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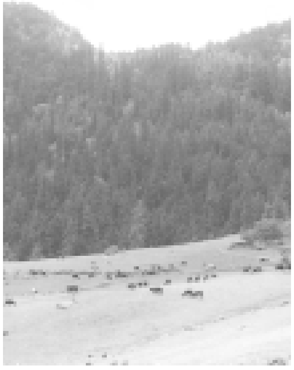

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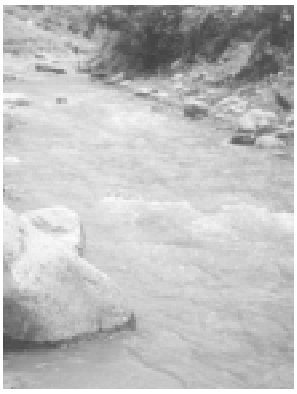

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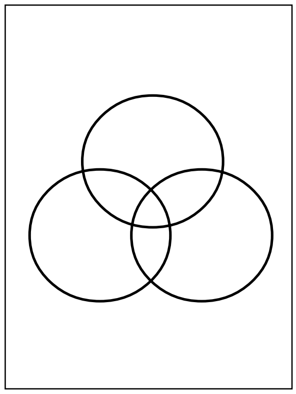

Only a unified theory that integrates the three domians of sustainable development - ecology, economy and sociology - can safeguard our future, **p 12**

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Without a unified field theory, sustainable development flounders

Theories of ecology, economy and sociology are partial and perhaps too simple, in isolation, to solve the complex problems of sustainable development. Past failure was due to such policies of government and non-government agencies which flop from one myopic solution to another. Unless we develop an evolutionary and dynamic integrated theory, which would recognize the synergies and constraints of nature, economy and people, we cannot assure a sustainable future. Are we doomed? Holling (p 12) points to a light at the end of the tunnel! [**POLICY**]

Forest management must integrate the lessons of ethnosilviculture

Timber-only forest management is incompatible with the conservation of forest ecosystems. The incorporation of non-timber forest products (NTFPs) in mainstream forestry is critical to the sustainability of not only the ecological systems but also the livelihoods and cultural values of local and regional stakeholders. Some scientific efforts have been initiated focusing on integration of NTFPs into mainstream forestry, but the extent and diversity of Nepal's forests are such that sustainable forest management will no longer be an option if we wait for dispositive empirical results. On the other hand, ethnosilvicultural knowledge accumulated over the centuries is vanishing without a trace. Gautam and Watanabe (p 55) have documented such expertise among Canadian Aboriginal communities and Nepali community forest users groups. Their work underscores the need to establish appropriate databases to document this ethnosilvicultural knowledge, and the importance of strengthening the traditional institutions that have been applying and expanding that legacy. [**ARTICLE**]

Rain, slope, and land use determine sediment load in upland streams

The mid-hills of Nepal have been facing a dangerous dilemma arising from the escalating demands of a growing population, on the one hand, and worldwide pressure for ecological preservation on the other. Environmental degradation has been due largely to human activities: agricultural intensification, cultivation of marginal lands, extraction of forest products, and infrastructure development. The resulting changes in water storage and runoff patterns have contributed to soil erosion. Because of the climate and topography of the region, stream discharge is low most of the year, with high flows and sediment concentrations limited to a few major events during the pre-monsoon and early rainy season. A work by Bajracharya et al. (p 51), however, confirms that land use and farming practices significantly impact discharge patterns and sediment loads in streams with steep gradients in the mid-hills. Preliminary analysis suggests that it may be possible to predict discharge, and hence sediment loads, from 24-hour rainfall measurements. [**RESEARCH**]

