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Practising sustainable silviculture

Paper presented by REINHARD WOLF on the occasion of the

Workshop on Forest Assessment and Sustainable Harvesting

Organised by FDC, FRDD & WWMP; 6-7 December 2001, BCCI Thimpu

The Photo shows severely degraded forest near Dochu La, Thimphu Dzongkhag; the degradation probably caused by logging, firewood collection and intensive grazing (winter grazing by Yak and summer grazing by cattle). This forest has almost no commercial value and its ecological and protective functions are also severely reduced.
It may take more than 100 years of active forest management, to transform such a degraded forest into an intact natural forest

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1. Definitions

According to the Dictionary of Forestry (1998), published by the Society of American Foresters, **Silviculture** is defined as the "the art and science of controlling the establishment, growth, composition, health, and quality of forests and woodlands to meet the diverse needs and values of landowners and society on a sustainable basis".

In the same line, LAMPRECHT (1993, in PANCEL, 1993) stresses, that silviculture is never and nowhere an end unto itself, but rather an instrument to sustain man's many requests from the forest.

Silvicultural Systems are "a planned series of treatments for tending, harvesting, and re-establishing a stand –note the system name is based on the number of age classes (coppice, even-aged, two-aged, uneven-aged) or the regeneration method (clear cutting, seed tree, shelter wood, selection, coppice, coppice with reserves) used"

Silvics means "the study of the life history and general characteristics of forest trees and stands, with particular reference to environmental factors, as a basis for the practice of silviculture"

In a paper, titled "Technologies for Sustainable Forest Management: Challenges for the 21st Century" J.A. SAYER, former Director of the Center for International Forestry Research (CIFOR) and his colleagues argue that definitions of **sustainability** will vary in time and space as society's expectations and aspirations change, so there can be no 'silver bullet' to ensure sustainability.

2. Diagnostic assessments

The gaps in knowledge and experience require an especially careful planning of all silvicultural measures (LAMPRECHT, in PANCEL, 1993). These must be built on inclusive diagnostic assessments of particular situations, which then can form the basis for the local silvicultural objectives. They will be determined largely by the site and stand conditions, and by needs of the local population. Diagnostic results and the definition of goals will permit the choice of the silvicultural system best suited to realize the objectives under a given set of conditions.

Site, composition and structure of the forests and the role they play in the lives of the inhabitants vary greatly from place to place. These variations influence the desired goals and also the chosen silvicultural systems. There are no generally valid procedures for forestry, neither are there silviculturally patent recipes.

All silvicultural activities in natural forests can be defined as the objective guidance of the ecosystem to sustainably meet the needs of society. This requires knowledge of:

- the natural site conditions (Soil, Climate, Vegetation)
- the composition, structure and dynamics of the stands
- the human demands of, and their impact on, the forest

These three areas and their respective silvicultural relevance are the subject of fundamental silviculture research.

3. What is the state of Bhutan's forests?

SAYER ET AL. state that much of the world's forest is over-utilised and under-managed, so that average productivity (of industrial roundwood) is 1 m^3/ha/yr. This low productivity means that most of the world's forest needs to be utilised to satisfy current demands for roundwood and fuelwood. A small increase in productivity in the more accessible and productive forests would free much forest from production obligations.

Is this statement also valid for Bhutan? Recent and earlier observations confirm this at least for the *accessible* forest areas.

4. The forestry situation in Bhutan, as observed 30 years ago

Another inspiring document for me is the report of Fritz Fischer, probably the first forestry consultant (in the modern sense) to come to Bhutan almost exactly 30 years ago. In his report, FISCHER states that in the north-western and central parts of Bhutan the proportion of biologically and ecologically sound forests in these regions is hardly more than 20% of the respective total land area. He further states that in Bhutan the notion prevails that forests and timber are available in abundance and that they represent a natural wealth which could profitably be exploited in a way similar to the exploitation of mineral deposits. It must be added that this view – which is wrong and could entail disastrous consequences – appears to be shared also by many outsiders" and: "at first sight one may indeed gain the impression that Bhutan is rich in forests. But many areas, though appearing to be covered with trees or classified as forested land, bear tree stands which cannot be considered as biologically sound, self-regulating and self-regenerating plant associations". And he continues: It may be quite possible that such a "tree cover", despite its biological deficiencies, can still fulfil important protective functions. But they will last for a certain period only and then come to an end if these forests are not cared for nor regenerated in time" and: "the main reason for the present situation – not to be veiled by the incontestable fact that some beautiful forests can be seen here and there – lies in the generally poor and inadequate condition of the forests as a whole. This, in particular, is the result of:

