Plant formations in central Bhutan and the challenges of conserving biodiversity

Reflections after a short-term visit in October 1998

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Preface

This paper is the output of a short-term consultancy in biodiversity monitoring, undertaken by invitation of the Bhutan-German Sustainable RNR-Development Projekt (BG-SRDP). The project supports activities in the field of forestry (community forestry, reforestation, forest management), agriculture (soil and water conservation, increase of productivity of agricultural crops) as well as animal husbandry (improved pastures, improved livestock breed). All those activities are assumed to have an effect on the biodiversity of those areas where interventions take place. In order to systematically measure and observe the changes in biodiversity which may be caused by project intervention, the project aims at the establishment of a monitoring system. This system should be simple and easy tu use, so that target groups and RNR staff can apply it.

The present stay enabled us to get familiar with the issues of biodiversity in Bhutan in general and in the project area in special, to meet with representatives of the Ministry of Agriculture (MoA), the National Environment Commission (NEC) and the BG-SRDP and to develop plans for future research (see schedule of visit in the Appendix).

Accordingly, this report comprises three parts:

1. General considerations on biodiversity issues in Bhutan
2. Suggested in-depth studies leading to an assessment of changes in biodiversity
3. Remarks on the Tsenden (as a genuine symbol of bhutanese endemism and culture) under forestry and conservation aspects.

In this place, we would like to thank all bhutanese partners in talks and on excursions for their hospitality and interest. Special thanks are extended to Mr. R. Wolf and Mr. Ugen Lhendup /GTZ for splendid organization and fruitful discussions.

1. General considerations on biodiversity issues in Bhutan

Since the early 1990s the usage of the term "biodiversity" had an explosive development in the popular press, governmental reports, scientific papers and meetings. In many projects related to environmental conservation, "biodiversity" has become a value of its own, and it is little asked what one is dealing with.

So before discussing the means of monitoring changes in biodiversity in Bhutan, it seems to be appropriate to outline the meaning of this term in general, and for the purposes of environmental conservation in special.

1.1 What is biodiversity?

Bio-diversity in the strict sense means "variety of life". This is by far more than the number of plant and animal species: within a certain population, it comprises the genetic/phylogenetic variety; within a community, it includes aspects such as the diversity of species, life forms, trophic groups, food webs and dynamics in time and space. On even lager scale (i.e. one country, district or project area with different habitat types), the variety of habitats can be an expression of biodiversity ("ß-diversity", i.e. between - habitat diversity, after WHITTAKER 1975, in contrast with "α-diversity" referring to the biological variety within one habitat type).

This means that species richness, which is commonly equalized with biodiversity, is only one aspect of the variety of life. For instance, a herbaceous pasture can be rich in flowering plant species but structurally poor, whereas forests may be composed of a smaller number of plant species but are structurally more diverse, providing a larger number of micro-habitats.

1.2 How to measure biodiversity?

Given this comprehensive definition of biodiversity, it is clear that the measurement of this complex is extremely difficult and labour-intensive. Numerous scientific working groups established in order to develop feasible approaches.

Species richness, even though being only one aspect of biodiversity, is most often used as a measure of the latter. There are several pragmatic reasons (GASTON in GASTON 1996, p. 78):

- species richness can be correlated positively with some measures of ecological diversity
- species richness may give some broad indication of diversity at a higher level, and perhaps of general morphological diversity
- the complexity of food webs is correlated with species richness; thus, species richness captures some elements of functional diversity
- relatively high species richness is often associated with relatively high topographic diversity; thus, species richness may capture some elements of the diversity of landscapes.

But even this "mere counting" of species and life forms poses great problems:

- the number of taxa in a certain area is influenced by the degree to what they have been studied taxonomically; it depends on which species concept was followed by the respective researchers and how many synonyms were recognised
- some life form groups are still difficult to count and to identify, i.e. microorganisms in the soil, insects.....
- the species richness varies with time and space: the larger the survey area, the more species are found; the longer the observation period, the more species might be found as well, depending on population dynamics or seasonal migration of animals or certain successional stages of the vegetation.

The only way to overcome these difficulties is the identification of biotic indicators or indicator groups for certain levels of biodiversity. Most of these will, however, only be applicable to areas of limited geographical extent (PEARSON in GASTON 1996).

For the time being, only some facets of biodiversity can be quantified, not the biodiversity *per se*.The choice and derivation of a measure will depend fundamentally on the use to which it will be put (GASTON in GASTON 1996).

1.3 Is a high biodiversity the ultimate goal for environmental conservation?

The term "biodiversity" is most often used in connection with concerns over the loss of the natural environment. In the context of environmental conservation issues, biodiversity is not a neutral scientific concept but percieved as a value, or as having a value: in many communities there is general acceptance that"biodiversity is *per se* a good thing, that its loss is bad, and hence that something should be done to maintain it" (GASTON in GASTON 1996, p. 5). But which aspects of biodiversity one has in view in each case? Mostly diversity issues are connected with the aim to maintain or increase the number of species. Often the decisive argument for conservation measures is the preservation of one or several endangered/endemic and attractive plant or animal species, no matter if these are indicators of habitats influenced by man or more or less natural environments, for ecologically stable or instable ecosystems....