Pre-eminent mountain geographer challenges Himalayan delusions

Jack Ives has been aptly described as a "dinosaur" – one of the last of the great geographer-explorers. Recently awarded the King Albert I Gold Medal (whose recipients include Sir John Hunt, organizer of the first successful ascent of Mt. Everest, as well as Bradford Washburn, creator of the National Geographic map of Mt. Everest), Ives pioneered a series of seven expeditions into the interior of Canada's Baffin Island, assigning names to peaks, glaciers, and rivers on this frigid landmass one and half times the size of Germany. His theory of "instantaneous glacierization" overturned the prevailing view that ice ages rolled down out of the north like a window shade: instead, Ives argued, they could begin as scattered snow patches that survived the summer on high plateaus of the interior of the Canadian north when mean temperatures fell just a few degrees, expanding rapidly to bury large areas. In 1989, Ives co-authored *The Himalayan Dilemma*, summarizing the controversial ideas that came out of the 1986 Mohonk Conference (which Ives organized); he was one of the architects of Chapter 13 (The State of the World's Mountains) of Agenda 21, a seminal document adopted by the 1992 UN Conference on Environment and Development in Rio de Janeiro (also known as the Earth Summit). Ives founded and edited the journals *Arctic and Alpine Research* and *Mountain Research and Development*. He established the International Mountain Society. And he is on the Editorial Board of the *Himalayan Journal of Sciences*. We are honored to publish a preview of his forthcoming book (p 17). We can only hope that this time the development planners will get the message.

Mild disturbance fosters forest regeneration

Eastern Nepal is rich in biodiversity and is much explored since the pioneering work of Hooker. More recently the forests are under pressure and degraded due to over-exploitation of resources for subsistence livelihood. Despite this increasing pressure some of the forests have been protected since long by local peoples. It has changed the regeneration status and diversity of the forest. Koirala (p 29) compares two forests of Milke region (east Nepal) at different levels of degradation. He finds that regeneration is more sustainable in the mildly degraded *Quercus-Rhododendron* forest than in mature and relatively non-degraded forest, where sapling counts indicate that *Symplocos* and *Quercus* are replacing *Rhododendron*.
[**RESEARCH**]

Four Nobel Truths

Nobel laureate Steven Weinberg offers career advice to graduate students (p 11). First, don't try to master your field before completing your PhD: you can learn on the job. Second, when choosing a research topic, look for areas that seems to be in a state of confusion: these are opportunities for creative research and significant contributions. Third, expect and accept wasted time: there is no shining path to the truth. Fourth, study the history of science, and your field in particular, in order to develop an appreciation for your own work. Good advice for students in any graduate degree program! [**ESSAY**]

Let's air our dirty laundry

Scientists and developers can't save the world when they have to play along to get along

Seth Sicroff

It's no secret: Nepal is a development basket case. Despite the fact that the country is overrun with foreign researchers and developers and flooded with loan and grant money, the major problems remain intractable. No one has any doubt where the roots of those problems lie: bad governance and self-interested assistance. Corruption is deeply entrenched in Nepal, as in most LDCs. Foreign aid is frequently a poisoned gift, designed to further the donor nation's priorities, often at the expense of the recipient. *Ke garne?*

What can the scientific community do to improve the effectiveness of development programs in Nepal (and presumably elsewhere)? The first step is to admit that we are part of the problem.

Let's start with an observation made by Gautam and Watanabe in this issue of HJS. Writing about the need to apply traditional silvicultural knowledge, the authors point out that "the NTFPs are so vast and diverse that merely waiting for scientific results may entail delays that preclude sustainable management." Clearly there are many other fields where we cannot afford the luxury of complete scientific investigation – and I strongly suggest that we not wait for a full investigation of this phenomenon before consideration of the next step. That is, what should a scientist do when he suspects that his research is an unnecessary obstacle to effective management?

Now let's look at a rather different sort of bottleneck. In 1989, Ives and Messerli published *Himalayan Dilemma*, a work that could well serve as a textbook on the inadequacies and misapplications of scientific research in the Himalayan region. One fairly typical example: it seems that, while researchers have been studying the hydrology of micro-scale watersheds in Nepal, they have been unable to correlate their findings with data gathered far downstream. The Indian government classifies all such data as secret – presumably to avoid giving away evidence that might be incompatible with India's unilateralist development of water resources. So, what should researchers in Nepal do when they cannot come to solid conclusions about critical phenomena such as the erosional impact of agricultural intensification, road-building, and forest removal?

These are among the simplest dilemmas facing Himalayan researchers. Here, based solely on my own experience, is a short laundry list of some of the nastier double binds that confront scientists working in the Himalayan region.