- unregulated methods of grazing;
- burning of forests (partly by negligence and carelessness, partly by intention); and
- (of somewhat lesser importance): very high consumption of wood for fuel and construction purposes."

Nevertheless, FISCHER saw quite some potential for forest management: "the author's findings do show the very remarkable growth potential which could be activated by intensive sylvicultural management. Bhutan's high mountain forests could in fact be developed – by adequate treatment – to become a real wealth. It is also known that permanently maintained, optimum productive stand compositions and stock volumes permanently safeguard an optimum protective effect at the same time". But again he is warning that "without additional adequate scientific knowledge of the local natural conditions (in a broad sense) any sylvicultural activity of significant extent would entail severe risks" and that "prior to determining and developing proper treatment methods it will be necessary to analyze carefully the natural evolution and growth processes of the various forest types. As long as such information is not available locally, it seems advisable to adhere strictly to the sylvicultural methods developed, and experience gained, in the scientifically well analyzed high mountain forests of the European Alps. High priority must be placed upon continuous maintenance of the forests' protection functions"…. As far as Switzerland is concerned, a century of application of a well-considered forest policy and of relatively intensive forest management has since succeeded in the creation of a present stage of the forests which will become capable within the near future of permanently and fully covering the country's entire wood demand".

The need to establish such a "knowledge base" is also stressed by DR. ARMIN SEYDACK (1999), GTZ consultant for research in forest dynamics of broadleaved forests. I would like to argue, that – in Bhutan – we are still at the beginning to acquire "adequate scientific knowledge", this is especially true for broadleaved forests, which are very complex, while there has been more research done for the conifer forests, which are also less diverse and complex and easier to manage.

And I also agree with FISCHER who recommends "first to concentrate and restrict forest exploitation to high priority areas, while at the same time protecting and preserving the very large areas of degraded forests with their completely inadequate stock volumes. These latter areas must be given the necessary time needed for regeneration of their production capacity and sustained yield potential."

5. Forest management and Biodiversity conservation

Biodiversity conservation is playing an important role in Bhutan. SAYER et al. argue, that in the 21st century, we will need more pragmatic and efficient options for conserving biodiversity. They further state that a remarkably small aggregate area of reserves would be adequate to conserve populations of most of North America's endangered species and that the challenge for biodiversity conservation is not to 'halt deforestation'; it is to secure a minimum set of strategically located old growth reserves in representative areas with high diversity and high endemism

I quote this in the light that – officially – the primary objective of Bhutan's FMU's is forest protection and conservation. This issue has been discussed in the past already during various workshops. I am of the opinion, that the primary objective of Bhutan's FMU's should be sustainable production of timber.

An improved (silvicultural) management and an increase in productivity in the more accessible and productive forests (i.e. the FMU's) would then free much (other) forest from production obligations.

SAYER et al. argue, that the forest management unit must be seen and managed in the context of the broader landscape. Product optimization is unlikely to be achieved by homogeneous treatments of extensive areas. Rather, it will require that different products are optimized in different parts of the landscape.

6. Domestication as a silvicultural goal

LAMPRECHT (1989) in his publication 'Silviculture in the Tropics' is proposing 'domestication as the silvicultural goal': He argues, that the first step toward introducing forestry management in previously unmanaged forests is always so-called domestication. This includes all measures for improving the economic performance of the stands at least to a level which can ensure that the costs of management for sustained yield are covered. In other words: the domestication measures must serve to create the initial stands necessary before the general principles of systematic sustained yield forest management can be applied. In this respect domestication is only a sort of intermediate goal on the way to achieving a … production forest.