When the aim of project activities is the conservation or increase of species richness, it should be borne in mind that species richness is only one facet of biodiversity and that the

pure number of species is less instructive than the information which species are present: for instance, distinction has to be made between levels of species richness which can be regarded as native (= naturally evolved) and as artificial (= human generated). Thus, areas rich in species do not necessarily have high conservation priorities.

These priorities should embrance other considerations such as the maintenance of the integrity and function of ecosystems, the diversity of habitats/landscapes and the level of threat of the ecosystems in question.

Yet it is not generally proved that the level of biodiversity can be used as a measure of environmental stability. The relationship between biodiversity and the functioning of ecosystems is still little understood. For instance, if conservation measures focus on watershed regulation: does it matter if this task is done by a plantation forest or a more diverse natural one? (LOVEJOY in HAWKSWORTH 1995). The same applies to the relation between biodiversity and the stability of an ecosystem. There are some indications that more diverse ecosystems have a stronger resistance in case of environmental disturbance, but there are also examples which point to the contrary. The response of a certain ecosystem largely depends on the nature of the disturbance (natural catastrophies of cyclic or periodic occurrence or "modern", human-generated influences) (ELLENBERG 1996).

Summing up, the question if high biodiversity levels are the ultimate goal for environmental conservation measures cannot be answered straight away. The answer depends on the extent of the area under concern and the main purposes of the conservation measure.

1.4 Maintenance or improvement of biodiversity levels in the BG-SRDP: what do we really want to achieve?

The major goal of the BG-SRDP project is to increase quality and productivity of the renewable natural resources (RNR) by means of sustainable management techniques, partial intensification and partial reduction of exploitation intensity. A desired effect of these measures should be "that the level of biodiversity in selected areas remains at least the same, preferably improves....." These aims resemble the main conservation and development objectives set up by the Royal Government of Bhutan for the whole country.

But, which aspects of biodiversity are meant? The forests are in the focus of different pressure groups, and each group has those components of biodiversity in view which serve its practical interests:

- the **forester** aims at the maintenance and regeneration of a few timber- and firewood-providing tree species
- the **subsistence farmer** needs to retain his multiple uses of the forest, which implies a conflict of its own:

    - the maintenance of a highly diverse woody component is desired for provision with fuel and construction wood and numerous non-timber forest products

    - simultaneously, the forests must serve as pastures with a productive, nutritive and palatable ground layer.

    Generally, the value of a pasture is increased with the opening of the tree canopy and the reduction of shrubs. As clearing of forests is (a) restricted and (b) leading to the reduction of wood and woody non-timber resources, the compromise chosen by the rural people is to permit very extensive grazing on little valuable pastures with huge distances to be made by cattle.

- **nature conservation agents** and policy makers may have the least concrete ideas in which way biodiversity is to be maintained or favoured (see previous paragraphs). In most cases species richness is in the focus, with emphasis given to endemic and endangered species.

Within the project area it is desired that the introduction of more sustainable RNR management techniques does not affect biodiversity.

As long as the bhutanese forest ecosystems are not better understood, we rely on **species richness** as one measure of biodiversity.

Species richness, however, should not be regarded as a value *per se*, or even as an indicator of the degree of integrity of an ecosystem. The contrary might be the case: pristine forests are often poorer in species and structure than disturbed ones. Consequently, also the criterion "species richness" of biodiversity has to be specified: in which compartment of the ecosystem species richness is to be maintained/improved? Or more simply: **which** species are to be conserved, not **how many**.

At this point we face the problem that the bhutanese forests are still insufficiently known biologically. How to evaluate the floristic changes in a forest under different management techniques when the natural species richness is not known? In which case species richness is an important criterion for conservation, in which case it might be meaningless?

In order to illustrate these problems, some examples of the most widespread vegetation types in the project area will be discussed in view of their species richness and degree of disturbance:

(1) In the **chir pine belt**, *Pinus roxburghii* has replaced the much more diverse "Warm Broad-leaved Forest"[1] in consequence of grazing and repeated burning. Native to edaphically dry habitats (steep rocky flanks exposed to desiccating valley winds), the chir pine and its shrubby and herbaceous companions have conquered such wide areas that their natural distribution is difficult to assess.

In this belt the species richness in the **woody** strata is most drastically reduced, compared with the natural forest: the pine is at most accompanied by *Quercus lanata*, rarely *Qu. griffithii*, and *Rhododendron arboreum* (all at higher altitudes), and some unpalatable shrubby species which are pioneers after fire. The opening of the tree canopy into mostly savanna-like formations, fire and grazing replaced the shade-tolerant, hygrophilous herbaceous layer by a dense grass formation dominated by Andropogoneae. This is relatively poor in species (although no little disturbed broad-leaved forest could be studied in comparison, it is assumed that their herbaceous layer is more diverse), but certainly more productive and

[1] terminology according to the Flora of Bhutan, Vol. 1,1.

more resistant to grazing and trampling. Moreover, the soil is ideally protected against erosion by the thick felt of roots produced by the creeping grass species. These properties make the chir pine savannas stable and sustainable human-made ecosystems. Losses in biodiversity (expressed by species numbers) oppose gains in stability under the prevalent human environmental factors.