1. Despite the fact that they are supposedly making important contributions to economically and ecologically challenged nations, INGO personnel as well as foreign academics doing research in the Himalayan region actually depend on the good graces of their host countries. Prudence is essential if one wishes to work for extended periods in a protected area. Researchers in Tibet are, of course, well-advised to concur with Chinese versions of that region's history, and to refrain from criticizing China's Taiwan policy, repression of minorities, and remarkably vicious authoritarian regime. But the self-censorship does not involve only historical and ethical abstractions: it also involves agencies and policies that are central to the researcher's work. Criticism of the management of Annapurna Conservation Area Project (ACAP), for instance, is extremely risky given the current King Gyanendra's longtime patronage of the King Mahendra Trust for Nature Conservation. The result is a sustained whitewash of both development and conservation efforts.

2. Self-censorship also applies when it comes to the performance of international agencies. In a world where who you know is everybody's stock-in-trade, it just isn't smart to point fingers at well-heeled organizations.

3. When it comes to remote locales, very few researchers or developers stay in the field long enough to make a great difference. Graduate students are more likely to endure the hardships (and learn the local language) than professors and developers, but they need to finish their degrees, go home, and look for work. The result is that a large proportion of basic research and development in the field is done by neophytes.

4. Certain topics are so politically potent that it is dangerous to take a contrarian stance. Examples: gender studies, garbage on Mt. Everest, Sherpa and Tibetan culture, ecotourism, rapid participatory assessment.

5. No one publishes his own failures. In many cases, these are the experiences that would be most instructive to others working in the same field.

Of course, there are people who tell the truth, and some who even get away with it. "It's all bullshit on Everest these days," Sir Edmund Hillary told an interviewer in the run-up to the Golden Jubilee celebration of his and Tenzing's first ascent of that peak. (He was referring to the commercialization of adventure.) In fact, there are competent and committed researchers and developers, even in Khumbu. But it's the bullshit that threatens to overwhelm every decent effort. It's the self-censorship, the evasion, the whitewash, that sustains the failure of development.

So, what to do? That is the question that we pose to our readers. ■

The truth won't out

Corruption and incompetence would not suffice to cripple development if scientists and developers were not afraid to blow the whistle and expose them. But it seems that the only way to protect your job in this little gossipy country is to protect the egos and reputations of those who are screwing up. Question: How can we put an end to self-censorship?

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CORRESPONDENCE

Chemical research should be a national priority

Rajendra Uprety

Though Nepal has been active in natural product screening, the total national research effort is negligible. Little of the research that is carried out is appropriate for the natural and social constraints. Natural resources are being overlooked, and data that is collected is not thoroughly analyzed and reported.

Chemistry research in Nepal was initiated during the seventies, when it was made a requirement for the Masters degree at the Central Department of Chemistry (CDC), Tribhuvan University (TU). More than 130 theses have been completed so far, in addition to six Ph. D. dissertations and two dozens other research works conducted by the department faculty. While the number and impact of these studies has been slight, we should not conclude that the research has no value at all. Manandhar 2003, Bajracharya 1998, and Kharel 2000 [1-3], for example, are valuable studies. Poudel (2002) reports on triterpines and betunelic acid, molecules with anti-cancer and anti-HIV properties, that have been found in the giant dodder (*Cuscuta reflexa),* an annual parasitic herb indigenous to Nepal[4]; if extracted and refined, such pharmaceuticals could produce significant revenues. And there are thousands of other possibilities.

Raja R. Pradhananga, professor and head of CDC, understands the unsatisfactory situation of chemical research in Nepal. "By adding a course on research methods, we can make the three-year B. Sc. a more research-oriented degree program", says Pradhananga. "There should be a law that the income tax paid by national or international organization involved in science and technology is allocated to research and development." Finally Pradhananga concludes, "the nation should, as far as practicable, make Tribhuvan University the focus of research activities."

In addition to CDC, there are many established national research centers with adequate scientific manpower and well-equipped research laboratories. The Royal Nepal Academy of Science and Technology (RONAST), the Research Center for Applied Science and Technology (RECAST), and Tribhuvan University are the institutions most responsible for enhancing the science and technology through research. Although these organizations have ambitious scientific goals, their paltry contributions have hurt Nepal. RONAST, RECAST, the Ministry of Science and Technology (MOST), and the Ministry of Population and Environment (MOPE) have never been able to justify their existence.