These are determined among other things by:

- Local site conditions and the natural production potential.
- The available tree species.
- The objectives of national, regional and local forest policies.
- The efficiency of the forestry organizations.
- Management costs and other micro-economic considerations.
- The accessibility of the forest area
- The availability of labor.
- Local and/or regional timber markets or forest industries.

Hence, concrete answers to the complex questions involved in identifying objectives can only be provided on the basis of comprehensive knowledge of the local situation. In the following, an attempt is made to summarize the most important general guidelines. It can safely be said that domesticated stands:

- Should be significantly more homogeneous, both floristically and as regards dimensions and age structures, than "untamed" stands.
- Should furnish raw materials which are in every respect substantially more homogeneous; as a rule a very limited number of different kinds of timber suitable for standardized utilization are

desirable, although these can – as in the case of the dipterocarps – by all means be a mix of botanically different species.

- Should have a large proportion of marketable species and a small proportion of species without value. However, one should not strive to eradicate the non-marketable species. "Weed trees" which are undersirable today may be economically interesting tomorrow. Moreover, they may have important unknown bio-ecological functions, and there is in any case a general obligation to conserve genetic resources. Where there is a lack of marketable species in the indigenous spectrum, exotics suitable for the site should be included in the growing stock.
- The domesticated stand should produce a larger volume of wood than the original stands.
- The quality of the timber ultimately produced should be clearly superior to that of the original timber.

7. Timber yield regulation ('logging') systems and forest regeneration

According to LEARY (1985, quoted by KLEINE, 1997), there are two broad categories for action, when resoucre use decisions are made: One relates to financial or economic considerations, whereas the other is ecological or environmental in nature, and each represents a particular view of the world. Frequently, a compromise between ecological considerations and economic demands must be found. This compromise considerably influences silvicultural decision making. Socio-economic constraints such as preference for a particular commodity or service, labour costs, limited availability or machinery, must be accommodated in a silvicultural decision, in order to make it operational and practical.

SEYDACK, in his paper titled 'The Broadleaved Forests of Bhutan: Management and Research Issues', argues that "The broadleaved forests are biologically diverse and ecologically complex (WANGCHUK 1999) and represent a unique gradient from temperate to subtropical forest types (OHSAWA 1999). These features accentuate both the importance of forest conservation as well as the inherent complexity of the required forest management. Land use pressures exist and are anticipated to increase regarding cattle grazing / fodder and timber use requirements (e.g. NORBU 1999, regarding cattle grazing as an integral part of broadleaved forest management). The challenge to meet the requirements of both biodiversity conservation and sustainability of resource use thus relates primarily to I.) the regulation of silvipastoral use and II.) the development and implementation of appropriate timber yield regulation systems."

In the Third Forestry Development Project/TFDP DAVIDSON et al. (1999) have identified a research focus towards the generation of technologies for sustainable broadleaved forest management ensuring suitable strategies for regeneration, safeguarding biodiversity and considering operational economics. In the paper titled 'Observation on regeneration of the broadleaved forests of eastern Bhutan', the authors report the following:

- The mixed broadleaved forests of eastern Bhutan have not been subjected to systematic management in the past and are now mostly "over-mature" from the commercial point of view and under heavy grazing pressure from domestic cattle. They are often stated to be in decline, both ecologically and economically. The policy of the Royal Government of Bhutan is to place these forests under sound, systematic management to arrest the deterioration and achieve sustainable renewal after harvesting, while, at the same time, providing for environmental conservation, including maintenance of biodiversity.
- Logging is the most important intervention in the silvicultural management system for these forests. There has been little prior silvicultural experience in the appropriate management of these forest types dominated by large trees of the FAGACEAE and LAURACEAE. Hence, there are no proven guidelines for harvesting. We have been examining the effects of different sizes of opening made during harvesting as well as exclusion of cattle by fencing on palatable and non-palatable natural tree seedling regeneration.

Preliminary results, after only one year, from a long-term trial set out in Korila Forest Management Unit, are as follows:

Three different intensities of logging by skyline in alternate strips were applied:

1. clear cut (size about 60m x 1,000m, or 6 ha);
2. patch cuts (each 60m x 80-100m, or about 0.5 ha, plus corridor) and
3. group cuts (each 30-60m x 30-60m, or about 0.15 ha, plus corridor).