A major disadvantage of this cultural landscape is the strong seasonality of the pastures. During the dry winter months cattle depend on the availability of shady or ground-moist pastures. Second, there is an enourmous loss of forest product resources that are provided by the quasi-natural ecosystems: more valuable firewood and a great number of non-timber forest products.

The fate of the latter is that their value is still under-estimated because most of them play a role in local subsistence economy only. This means their value never appears in monetary calculations, statistics of per-capita income ..... i.e., statistics commonly used to express the value of an economic system or the degree of prosperity of a country's population. If all products taken out of a community forest (broad-leaved forest rich in species) are converted into monetary values, the species-rich quasi-natural forest certainly turns out to be more profitable than the chir pine "monoculture". PHUNTSO NAMGYEL & GHIMIRAY 1997 report on an informative study undertaken in the respective vegetation zone in the Nahi valley. Accordingly, only that part of forest products which is sold on the local market contributes c. 20% to the monetary income of the households. Which percentages will be reached if all other products gathered for utilisation in subsistence economy are converted into monetary values?[2] The farmers living in reach of highly diverse forests are then much richer than usual statistics suggest! In comparable studies undertaken in the Amazonian natural forest (PETERS & al. 1989) the monetary values calculated for the quasi-natural forest from which products are extracted in a sustainable manner far exceeded those obtained by clear-cutting, sale of timber and conversion of the forest into a pasture.

Concerning biodiversity (in terms of species richness), comparative quantitative studies are needed, in which the total number of species is less important than the species composition in the different degradation or regeneration stages of the vegetation. As the species inventory of the broad-leaved forests is almost completely destroyed when the chir pine community takes over, there is a risk of species extinction that grows with the extension of the secondary formation.

Hence, comparative studies must list those species which are confined to the little disturbed broad-leaved forests in the chir pine belt and discuss the value of those species appearing

[2] This would be a fair procedure as people living in towns or more degraded landscapes also have to buy fuel and construction wood, fruits and - eventually - vitamin C and other synthetic drugs in the pharmacy!

when grazing and woodcutting intensity increase. Second, the ability of the various woody species to regenerate under different degrees of grazing and woodcutting pressure should be recorded.
From these studies it will depend whether the set-up of "biodiversity conservation plots", nature reserves respectively, is a necessity.

(2) In the **blue pine forest** belt, *Pinus wallichiana* is the respective, aggressive, light-demanding, fire- and grazing-resistant pioneer of secondary forest which replaces a number of middle montane forest communities (Evergreen Oak Forest but also Cool Broad-leaved Forest, at higher altitudes Spruce and Hemlock Forest). The extreme impoverishment in structure and species richness going along with the dominance of the blue pine is well known. Growing up in thickets, the pine excludes any competitor in the tree layer. Intensive shade and the acid-producing leaf litter cause strong changes in the ground layer. The structurally and floristically poorest blue pine communities are young thickets which almost lack any undergrowth. Mature stands are more light and allow the recolonisation of some broad-leaved trees and shrubs in the undergrowth. This observation gives reason to assume that the young blue pine-dominated secondary forests spreading in vast areas after the abandonement of shifting cultivation will increase in species and structural richness with growing age.
It remains a matter of quantitative studies how much the undergrowth of mature blue pine secondary forests differs from those of primary broad-leaved, Hemlock or spruce forests. The strongest reduction in species richness (meaning conspicuous plant species) certainly takes place when Cool Broad-leaved and Evergreen Oak Forests (the transition to Hemlock Forests included) are converted into blue pine "monocultures". These humid middle-montane forest types are assumed to have the greatest floristic diversity and contain conspicuous bhutanese endemics such as *Exbucklandia populnea* and the Tsenden (see chapter 3). Extensive grazing might slightly increase the number of vascular plant species in the undergrowth, but probably at the expense of more sensitive, perhaps less conspicuous species (fragile herbs and mosses). This also refers to the Warm Broad-leaved Forest, whose species which disappear or do not regenerate any more when the intensity of anthropo-zoogenic exploitation increases, are to be identified.

(3) **Upper montane coniferous forests**
With the upper limit of the oaks and evergreen laurophyllous trees, the upper montane forests naturally diminish in species numbers and structural diversity: Hemlock, spruce, blue pine and, towards the treeline, fir, grow in pure or mixed stands with varying but simply structured understoreys. These are dominated by bamboo and/or rhododendrons. Other

broad-leaved trees (birches, maple, *Sorbus*) are usually less numerous. The ground layer is dominated by mosses and liverworts.

Pristine, mature upper montane coniferous forests are very poor in flowering plant species. Natural die-back of the canopy trees initiates phases of higher floristic diversity: light-demanding birches, bamboo, *Rhododendron* spp., herbs but also the canopy trees themselves are able to regenerate in the light of the forest gaps. Small gaps created by artificial clearing have the same effect.

Thus the opening of the upper montane forests has a positive effect on floristic diversity. Especially Bhutan's most showy woody plants, the rhododendrons, are richest in species in light habitats such as along trails, on forest edges and in gaps. In pristine forests this variety of rhododendrons grow is highest on steep rocky slopes where the tree canopy is naturally open. In closed undisturbed forests very few shade-tolerant or even shade-demanding species occur.

What do we want? The enrichment uf upper montane forests with showy plants is desirable, especially in areas favoured for eco-tourism. But, where trees are cut there are people, and where people live there are cattle.....