During its two and half decades, RECAST has attempted a mere handful of research projects, and the titles have been more compelling than their results. Several of the research reports end with "not applicable at the moment," "budget not available in time" and "due to financial constraints, experimentation couldn't be done properly and study tour could not be taken" [5]

RONAST reports about forty research projects on natural resources and environmental analysis in the natural product and environmental analysis over the course of its twenty years. Many of them are concerned with the analysis of environmental parameters in Kathmandu Valley. Out of these, a few such as 'Pollution monitoring in the water supply system of Kathmandu City' by T. M. Pradhananga[6], are considered significant. Pradhananga, chief scientific officer at RONAST, maintains, "Both government and scientists are responsible for the failure of the research and development programme. We the scientists could not convince them of the significance of science and technology and they could not understand us."

When a researcher lands a foreign project, RONAST greets it with bureaucratic meddling and roadblocks. A research project conducted under the auspices of RONAST by Wageningen Agricultural Univesity (Netherlands) with the collaboration of Nepal Agricultural Research Council (NARC) and the Department of Bimolecular Sciences, was forced to tolerate intolerable bureaucratic impediments. The report concludes, "On many occasions, researchers are bogged down by bureaucratic administrative hurdles, due to which many field projects were cancelled. [I]n order to produce good results, a proper environment should be created, free from administrative hurdles; and the allocated budget should be released on a timely basis". [7]

K. D. Yami, the main investigator in this project and Chief Scientific Officer at RONAST, states: "The main reason for the failure of research programme is the chronic and unresolved conflicts embedded among the research personalities when they occupy high-level bureaucratic positions in different institutions. Most of the time, it is seen that neither the research personalities nor the government people identify the common and main problems. And their commitments always end only in seminar or meetings. RONAST, being an autonomous body, can conduct many more research activities comfortably if a favorable environment is created. But up to now, research institutions have not had a healthy relationship with RONAST" . She adds, "We have knowledge and programmes useful to society but the government policy hasn't given a high priority to science and technology, nor have the private sectors".

Only if we can move beyond the past conflicts between research institutes and between high officials can we advance in science. Nepal has over a dozen well-equipped and organized laboratories and adequate man-power. The laboratories of the Central Department of Chemistry, Natural Products, Royal Drugs Limited, Quality Control and Department of Food Technology, Nepal Standard and Quality Controls, RONAST, RECAST, Kathmandu University and Pokhara University, have advanced equipments. Tribhuvan University and other universities have already produced many M. Sc. graduates. The Nepal Chemical Society claims membership of more than 1500 chemists.

I would like to suggest two steps that might help promote scientific research. First, an interdisciplinary and high-level task force should be created, with members drawn from government and the private sector. Second, Nepal Chemical Society, in collaboration with CDC, should take the lead in research and publication activities as an open forum. ■

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▶ BOOK

How to control illegal wildlife trade in the Himalayas

As Nepal's greatest natural resources approach extinction, the stakes could hardly be higher

Ram P Chaudhary

Cites Implementation in Nepal and India – Law, Policy and Practice

by Ravi Sharma Aryal

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The international trade in wild animals, plants, and wildlife products is big business, with worldwide transactions of over US$ 5 billion a year. Most of it is entirely legal, regulated by national laws and international treaties. But about one-fourth to one-third of the trade entails unlawful commerce in rare and threatened species that are usually poached or collected illegally and smuggled across frontiers. The trade in endangered fauna and flora is diverse, ranging from live animals and plants to a vast array of wildlife products derived from them, including food products, rare and exotic leather goods, tourist curios and medicines. Such illegal trade is one of the main engines driving species to extinction.

Although population increase and poverty are generally cited as the indirect causes of poaching and illegal collection, the major threats are conflicting laws and perverse incentives on the part of rich and influential consumers. An important challenge, at present, is to systematically study the population of threatened fauna and flora so as to understand their status and conservation requirements[1].