Unfenced and fenced transects 100m x 10m, each with four equidistant 10m x 10m embedded plots were established across the openings at right angles to the skyline corridor and extending into intact forest on one side. Regeneration is being identified and tallied and position of each seedling mapped on all 60 plots twice a year, coinciding with the ends of the dry season, October to March, and wet monsoon season, April to September.

There are 23% more new accessions and 22% fewer losses of previously enumerated palatable seedlings in the pooled fenced plots compared with the unfenced ones. These differences are attributed mainly to exclusion of cattle, since there are no differences between fenced and unfenced plots for gains/losses of non-palatable seedlings. In pooled plots on fenced cut over (open) areas, 62% more new palatable seedlings accrue and 30% fewer of the existing seedlings are lost, compared to the unfenced cut over areas where cattle have been grazing during the dry season.

As yet there is little difference among the three sizes of openings in fenced areas and comparable and adequate numbers of naturally regenerating seedlings have emerged (about 4,200/ha in each). However, in the unfenced areas, there is less than half the number of palatable seedlings in the large clear cut coupe compared with both the patch and group cuts (about 1,400 versus 3,000/ha for each of the latter) indicating cattle grazing has been more intense in the largest opening.

Option 3 can possibly be operated with natural regeneration, although artificial regeneration with fencing is currently envisaged / practiced in conjunction with all three options. Fencing would also be required for natural regeneration in group clear cuts. Anticipating a rotation of 80 years three strips would be cut adjacent to each other with intervals of 27 years.

In another document, DAVIDSON (2000) argues, that single tree harvesting mimics natural gap formation fairly closely, and maintains watershed protection values. Grazing is less, because the relatively small gap may not attract cattle as much as has been shown in open closure.

He is also reporting some general finding:

- Survival and growth of planted seedlings are much less than for naturally regenerated seedlings on similar sites, when both are fenced
- Growth rates of seedlings and of young trees of the timber canopy representative is very slow. Fencing probably will be required for at least 10 years and the rotation to produce a 75 cm dbh log will exceed 100 years and may require 150 years
- Felling of timber trees in interlines is detrimental to seed supply for the gaps and may increase the size of the gap opening too much
- The present strip clear felling system with planting is unlikely to perpetuate the diverse natural broadleaved forests
- Small openings with one to a few trees removed at a time is the way to proceed, possibly without even fencing, provided grazing pressure remains low (i.e. much lower than is presently ….);
  management induced ecosystem disturbance must imitate the effects of the natural disturbances, and one must balance the combined frequency and severity of disturbance with the ecological requirements of the species and serial stage(s) one wants to sustain. This requires the matching of disturbance regimes to the ecology of the local site and landscape
- The present skyline harvesting system used in production forest working circles should be modified to reduce the size of opening from a single clear felled sub-coupe of approximately 6 ha, to one creating several patch or group openings along the line

totaling 2-3 ha per sub-coupe (including the skyline corridor), and with each opening separated by a patch of intact forest

- Stand replacement should be by natural regeneration and supplemented by planting only in areas that remain under stocked after a waiting period of one to two years

DHITAL (1999) reports that inducing natural regeneration in broadleaved forest has become very difficult: “Nature does not seem to be responding to the silvicultural systems prescribed in these forest types”. This again highlights the importance of gaining an increased understanding of natural regeneration dynamics.

According to SEYDACK (1999) clear felling systems are unlikely to perpetuate diverse natural forests in which catastrophic canopy disturbance does not form part of the natural disturbance regime. He anticipates a number of potential problems:

- Recruitment problems in proximity to conspecific adults. Poor recruitment performance may thus result during the second rotation when the canopy is dominated by a few, commercially desirable species.
- Growth law effects: early growth peaks and early senility, i.e. growth declines, are often encountered in gap opportunist species raised in full sunlight during the establishment phase.
- Short merchantable bole lengths. Open grown trees tend towards crown formation at lower heights.
- Inferior timber quality.
- Open-grown seedlings are more prone to herbivores and sometimes also diseases.

