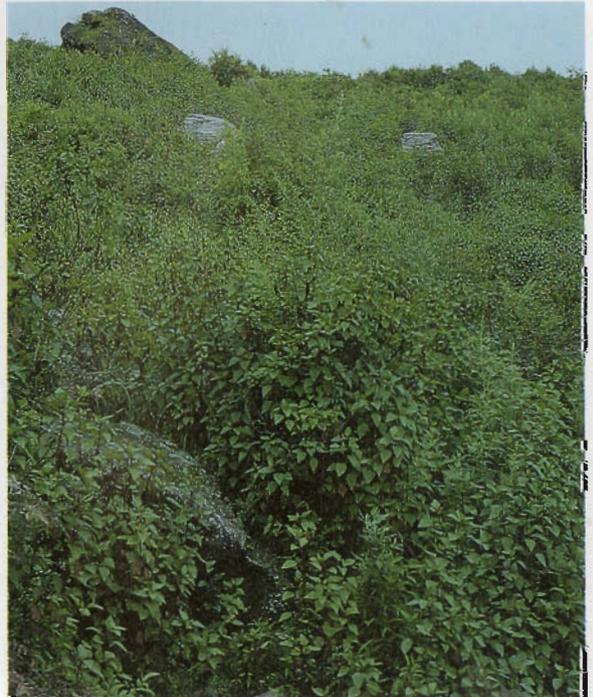
### **Role of *Eupatorium adenophorum* (Banmara)**

No story of the ecosystem of midland hills in eastern Nepal will be complete or comprehensive without taking note of the role played by a newly introduced forest weed called Banmara, meaning forest killer. The spread of Banmara in Nepal coincided with the spread of the then Congress activities to overthrow the Rana regime in 1951. Thus, in some areas, this weed is also known as the "congress weed". In plant science, it works out to be *Eupatorium adenophorum*.

Banmara has a remarkable range of altitudinal distribution (800 m to 2,000 m), which overlaps with human settlements. Thus it becomes a central theme in farmland, pasture, and forest management. Abandoned slopes after slash-and-burn cultivation are generally invaded first by the Banmara. This provides a vegetal cover to exposed slopes. Similarly, fresh landslides or areas with deep gully cuttings and



An abandoned slope invaded by the forest weed *Eupatorium*, after slash-and-burn cultivation. Burnt trees are seen on the fore-ground



The *Eupatorium* gives a blanket cover to the deforested slopes

open grasslands are also encroached by this plant. It never invades deep forests, where light becomes a limiting factor for its growth. Heavily disturbed forests, however, allow its growth as soon as forest floors receive adequate sunlight. Then it hampers the natural process of forest regeneration through seeds.

Invasion by Banmara over marginal grazing lands has become the main cry of midland farmers. Attempts to control it through the use of a gall fly (*Procecidochares utilis*) have not yet achieved any great success.

In the Arun Basin, the Banmara is a boon in disguise because it reduces soil erosion. Moreover, it has been used as green manure during the spring, when the plant is heavily laden with leaves. It has also been accepted as a cattle bedding. Dried Banmara may be burnt to yield potash rich fertilizer (Wilson et al. 1985).

### Biological Diversity

There has been great awareness and serious concern about the conservation of biological resources and their development in the context of environmental management. Biological diversity in the Arun Basin is not only a source of ecological information on the 'health' of an ecosystem, nor just a source of aspiration for aesthetic luxury or academic exercise, but also a source of many valuable commodities of interest to our own society. A large number of plants or animals are still poorly known despite their high economic potentiality as medicines, oils, fibres, fodder, etc. However, there has been an ever-increasing threat to many biological species from habitat destruction and poaching. It would be a matter of shame to this generation if they become extinct before they were known to mankind.