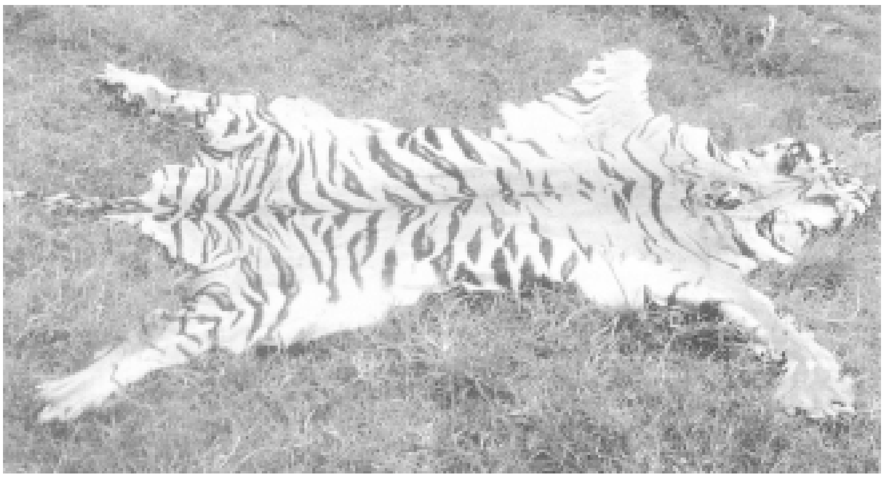
The decline in biological resources in Nepal has been due largely to the lack of policies to guide legal, institutional and operational developments in this sector. Biodiversity policy in Nepal has usually been shaped by political and economic motives rather than ecological and social considerations[2].

An international treaty, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), came into force on July 1, 1975. That same year, Nepal became a party to the treaty, and to date 165 countries have agreed to adhere to CITES. Its enforcement is the responsibility of the signatory states, and governments are required to submit reports and trade records to the CITES Secretariat.

Regulation of international trade in wildlife and wildlife products is an intersectoral endeavor, with social, economic, ecological, cultural, and political dimensions. Aryal's book covers the spectrum of issues, focusing on the gaps and weaknesses in the laws, policies, and implementation measures in Nepal and India, countries that cover a major part of the Himalayas. Aryal also discusses cross-sectoral issues, which must be addressed in order to control smuggling across international borders.

The book is divided into seven chapters addressing a range of topics related to CITES implementation in Nepal and India. Chapter One provides a general introduction to the concept of endangered species, and to the state and importance of biodiversity. Chapter Two briefly summarizes the history of cultural and legislative efforts to protect forests and wildlife in Nepal and India. Chapter Three explains the concept and principles of CITES, discusses issues raised and progress made during the COP (Conference of Parties), and reports on typical cases of infringement of CITES in Nepal and India.

While neither Nepal nor India has drawn up specific legislation to implement CITES provisions, both countries have adopted numerous policies, laws, and conservation measures bearing on the implementation of this treaty. These are presented in Chapters Four and Five, the centerpiece of Aryal's book. Article 26.4 of the Constitution of the Kingdom of Nepal (1990) provides directives for the protection of the environment at large; the National Parks and Wildlife Protection Act (1973), the Forest Act (1995), Nepal Biodiversity Strategy (2002)[3], and other related Acts and policies are fulfilling the objectives of CITES in Nepal. Implementation of CITES in Nepal is further strengthened by the 1991 Nepal Treaty Act (NTA) which specifies that when a matter in a treaty is inconsistent with the existing domestic laws, the domestic laws shall be void to the extent of the inconsistency, and the provision of the



CREDIT: Ravi Sharma Aryal

The international illegal trade in wildlife and wildlife products is one the major engines driving species to extinction. The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which defines standards for use of wildlife and their products, represents a major global commitment to reverse this trend. It remains to be seen whether the terms of this treaty will be enforced. Focusing on Nepal and its neighbors, Aryal discusses the obstacles to its successful implementation: imprecise legislation, inconsistent policies, lack of coordination among relevant institutions (particularly, those responsible for regulating international trade), and the deadly threat posed by poachers determined to protect their endangered livelihoods. Aryal's recommendations are detailed, far-reaching, and compelling.

treaty shall prevail as the law of Nepal. Strangely, Aryal is silent about the Local Self-Governance Act (1998). According to this law, the District Development Committee (DDC) is the implementing body of the local government. Section 189(g) (1) of the Local Self-Governance Act requires the DDC to formulate and implement plans for the conservation of forests, vegetation, biological diversity and soil. Section 189(g) (2) further requires the DDC to protect and promote the environment. Similarly, Section 28(h) (2) requires that the Village Development Committees (VDCs), the next smallest unit of local governance, formulate and implement programs for the conservation of forests, vegetation, biological diversity, and soil.