The stands produced from clear fellings would be dominated by characteristics of plantation systems and may be able to play a role in production forestry with the necessary silvicultural inputs and in the absence of serious encounters with the potential problems mentioned. In view of the potential problems possibly associated with plantation stands and their lower conservation value, the clear felling option should ideally only be opted for on a smaller portion of the broadleaved forest area. It is accordingly considered advisable to extend the range of yield regulation systems with options 4 and 5 below:

1. Two-thirds group clear cut: every third strip is left as natural forest; i.e. not involved in group clear cutting. The final result of this approach would be that each group clear felling strip would have unaltered natural forest along one of its sides (there would be a natural forest “skeleton” between the quasi plantation stands).
2. Maturity condition-based selective harvesting with natural regeneration; possibly not even requiring fencing under low to moderate cattle grazing pressure.

The proposed option 5 allows for the differentiated harvesting of canopy trees of declining productivity and value and the retention of productive canopy trees for optimal productivity and seed release. In order to implement such a system, maturity condition-based harvest selection criteria have to be worked out for all relevant species.

Since cable line logging cannot be used in conjunction with such a system of yield regulation, *in situ* processing of boles and low impact logging techniques would have to be optimized, improved or developed. SEYDACK concludes that an optimal mix of yield regulation options 3, 4 and 5 – with the last option (5) to be implemented over most of the broadleaved forest area - would seem most appropriate for Bhutan; given the nature of its forests, its terrain and the requirements for silvipastoral and timber utilization as well as those of forest conservation.

In line with what FISCHER has formulated 30 years ago, SEYDACK present following research needs:

a) Comprehensive forest inventory and forest type classification

b) Long-term study and monitoring of forest dynamics via a permanent sample plot system

c) Regeneration dynamics

d) Grazing impacts on regeneration

e) Implications of open-planting growth responses under clear felling silvicultural systems

f) Development of a low impact naturalistic yield regulation system

SEYDACK emphasizes, that a deeper understanding of the inherent regeneration dynamics of the broadleaved forests is indispensable as basis for management approaches in order to sustain harmony between conservation and utilization both regarding silvipastoral and timber utilization. Finally, listed projects e) and f) would be of significant importance for sustainable timber utilization from the broadleaved forests of Bhutan.

8. Regulation of cattle grazing

While logging is the most important intervention in the silvicultural management system for FMUs, **regulation of cattle grazing** is probably the most important single aspect with regard to conservation and management of most parts of Bhutan's forests. FISCHER (1971/76) argues, that while the introduction of systematic forest management and wood utilization is still in an early infant stage, all forested and other areas beyond the cultivated fields (which are always confined to the vicinity of habitations) have for a long time been fully occupied and used for cattle grazing. He repeatedly mentioned that cattle-farming is a part of the country's integrated soil utilization system. But the productivity of such a grazing method is low, where as its effects are extremely damaging. He also mentioned that not only future development in the field of forest management and wood utilization, but even the future physical existence of all of Bhutan as a high mountain state, will depend upon whether and how the precarious situation caused by the traditional, detrimental practices of cattle-farming … can be overcome. Allusion to the fact that Bhutan, in spite of its badly regulated system of cattle-farming, and in spite of severe burning and other destruction of its forest vegetation, has been able to persist for several centuries, cannot be taken as valid. Nobody can tell for sure how often and for how much time during its past the country has been subject to severe human and animal epidemics which periodically allowed the natural environment to recover and to regenerate." FISCHER therefore emphasizes that an "ultimate complete separation of pastures and forests is urgently necessary"

This proposal – in addition to a number of other highly relevant recommendations – has been repeated by PROF. DR. GEORG MIEHE (2000) / University of Marburg / Germany, at the end of his recent mission (Bhutanese – German Joint Investigations on the Biodiversity of Forests and Alpine Pastures; 6 Months-field campaign from April 20 to October 20, 2000; a joint Bhutanese-German contribution to the "International Year of the Mountains").