On the first glimpse, grazing of the upper montane forest increases the floristic diversity as well. Weedy herbs are taken up from the broad-leaved forest and alpine ones invade the fir forests. Trampling damages the mossy ground layer and exposes mineral soil which is the preferred germination bed for several tree species.

Browsing, however, strongly affects the dynamics of regeneration in these forests. Rhododendrons are indeed a valuable element of biodiversity in Bhutan, but they are favoured indirectly by grazing, at the expense of other broad-leaved understorey trees and the canopy-building conifers. One can even regard them as grazing weeds! ROSSET & RINCHEN (1998) have shown in exclosure experiments to what extent the regeneration of Hemlock, fir and birches is reduced on grazed plots, in favour of *Rhododendron* spp.

On the other hand *Rhododendron* thickets, less intensively grazed by wild and domestic animals, are supposed to provide shelter for the regeneration of the shade-tolerant fir (BÜRGI, RINCHEN & TSHEWANG 1992).

In many grazed upper montane forests visited during our excursions, there was an overmature canopy of the conifers; the understoreys were dominated by bamboo, *Rhododendron* and *Daphne bholua*, but there was a total lack of conifer regeneration. Thus the future of these forests appears to be questionable. It is true that the upper montane conifers live several hundreds of years (with at least 400 years the cycle of the fir is longest), thus it doesn't matter if there is no regeneration for some decades (op.cit.). But if there are no younger trees at all, a long phase of pure broad-leaved forests is to be expected when the

present conifer canopy breaks down, as it is observed on larger clearings (BÜRGI 1994). Clear-cut areas, once or several times burnt, favour the invasion of bamboos, *Juniperus recurva* (in the fir belt) and bracken as common secondary formations. These species are more resistant to grazing than the ground layer of a fir forest. Open juniper stands with Rhododendrons and a number of herbaceous plants are richer in species, structurally more diverse and provide better pasture than closed coniferous forests. On the other side, Hemlock, fir and spruce forests provide valuable timber and habitats for a number of wild animals. It depends on the purpose in which direction conservation measures are to be driven.

In any case, future decisions require a more comprehensive knowledge about the functioning of the upper montane forest ecosystems: the natural turn-over of the canopy trees, the bamboo cycles (periodic spreading and die-back), the role of Rhododendrons in these cycles, and the influence exerted by cattle grazing on these complicated patterns. The exclosure plots set up in Bumthang are a very valuable start of the necessary monitoring.

(4) **Alpine vegetation**

This is the least studied vegetation belt, even though it is reported to be of very high biodiversity value in Bhutan. Expeditions largely focussed on floristic or zoological inventories and little on ecological questions.

As far as we can state according to our experience gained in other Himalayan countries and one short visit to the lower alpine belt S of Hurchi/Bumthang, the high biodiversity (in terms of richness in plant species) is promoted and maintained by human's activities to a large extent. The pristine lower alpine vegetation consists of a rather monotonous *Rhododendron* scrub or dwarf scrub which is even poorer in species and structure than the upper montane forests. The highest diversity in the monospecific *Rhododendron* thickets is performed by the moss layer and epiphytic thallophytes. Light-demanding flowering plants are driven into extra-zonal habitats of minor extent: rocky slopes, seasonally waterlogged or dry rock plateaux, swamps and their margins. *Juniper* dwarf scrub may form natural mosaics with the herbaceous communities on sunny rock slopes, but usually fires have reduced the easily inflammable junipers in favour of floristically rich meadow-steppe-like formations. Cutting or burning of the Rhododendrons (preferred firewood in the grazing places) initiates the establishment of grasslands as well. These are mainly composed of Cyperaceae which are that diet preferred by Yaks. The rich variety of showy alpine flowers, which attract diverse insects but also tourists, is largely due to the spreading of unpalatable herbs ("grazing weeds") in these

grasslands. They originate from the free gelifluction belt or from rare naturally disturbed sites in the lower alpine belt; thus their area is drastically increased in consequence of the open habitats offered in the course of grazing activities.
Grazing and fire are certainly tools for the floristic enrichment of the alpine zones.

What do we want?

- "Museums" of the quasi-natural vegetation and refuges for the wild fauna related to it? This is certainly desirable in some remote areas of Bhutan where people can afford a complete abandonement. These will be the only places in the whole Himalayas where undisturbed landscapes can be seen!

- Increase/maintenance of high biodiversity (in terms of species richness)?

- Increase/maintenance of stability and sustainability of high-altitude pastures and ethnobotanic resources?

If conservation measures aim at the last two points, the problems of lack of knowledge rise again:
- In which environment which grazing intensity is still tolerable from the aspects of sustainability and productivity?
- Which levels of species richness have the sustainable pastures? Which plant species disappear with increasing grazing intensity, how widespread are their natural habitats? Which species appear with increasing grazing pressure, and what are their natural areas of distribution?
- Which plants are collected by people in the alpine environment? Are these plants grazing weeds or do they belong to that group of species vanishing with growing grazing pressure, which means that they are threatened from two sides? (First inventories dealing with these questions were undertaken in Lingshi area)
- For which plants there is food competition between domestic and wild herbivores?

For the answer of these questions comprehensive inter-disciplinary field studies are required.