In Chapter Five, Aryal compiles the scattered laws impinging on control of illegal exploitation of wildlife in India. The Constitution of India as amended in 1976 (Articles 48.A and 51-A9g) directs the government to protect the environment. The Indian Forest Act of 1927, the Forest (Conservation) Act of 1980, the Biological Diversity Act of 2002 and other relevant laws are important tools for the protection of endangered species.

Medicinal plants, many of which are rare and threatened, are used in two ways: first, in medications prescribed by traditional systems, and second, in medications that have become accepted in Ayurvedic, Tibetan, and allopathic (or Western) medicine. In general, the collection of medicinal plants for traditional local use is not a problem since this use has developed gradually and in harmony with nearby natural ecosystem[1]. Accordingly, the 1991 amendment of the 1972 Wildlife (Protection) Act of India allows scheduled tribes in India to use locally available medicinal plants in a sustainable fashion. Such protection of customary rights is not found in any Nepalese law, and Aryal takes issue with the provisions of the Indian Wildlife (Protection) Act. I believe, however, that through this law the government of India gives due recognition not only to the rights of indigenous peoples to preserve their culture, but also to the importance of safeguarding the transmission of indigenous knowledge from one generation to another.

Aryal has rightly mentioned the importance of transboundary cooperation. The CITES treaty could play a crucial role in the interdiction of smuggling across the Nepal-India and Nepal-China borders. The protection of wildlife is currently hampered by differences in the degree of protection among the three countries. For example, in China a person can be sentenced to death for killing an individual of an endangered species such as the giant panda[4]. In Nepal and India, however, the penalty is imprisonment for few years or nominal fine or both. Tri-national consultative meetings on biodiversity conservation will be vital in plugging the gaps and untangling the legal inconsistencies.

In Chapter Six, Aryal undertakes a review and detailed analysis of existing plans, policies, and regulations, as well as interview survey conducted in some border areas and in the capital of India about the administrative practice and constraints in order to expose the obstacles impeding effective implementation of CITES. The problems are diverse, ranging from lack of clarity in legislation to lack of coordination among the relevant institutions, from dubious nomenclature and out-of-date species lists to lack of competent staff in the field to threat for guards posed by the poachers.

Chapter 7, "Conclusion and Suggestion," presents Aryal's astute recommendations for improvements in strategy and administrative structure that would facilitate implementation of CITES in Nepal and India. I would cluster all the Aryal's recommendations at three levels.

Recommendations at the systemic level include:

- translation of international treaties to national legislation
- amendments in laws and policies with the view to closing existing loopholes
- strict enforcement of existing legislation
- implementation and monitoring of trans-boundary wildlife trade regulatory mechanisms.

Recommendations at the institutional level include:

- development of strong linkages among the relevant institutions
- development of technical infrastructure, publication and dissemination of information, and promotion of skills pertinent to CITES enforcement among police, custom officers, and immigration officials
- insulation of CITES administration from political interference.

Recommendations at the individual level include:

- development of professional ethics and accountability
- expanded professional networking
- enhancement of job security, benefits, and incentives, including life insurance
- expanded opportunities for career advancement.

I might offer a few reservations about the book itself. Although the printing is of good quality, the high price may discourage some readers for whom the book would be a useful reference. The small font used in the footnotes is also rather frustrating. The book is illustrated with photographs, a number of which are redundant. A useful supplement would be a compilation of photographs of all endangered fauna and flora listed under CITES.

Nonetheless, the book will be a valuable resource for policy makers, politicians, wildlife traders, protected area managers, conservationists, national and international agencies, NGOs and INGOs, professors, students and general readers. ■

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Himalayan perceptions: Environmental change and the well-being of mountain peoples

Fifteen years ago, the Himalayan Dilemma buried the most popular environmental paradigm of the 80s. What will it take for policy-makers to get the message?