SEYDACK (1999) writes on the same issue, that "Cattle grazing / browsing is reported to occur widely over most of the forests of Bhutan and is considered to be a problem for forest regeneration. Cattle grazing at considerable intensities can indeed be expected to be problematic for forest regeneration: it represents an artificial herbivore pressure (less tissue selective than natural browsers) and often takes place by seasonally-starved animals. This is expected and found to be especially troublesome in open areas and for palatable gap opportunist species. Species of this guild are geared to opportunistically shoot up in gaps in order to finally occupy upper canopy positions (high growth rates) and under such conditions become metabolically activated; which presumably increases seedling palatability. Slowly growing seedlings of the same species under full or partial shade are presumable less palatable. The vulnerability to herbivore browsing of metabolically activated seedlings is also inferred to explain the lack of success of many enrichment planting attempts where planted stock is often actively selected by herbivores in preference to naturally established seedlings metabolically cued to sub optimal light conditions"

In the same line, DAVIDSON et al. (1999) argue ….

> …. that cattle can cause significant disturbance to catchment hydrology on steep slopes and they find seedlings of all of the broadleaved timber tree species very palatable (see also Alirol 1979, Bjønness 1980, Van Ijssel 1990, Carson 1992, Gyamtsho Pema 1992, Driscoll 1997). Trees such as *Quercus semecarpifolia* and *Q. lamellosa*, if lopped heavily for fodder, do not produce seeds.

They further report that the evolution of livestock herding and management systems in the hills from "traditional" to the present is a historical phenomenon. The national cattle population in Bhutan increased rapidly from about 125,000 in 1973 to about 400,000 in 1990 (Dorji 1993). A number of changes have taken place in livestock management in recent years (within a single human generation and within about a quarter of a forest generation) in response to changing demographics, socioeconomics and biophysical situation. These changes have not been abrupt but have been slow and strategic responses by the traditional herders. Yonzon (1998), in carrying out a number of transects to survey wildlife in four FMUs in eastern Bhutan, including Korila, also recorded the relative frequency of encounters of humans and cattle in the forest. He found the frequency of encounters of cattle at almost 20 percent and people at 15 percent, the former some 10 times the frequency that native mammals and large-sized birds were encountered (Yonzon 1998: p16).

As one goes higher in elevation in the broadleaved forest zones, there is increasing demand on the forest to meet fodder requirements. Fodder deficiencies are much more severe in the pre-monsoon period (April-May) and become the main constraint to livestock production.

Most villagers, particularly the poor, in eastern Bhutan are totally dependent on grazing lands (*tsadrog*) and forest lands to meet their animal's grazing needs, and, given the high numbers of animals maintained, must of necessity exploit these areas heavily. Many of the grazing areas, particularly those near roads and villages become no more than resting places where animals are tethered or housed in temporary barns, particularly for calving and milking. The livestock density per cultivated hectare is therefore very high.

They quote CARSON (1992), writing on grazing in the Himalayas:

> "Free grazing of livestock is the single most serious cause of marginalisation of agricultural and forestry lands and changes are required to make this land use productive and sustainable"
>
> "Livestock herd management itself is also a critical issue, with large herds of cattle seemingly required to maintain adequate breeding stock to perpetuate the herd. The apparent inability to cull the lower quality cattle forces a large number of scrub/feral animals onto the common lands, including forests. This, in turn, causes tremendous damage to the vegetation and soil.
>
> "Free grazing must be recognised as a major contributor to land degradation and at the same time a major obstacle to upgrading soil fertility management. It is often countered that these animals are essential to produce manure to meet the farmer's compost needs, and that the manure resource alone justifies the predominance of non-productive animals in the system. Quite the reverse is true. As long as these animals are in the system, the farmer is not motivated to look at more environmentally sound cropping systems, involving fodder legume rotations, horticultural perennial crops and more intensive grazing and forest land management. It has been hoped that as more productive (and profitable) livestock are employed, these problems will sort themselves out. With no restriction on the grazing animals, manures cannot be used on the land of the farmers' choice."

9. Afforestation

According to FISCHER, afforestation should be given rather secondary priority …. And only be taken into consideration once proper management and care of the existing forests – all degraded forest areas included – has in fact been introduced and become firmly established ….and … the unsatisfactory methods at present applied for cattle-farming are improved and reorganized.

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