1.5 Conclusions: Search for solutions in the conflict between the needs of protection and exploitation

The examples of issues in biodiversity conservation given in the last paragraphs have shown that

- species richness is only one facet of biodiversity
- a decline in species richness does not necessarily correlate with increasing degrees of human pressure: depending on the level of natural species richness, the relation might be inverse (examples: upper montane/lower alpine ecosystems)
- the absolute number of species is ecologically, and also from the conservation point of view, less important than the information, **which** species are present.

Thus, the increase in species numbers is not in any case desirable. Cattle grazing effects the introduction of alien species to any type of forest or alpine formation. It is still unknwon which species might be pushed away by the introduced ones. Furthermore, the influence of grazing on the regeneration of different tree species is still insufficiently known. In some upper montane and alpine areas, the continuation of extensive grazing might be a precondition for the maintenance of both villagers' subsistence economy and diverse cultural landscapes rich in medical plants or attractive for tourism. [3]

For most forest ecosystems, however, the **complete separation of forest and pasture** appears, in the long run, to be the only reasonable way out of the conflict between the needs of pastoralism, multiple forest utilisation and biodiversity conservation.

Before this is feasible, the fragmentation of distinct watershed areas into compartments of different focusses and intensities of RNR utilisation is a reasonable compromise, as long as each forest type is excluded from human influence in selected areas. In this way, possible species endangered by over-utilization can be preserved, and a variety of more or less human-influenced landscapes can be created or maintained (= high diversity of landscapes as another aspect of biodiversity).

In the BG-SRDP, first starts in this direction are being made: the management plans of Kothoka and Nahi watersheds show such a fragmentation into diverse types of utilisation.

As stated in the previous paragraphs, more knowledge is required in order to refine such plans of sustainable land use. Intensified research should focus on

- mappping of plant and animal species in the whole of Bhutan in order to assess their distribution area and frequency. This implies the strengthening of Bhutanese capacities in taxonomic research and field botany/zoology

[3] There is the famous example of the N German *Calluna* heath, a dwarf-shrub pasture which spread in consequence of forest over-utilisation and extensive grazing. With the abandonement of shepherding and the separation of pastures and forest, the heath areas diminished drastically, so that the last patches are now being preserved as National Parks of Cultural Heritage. Characteristically, it turned out that the only reasonable means of preserving this ecosystem is the continuation of the traditional use - extensive sheep pastoralism.

- set up of permanent observation plots on which long-term dynamics of the ecosystems under different intensities of utilisation are monitored, and/or
- exemplary inventories of plants and animals in specific vegetation types with varying intensities of human utilisation and different successional stages
- studies of the productivity and carrying capacity of native grasslands in intensive grazing systems

It would be convenient to identify indicator species or species groups characterizing certain stages of degradation, threat to rare species etc. This, however, requires broad activities in biological fieldwork.

A respective research proposal for the BG-SRDP area is given in the next section.

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2. Proposal of a biodiversity monitoring system and respective in-depth studies in the BG-SRDP

2.1 General remarks

If it is attempted to understand the changes taking place in a certain vegetation type after the modes of utilisation are altered, there are two main approaches:

(1) **Permanent observation plots** are set up on which the variables under concern are monitored regularly; the first inventory is made prior to the planned change in utilisation intensity

(2) **Transect studies** are undertaken along gradients of exploitation intensity in a certain vegetation unit, e.g. along a trail connecting two villages at similar altitude.

The second approach has the advantage in yielding results immediately after the evaluation of one fieldwork campaign. If the record plots are carefully chosen, the gradient series might represent the time series obtained from the permanent observation plots after some decades only. The disadvantages are that large amounts of records are required in order to distinguish between the natural variability and gradient-specific variation in species composition. Second, it might be difficult in many areas to find a sufficient number of plots with almost identic altitude, slope inclination and exposure and comparable dynamic stage (e.g. in the bamboo cycle). In contrast, returning to a permanent observation plot, one can be sure that the principal physical site conditions remain the same.
Third, the transect approach cannot cover any isolated aspects of human resource exploitation prior to the planned changes in landuse: the gradient of floristic changes between two villages usually reflects the total of human interference, i.e., grazing plus woodcutting plus exploitation of non-timber forest products. There will be very rare or no forest spots where a collection gradient of non-timber forest products exists but no grazing and woodcutting is practised, and so on. Thus, the development of species composition in forests alloted to a specific use under the exclusion of cattle can only be studied in an experimental setting.

Transect studies of the vegetation are regarded the most appropriate approach to obtain ecological data in the project area, as long as definite changes in forest utilisation do not take place and further scientific knowledge is needed for the setting up of reasonable management plans within a realistic time span. At the same time, selected plots should be

marked in order to allow long-term monitoring where stronger changes in forest utilization are expected in future.

2.2 Proposal of study sites

After the short survey undertaken in the core areas of the project it is difficult to suggest any sites for vegetation studies which can be regarded as representative for the whole districts. With a more intimate knowledge of the latter, other localities might turn out to be much better suited for vegetation surveys. On the other hand, two arguments vote for in-depth studies in the core areas: (1) changes in land use will take place here first, (2) the locations are relatively easy to reach.