The Arun Basin marks the beginning of the east Himalayan humid flora, which extends to Sikkim, Bhutan, Assam, and south east Tibet. The preponderance of rhododendron, oak, maple, magnolia, laurel, and orchids adds a distinctive feature to this Basin, as compared to other areas in Nepal. Occurrence of a number of relic plants, such as *Tetracentron sinense* and *Cycas pectinata*, *Gnetum montanum* and evidences of evolving new species through free hybridization e.g. *Rhododendron campylocarpum* x *R. thompsonii*, *Meconopsis napaulensis* x *M. paniculata* illustrate the significance of this Basin as a biological treasure in the Hindu Kush-Himalayan region. There are some 17 species of oak trees (Cupuliferae) in the Hindu Kush-



*Rhododendron arboreum* is the National Flower of Nepal (Lali Guras). Flowering period falls between March and May



*Rhododendron cinnabarinum* is one of the most beautiful shrubs at Sub-alpine regions

Himalaya and 15 of them occur in the Arun and the Tamur Basins of east Nepal. Of them, only 10 species extend to central Nepal, while all of them continue to occur eastwards to Sikkim and Bhutan (Dobremez 1976).

Similarly, of 30 species of *Rhododendrons* only 15 species occur in central Nepal, while most of them extend eastwards. The distribution of *Primula* (Primrose) also suggests a close affinity of east Nepal with Sikkim rather than with adjoining central Nepal (Shrestha 1982). The wealth of flowering plants and ferns of east Nepal amounts to over 3,000 species which is over 50 per cent of the total Nepalese flora (Shakya 1979). The pattern of vertical distribution (see Table 5) suggests that the sub-tropical and the temperate zones (1,000 m-3,000 m) have a rich flora, with over 1,600 and 1,400 species, respectively. In Nepal Himalaya, this belt is quite heterogeneous from eastern Nepal, to western Nepal as indicated by forest types (Table 5). Besides, this belt is being used intensively for human occupation and agriculture.

Table 5 : NUMBER OF PLANT SPECIES BY CLIMATIC ZONES

Plant Group	Climatic Zone					Total No. of Spp.
	Tropical	Sub-tropical	Temperate	Sub-alpine	Alpine	
Pteridophyte	97	191	187	73	12	303
Dicotyledons	683	1048	915	664	327	2196
Monocotyledons	289	380	328	211	102	770
Gymnosperms	3	5	5	5	2	14
Total	1072	1624	1435	953	443	3283

The floral wealth of the Arun Basin has been widely recognized because of the contributions of Japanese scientists (see, for example, Hara 1966 and Numata 1983 a,b, and c). The wealth of wildlife still awaits further exploration and publication. The Arun valley Wildlife Expedition, led by E.W. Cronin during 1970-73, made a large collection of mammals, birds, reptiles and insects (Cronin 1979). The Barun Valley Report (1984) listed 25 mammals, including Musk deer, Snow leopard, Water shrew, Red panda, Magnificent flying squirrel, Himalayan striped squirrel,

Himalayan black bear and Assamese monkey. It listed 131 birds for the Barun valley, including, two new records (Spotted wren babbler and Dark slaty-bellied ground warbler). In August-September 1986, the ICIMOD Scientific Expedition to Arun spotted 112 species of birds while traversing north-south. (Appendix II). Among the birds, mention may be made of the largest Himalayan bird, the Lammergeier, which soars even at an altitude of over 7500 m with its huge wing span of 2.7 m, the Spiny babbler (a Nepalese endemic species), Peregrine falcon, and the Long tailed cuckoo dove. The butterflies of Arun Basin are known only meagrely. Murata and Hori (Numata 1983 c) reported 51 species and the ICIMOD expedition added a very rare species 'The Blue Duke' from the Num area in the Arun valley.