Jack D Ives

Perceptions of environmental change affecting the Himalayan region have undergone extensive revision over the last thirty years. During the first half of this period it had been widely assumed that environmental collapse was imminent due to exponential increase in pressure on the natural resources driven by rapid population growth and deepening poverty. One of the many statements of imminent catastrophe was issued by the World Bank in 1979[1], predicting that by the year 2000 all accessible forest in Nepal would be eliminated. Although the linkage of human poverty and natural disaster continues to attract serious debate, the catastrophist paradigm has been discredited by an avalanche of research, not to mention the passage of time during which the heralded disaster has failed to materialize. This has opened the way for a more realistic appraisal of the actual dynamics of change in the region.

The publication of *The Himalayan Dilemma* (Ives and Messerli 1989)[2] fifteen years ago derived from an international conference on the 'Himalaya–Ganges Problem' held at Mohonk Mountain House, New York State, in May 1986. The conference had been called to investigate the validity of the prevailing Himalayan environmental paradigm of the 1970s and 1980s that came to be known as the *Theory of Himalayan Environmental Degradation*. In brief, the Theory proposed that increased devastating flooding on the Ganges and Brahmaputra lowlands was a direct response to extensive deforestation in the Himalaya. The deforestation was presumed to result from a rapid growth in the mountain subsistence farming populations dependent on the forests for fodder and fuel and for conversion to terraced agriculture. As steep mountain slopes were denuded of forest cover, it was assumed that the heavy monsoon rains caused accelerated soil erosion, numerous landslides, and increased runoff and sediment transfer onto the plains. This was further assumed to induce a progressive increase in flooding of Gangetic India and Bangladesh, putting at risk the lives of several hundred million people.

> **Himalayan perceptions: Environmental change and the well-being of mountain peoples**
>
> by JD Ives
>
> Routledge, London and New York
> To be published in August 2004

The 1986 deliberations were frequently heated, but a consensus was reached to the effect that the Theory lacked scientific substantiation. This was reflected in the 1989 book; we stressed, however, that a great deal of more focused and more rigorous empirical research was required in order to substantiate the many issues that had been raised. *The Himalayan Dilemma*, while effectively contesting many unproven assumptions that collectively formed the Theory, could be seen as essentially an attempt to prove a series of negatives. Nevertheless, the academic response to the book was generally positive and it is still quoted in almost every scholarly publication on the Himalayan region. Forsyth (1996)[3] credited the Mohonk Conference with achieving the first major environmental paradigm shift and, along with Thompson (1995)[4], referred to the unfolding discourse as *The Mohonk Process*.

Despite the positive reception on the part of academics, the perceptions generated by the Mohonk Process had little impact on environmental policies. Regional authorities, for example, to this day maintain embargoes on logging in the mountains based on the justification that extensive deforestation was causing seri-

Himalayan Perspectives returns to the enormously popular development paradigm that Ives dubbed the 'Theory of Himalayan Degradation'. According to this seductive construct, poverty and overpopulation in the Himalayas was leading to degradation of highland forests, erosion, and downstream flooding. In the 'Himalayan Dilemma', Ives and Messerli exposed this "Theory" as a dangerous collection of assumptions and misrepresentations. While most scholars in the field promptly conceded Ives and Messerli's points, the Theory has somehow survived as the guiding myth of development planners and many government agencies. In his new book, Ives returns to drive a stake through the heart of this revenant. His book not only reviews the research that, over the past 15 years, has confirmed the arguments of the 'Himalayan Dilemma'; it also takes a close look at all those destructive factors that were overlooked by the conveniently simplistic 'Theory of Himalayan Environmental Degradation': government mismanagement, oppression of mountain minorities, armed conflict, and inappropriate tourism development.

ous flooding and major dislocations downstream.

Since 1989, and partly as an outcome of the Mohonk Conference, a vast amount of related environmental research has been undertaken; its publication, however, has been scattered widely throughout the literature. The new book, therefore, attempts to bring together and analyze the more recent studies in the context of the earlier work that led up to the 1989 publication. It presents a final rejection of the earlier environmental paradigm; this becomes the more important considering the inappropriate environmental and developmental policy decisions to which the region is still subjected. Furthermore, the inept and sustained focus of much of the government legislation has served to paint the poor mountain minority people as the prime cause of environmental degradation and so deflect attention from the real problems.