(1) Warm broad-leaved forest/chir pine forest:

- **Nahi valley:** on both, North- and South-facing flanks, gradients of human impact can be studied, depending on the distance to the village Nahi and smaller settlements. The less disturbed broad-leaved forest of the N-facing flank will soon be changed when the road to Nahi is constructed; thus it might be worth to set up some monitoring plots here when the exact line is known. The management plan is a further guide for the placement of such plots.

  The S-facing slope is dominated by chir pine communities in different regeneration stages after fire. With the help of local foresters and villagers, vegetation records can be brought into a series of growing age of the regeneration stages after fire, and the respective floristic changes worked out.

  The area between the link road and Nahi village covers an altitudinal span between c. 1.500 and 1.800 m, higher altitudes are reached in the upper part of the valley (not visited). The time estimated for the execution of the proposed fieldwork in this valley section is c. 10 days.

- **Lingmutechu catchment area:** Around Naabji, degradation stages of the upper chir pine belt (with *Rhododendron arboreum* and *Quercus lanata*) can be studied in different aspects (1.900-2.100 m). In the broad-leaved forests of the upper flanks suitable transect lines are still to be searched.

  Estimated survey time: 4-7 days.

- **Punakha Tsang Chu** between Jafu and Jala: the old trade route offers transect studies between both villages and some intermittent grazing places with little variation in altitude (2-3 days).

(2) Cool broad-leaved forest / evergreen oak forest / blue pine forest:

_ **Punakha Tsang Chu** between Jafu and Jala above the old trade route: between the grazing place / logger camp in 1.900 m and the actual upper limit of Tsenden logging transect studies concerning grazing influence can be done in evergreen oak forest (see also part 3 of this report).

_ **Kothoka valley** and trail from Kothoka to Jala:
Above Kothoka there are relicts of evergreen oak forest, forming mosaics with secondary forests of blue pine. Comparative vegetation records may demonstrate the similarities and differences in the floristic composition and the losses in floristic richness going along with the dominance of *Pinus wallichiana*. Little disturbed evergreen oak forests can be studied above Jala. Estimated survey time: 4-5 days.

(3) Upper montane coniferous forest:

_ **Kothoka FMU:** between Phobjikha and Gogona several degradation stages of Hemlock, spruce and fir forests can be studied, but grazing influence is to be seen everywhere in the near of the trail. The steep rocky slopes of the peaks above Gogona might be less grazed because of difficult access. Survey time: c. 4 days.

_ **Above Hurchi/Bumthang:** this locality, even though outside the project area, offers the opportunity to study middle and upper montane coniferous forests under quasi-natural conditions for comparison. The degree of humidity, however, might differ from that in the Kothoka area. Survey time: c. 5 days.

(4) Alpine belt

A more specific research proposal can only be made after the respective areas in Wangdue and Punakha have been visited. It is suggested to undertake a longer joint excursion with bhutanese colleagues, to make transect records on the spot and discuss the choice of suitable monitoring plots. The survey time depends on the extent of the area.

2.3 Methods and logistic preconditions

Any follow-up studies on biodiversity issues should be undertaken by Bhutanese researchers (foresters/botanists), initially in cooperation with foreign colleagues. During our survey excursion we experienced a fruitful exchange of experiences and knowledge on such joint ventures. The location of the NRTI in Lobesa is an ideal precondition for the combination of

future surveys with practice teaching of students in the field. Contacts between the NRTI and the BG-SRDP are already established.

Inventory methods are to be discussed and refined. They should be approximated to those which are already widely practised in Bhutan but secure a complete floristic inventory (widening of record plots according to the variability and species richness of the vegetation). The magnitude of each species should be indicated. A minimum set of environmental information should be collected, too.

The execution of these studies completely depends on the successful **determination of plant species**. Consequently, all activities should aim at the inclusion of the National Herbarium of Bhutan and its staff. Taxa which can not be named in the country because not yet covered by the Flora of Bhutan or not represented in the Herbarium collection should be collected with at least two specimens, one of which being allowed to be sent abroad for determination by concerned specialists. It is emphasized again at this place that **any** scientific work related to biodiversity depends on the **functioning of a reference collection**, i.e., sufficient skilled Herbarium staff, funds and scientists for the supplementation, updating and maintenance of the collection and for the organisation of international cooperation in taxonomic research.

3. Notes on the Tsenden, with respect to biodiversity conservation in Bhutan

The Tsenden, Bhutan's National Tree, still has a dubious identity taxonomically (LONG 1980, SILBA 1987). The first botanical descriptions were made in Europe on the basis of cultivated specimens with partly unknown origin. Historic sources mention that Tsenden trees planted in Bhutan and Sikkim had been introduced from Tibet; natural stands in Bhutan were unknown outside the country.