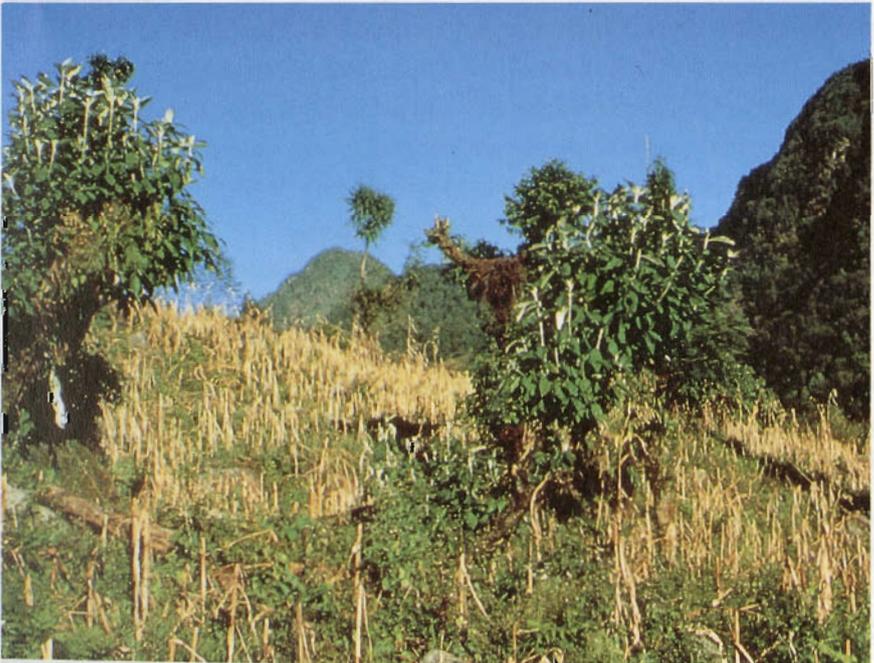
Fish fauna of the Arun river has not yet been investigated systematically. On the basis of various publications, Rajbansi (1982) listed 84 species of indigenous fishes for the Kosi Basin. Of them, 13 species may be attributed as special to the Kosi Basin (Appendix IV). The famous Jalkapur i.e. water camphor in Nepalese language, was described as *Barilius jalkapooei* only in 1977, although its delicacy was widely known in Nepal since time immemorial. This fish is not known outside the Kosi Basin. Similarly "Pothia" (*Puntius clavatus*), "Thed" (*Labeo angra*), "Bogra" (*L. bogra*), Bata (*L. bata*), etc., are also not recorded in other parts of Nepal. The Kosi is also famous for well known game fish, like "Mahasher" (*Tor putitora*), "Shahar" (*Tor Tor*), Asla (*Schizothorax sp.*) and other table fish of high repute like "Rohu" (*Labeo rohita*), and "Katile" (*Acrossocheilus hexagonalepis*). These fish are known to be migratory and are susceptible to any changes in the quality of water. In an area like the Arun Basin, where there is a serious lack of information on physical environment, biological indicators like fish, birds, and plants could profitably be used to examine "the health of an ecosystem" for development planning.

The contemporary world has begun to realize that conservation of biological diversity should be a component of every development scheme. This is more true for mountainous regions in the Himalaya where poverty, hunger, and diseases are displacing poor farmers to regions where they have to destroy rich genetic materials in order to make a living.

Formation of parks and reserves in the threatened areas would be an important element for survival of biological diversity; but such protected areas will survive only if they exist in the context of an economy that can support them (Raven 1986).



The Barun valley has virgin forests even at low altitudes. A typical mixed forest of oak and laurel with some maple is seen at about 2,000 m



Encroachments into the Barun Valley for growing maize. Some remnants of *Saurauja* trees are seen in the maize field

Proper management of national parks is not viable without adequate provisions for the basic needs of rural communities that reside on the fringes of such protected areas (HRH Prince Gyanendra 1985). The Makalu- Barun Nature Conservation Seminar (1985) has emphasized that the Barun valley and its adjoining areas, extending to the Sagarmatha National Park, be identified as a protected area -- a Nature Reserve (Fig. 9A). Strong opinion among scientists and conservationists has already been formed to create a protected area of some 1,400 km<sup>2</sup> in Nepalese territory to preserve a "pristine wilderness" in the Himalayas. About 900 sq km of the proposed area lies in the Arun Basin, and this area provides the much needed ecological support to the Sagarmatha National Park, which has all of its area above an altitude of 3,000 m.