Thus, the true origin of the Tsenden is a second mystery. The only conspicuous trees grow, obviously planted, near religious buildings or farmhouses. There are, however, some natural stands in areas which are difficult to reach, e.g.: in the Pho Chu valley NE of Punakha, W of Pele La around Nobding and on the opposite flanks, and on the W-facing flanks of the lower Punakha Tsang Chu S of Wangdue Phodrang. The last location we were able to see briefly. This check revealed that the Tsenden may indeed form naturally established stands between 2.300 m and at least 2.600 m. It is not restricted to dry rocky habitat (where there are less competitors) but may form the top canopy of cool broad-leaved forest and evergreen oak forest on deep soils (with another endemic tree, *Exbucklandia populnea*, being present as well). Hence, the Tsenden might be a natural emergent tree in lower to middle montane

cloud forests which are very widespread in Bhutan. Are these populations relicts of a formerly wider distribution area? The remoteness of the known stands supports this assumption. The wood of Tsenden is excellent for the construction of buildings. Nowadays, only sacred historic buildings are restored with Tsenden wood, but in earlier times? At least shingles of Tsenden wood were used by anyone who could get them, because they were even higher valued than those made of oak or fir (we thank Dasho Sangay Thinley for this information).

Consequently, it is probable that the last bit of formerly widely distributed natural Tsenden forests is being cut down at present. Unfortunately, this is happening before these forests are mapped (i.e. their real extent assessed) and biologically investigated. At the site S of Wangdue, where logs are being prepared for the reconstruction of Taktsang, some trees are left behind in order to ensure regeneration, but these are principally of inferior timber value. On the clearings, there is indeed some regeneration of Tsenden visible, but the number of seedlings of blue pine is much higher. Who will win the battle of competition in the regenerating forest? The Tsenden might have a juvenile growth rate that is even faster than that of the blue pine, but the natural competition is disturbed by cattle: cattle follow the woodcutters to the clarings, looking for light-demanding herbs and grasses, and bring a new environmental factor to these forests which had been more or less pristine before. Will logging plus grazing convert also these naturally species-rich forests into blue pine "monocultures"?

Thinking of future supply with the valuable Tsenden wood, several **plantations** were established in Bhutan - JENSEN (1990) reports about 81.5 acres of pure and 619.5 acres of mixed plantations. These figures have certainly increased meanwhile. It is, however, highly probable that most of these forestry plantations originate from seeds imported from India, under the name *Cupressus cashmeriana* Carr. - not from the wild or ancient cultivated stands in Bhutan. Whether this Indian taxon really differs from the Bhutanese endemic called *Cupressus corneyana* Carr. is still a matter of controversy. SILBA (1987) united both taxa under a new name, *Cupressus himalaica*, whereas the Flora of Bhutan (1983) makes a distinction on the basis of the colour of the foliage and the surface structure of the female cones. Indeed, the colour of the foliage remains glaucous in the Indian plantation trees - still when they are more than 20 years old. In contrast, Bhutanese Tsenden trees lack the bluish teint, at least when they are more than 2 metres tall. Moreover, the Indian plantation trees are reported to have a different smell (Mr. Tashi, Forestry counterpart in the BG-SRDP, Lobesa).

In any case, the origin of the glaucous Tsenden trees imported from India is obscure. It is well probable that they are cultivars of seeds brought from Sikkim to England in 1948.

However it is: with these notes, we would like to strengthen the awareness of the Tsenden problem among Bhutanese officials, pointing to a still unused genetic pool for forestry activities: the relict natural Tsenden stands. No matter what taxonomic botanists will decide about the relationship between the Indian and the Bhutanese cypress: the genetic pool for reforestation measures can be enormously enlarged if seeds of the indigenous trees are systematically used in the nurseries. As it is demonstrated by old planted indigenous Tsenden trees, the altitudinal range is between 1.200 and almost 3.000 m, implying a probable precipitation range between 600 and more than 2.000 mm. Even though excellent growing parameters are reported from the Indian cultivars (JENSEN 1990), the indigenous populations might be better adapted to special site conditions.
The second argument for nursery trials with seeds from indigenous stands is the genetic preservation of the endemic taxon, including artificial reforestation measures at the logging sites (if necessary) and on other suitable deforested or degraded slopes.

The following Tsenden-related program would be worth being included in the National Biodiversity and Environmental Action Plans of the Royal Government of Bhutan:

(1) A **complete inventory** of relict natural stands (extent, floristic composition, altitudinal range, dynamic status, degree of threat, etc.)
(2) **Cultivation trials** with seeds from the natural stands and selected vital cultivated trees
(3) **Ecological studies** in the relict forests concerning the natural regeneration of Tsenden (a) in pristine forests, (b) after logging without grazing, (c) after logging and subsequent grazing. The logging site S of Wangdue would be well suited for these studies. The fencing of some monitoring plots à 1 ha in clearings of different age will be helpful in order to control the effects of grazing on the regeneration. Appropriate inventory methods were developed by the RNR-RC Jakar.
(4) Until these studies yield results, a **provisional management plan** should prevent that the last natural Tsenden forests disappear before their regeneration modes are known.

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LONG, D.G. (1980): The weeping cypress, *Cupressus corneyana* Carr. Notes relating to the flora of Bhutan: IV. - Notes R.B.G. Edinburgh 38, 2: 311-314.

SILBA, J. (1987): Nomenclature of the weeping himalayan cypress. - Phytologia 64, 1: 78-80.

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Appendix 1: Schedule

October 1, 1998

Arrival in Paro with Druk Air, transfer to Thimphu. 14-17 h: meeting with Mr**. R. Wolf**/GTZ; discussion of the schedule. 19 h: meeting with **Dr. Pema Gyamtsho**/ Head PPD, Ministry of Agriculture

October 2, 1998

Thimphu - Lobesa

Because of the Tsechu festival and a subsequent forestry seminar in Bumthang the envisaged meetings and courtesy calls have to be postponed.

Lunch with Mrs. **R. Pradhan**/National Herbarium and Mr. **H. Noltie**/RBG Edinburgh; discussion of joint field excursions.

14 h: meeting with **Dr. J. Krug**/medical plants project, Lingshi/Yusipang

17 h: Transfer to Lobesa with R. Wolf.

October 3-19, 1998:

Excursions with BG-SRDP staff and forestry personnel within Wangdue and Bumthang Districts, with the aim to familiarize (1) with biodiversity issues in connection with forest utilisation, (2) with the standards of specific education of the respective counterparts.

October 3, 1998:
Lobesa - Lingmutechu - Lobesa
1-day-excursion into a tributary valley E of Wangdue: introduction to multiple uses of warm broad-leaved forest by Forestry Scout, Subba.

October 4, 1998:
Lobesa - Nahi - Lobesa
1-day-excursion to the Nahi valley for which a management plan has been developed in connection with the BG-SRDP. Impressions on the influence of fire and grazing on the biodiversity of warm broad-leaved forest and the chir pine - dominated secondary formation.

October 5-10, 1998:
Lobesa - Phobjika - Gogona - Kothoka - Chele La - Jala - Lobesa
Excursion in company of Forestry staff from Wangdue and Phobjika, traversing upper montane *Abies-Picea- Tsuga* forests, *Pinus wallichiana* secondary and evergreen broad-leaved forests. Exemplary vegetation records were made in little disturbed and more strongly human-influenced forests, in order to assess the effects of grazing and woodcutting on the floristic composition of forest communities. Questions of forest regeneration were discussed with the bhutanese counterparts.

October 11-17, 1998:
Excursion to Bumthang

October 11, 1998:
Lobesa - Pele La - Trongsa - Yatung La - Jakar
Transfer by car to Jakar/Bumthang. Stay with Mr. **H. Dekena**/Druk Seed Corporation.

October 12, 1998:
Excursion to Duri, together with Mrs. **R. Pradhan** and her colleague. We take advantage of Mrs. Pradhan's outstanding knowledge of the bhutanese flora and have fruitful discussions about the challenges of biodiversity problems in the country.
In the late afternoon visit of the RNR-RC Jakar. The Programme Coordinator Leaders **Kinzang Wangdi** and **Dr. W. Roeder** informed us about partly fenced permanent observation plots that are monitored since 9 years, and a visit of these plots is kindly arranged for the next day.

October 13, 1998:
Joint excursion with Mrs. **Pradhan** and Forestry-Researcher Mr. **Rinchen** to the permanent observation plots above Hurchi (*Tsuga-Picea-Abies* forests). Discussion about possible factors influencing the regeneration and competitive power of the canopy trees. Continuation of this discussion in the evening, based on the data evaluated by Rosset & Rinchen 1998, considerations about publication.
With the help of Mrs. Pradhan and Mr. Rinchen, a 3-days excursion to the alpine belt is organized for the next days.

October 14-16, 1998:
Jakar - Hurchi - High Camp - Hurchi - Jakar
Joint excursion with Mr. **Rinchen** and two local mule handlers, tent camp in 4.340 m. Discussions on grazing influence on fir forests and alpine *Rhododendron* scrub; vegetation records in both natural and grazed fir forests and alpine plant formations.

October 17, 1998:
Jakar - Lobesa
Return to Lobesa with observations along the road.

October 18-19, 1998:
Lobesa - Hisithangka - High camp - Jala - Lobesa
2-days-excursion with Mr. **R. Wolf** and **Mr. Subba** (Forestry Unit Wangdue) to relict natural stands of Tsenden above Hisithangka, S of Wangdue. Observations were impeded by lack of time and constant mist and rain, but it became clear that basic research in favour of a sustainable management of these populations is urgently needed.

October 20, 1998:

Transfer from Lobesa to Thimphu

Visit at the RNR-RC Yusipang; discussion with the Programme Coordinator Mr. **Phuntso Namgyal**, about possible main topics of future joint applied research and capacity building.

In the afternoon debriefing at the Joint Secretary of the Forest Services Division, Ministry of Agriculture, **Dasho Sangye Thinley**, with a fruitful discussion about issues of forest inventory and forest grazing.

Meeting with **Dr. Sangye Wanchuk**, Head of the Nature Conservation Section, Ministry of Agriculture: Information about the verification of proposed future joint research, discussion about research priorities and schedule.

October 21, 1998:

Short meeting with Mr. **Janbay Dorje**, Director of the RNRTI Lobesa.

Audience with the Minister of Agriculture, **Lynpo Dr. Kinzang Dorje**, discussion of the institutional framework of future research cooperation.

Audience with **Dasho Nado Rinchen**, Deputy Minister of the Ministry of Agriculture and Head of the NEC: introduction of proposed joint projects.

In the afternoon meeting with **Dasho Sherab Gyaltsen**, Acting Director of the REID (Research Extension & Irrigation Division): discussion of solutions for the problems of forest grazing.

In the evening final talk with Mr. **Wolf**.

October 22, 1998:

Transfer to Paro, departure with Druk Air to Kathmandu.