Himalayan Perceptions has two primary aims: one is to follow through on the academic discourse, to examine the results of the post-1989 research, and thus to update *The Himalayan Dilemma*; the second is to assess the problems that threaten the stability of the region as the new century unfolds. As a corollary to this, some of the reasons why scholarly research has had little, or no, inherent impact on environmental policy making are discussed. In particular, the perpetration of disaster scenarios by the news media is explored because it is believed that this is one of the reasons why the public at large still accepts the notion of impending environmental catastrophe.

The region discussed here extends well beyond the limits of the Himalaya *sensu stricto* (the 2,500 kilometre arc from Nanga Parbat, above the middle Indus Gorge in the northwest, to Namche Barwa, above the Yarlungtsangpo–Brahmaputra Gorge in the east). Coverage is extended to include the Karakorum, Hindu Kush, and Pamir mountains in the northwest, and the Hengduan Mountains of Yunnan, the mountains of Northern Thailand, and the Chittagong Hill Tracts, in the southeast. The United Nations University (UNU) mountain research project, from its initiation in 1978, has investigated test areas throughout this broader region, and the new book represents a contribution that concludes the quarter century of UNU effort.

Himalayan Perceptions attempts to analyze the manner in which the perceptions of the Himalayan region have evolved over the last three decades. It explores how the simplistic environmental alarm arose and why it held sway for so long. Without doubt, the environmental problems assumed to be threatening the region in the 1970s and 1980s were causing widespread concern and affected the way in which international aid was manipulated. Over the last fifteen years it has become increasingly clear that the more dominant causes of instability are socio-economic, administrative, political, and the spread of violence and terrorism. The continued debilitating poverty is regarded, at least in part, as a consequence of mismanagement in its broadest sense. Therefore, in addition to assessing how the environmental discourse has played out since 1989, issues involving poverty, oppression of the mountain peoples, unequal access to resources, insurgency, and military conflict are presented. The importance of tourism is also addressed because it is a major force that has both positive and negative aspects and is now menaced in many places by the growing political tensions and violence in the region.

I have tried to write in the spirit of the United Nations General Assembly of 1997 (Rio-Plus-Five), convened in order to evaluate the progress achieved in the five years following the 1992 Rio de Janeiro Earth Summit (UNCED), and of the UN designation of 2002 as the International Year of Mountains (IYM). Since the primary goal of IYM is 'sustainable mountain development', it is considered that prospects for achieving this goal, at least within the Himalayan region, will be limited by the degree to which the problems can be correctly defined. If progress has been made towards producing a more accurate definition then the writing of the book will have been well worthwhile.

There are eleven chapters. Chapter One, entitled *The Myth of Himalayan Environmental Degradation*, provides an overview of how the Himalayan region has been perceived over the last thirty years and of how research has progressively influenced, or failed to influence, efforts to obtain regional 'sustainable development'. It includes a restatement of the *Theory of Himalayan Environmental Degradation* that was widely publicized by Erik Eckholm's book *Losing Ground* (1976)[5]. This is followed by a review of the later Himalayan environmental research, in effect, a synthesis of the first of the book's main themes. Chapter Two is an outline of the region under discussion – the Himalaya, defined very broadly. Chapter Three examines the discourse on the status of Himalayan forests; it contrasts the more humid eastern and central Himalaya with the increasingly drier conditions as one moves progressively toward the northwest into Northern Pakistan and Tajikistan. Chapter Four, *Geomorphology of agricultural landscapes*, addresses the complex relationships between land-cover type, especially agricultural terrace types and their management, precipitation, soil erosion, and downstream effects. Chapter Five, entitled *Flooding in Bangladesh: causes and perceptions of causes*, questions the relationships between land-use/land-cover changes in the Himalaya and flood plain responses. Drawing on extensive recent work by Thomas Hofer and Bruno Messerli[6], amongst other studies, it concludes emphatically that the primary cause of flooding in Bangladesh, and by extension in northeast India, is heavy monsoonal rainfall across Bangladesh and adjacent areas of lowland India.

The first five chapters, therefore, expose the *Theory of Himalayan Environmental Degradation* as an insupportable mental construct that should be totally eliminated as a basis for environmental and developmental policy making. The following five chapters turn attention to some of the actual problems that require far more rigorous attention by governments of the region and by foreign aid and development agencies in general.

The major physical hazards that pose a challenge to sustainable development in the Himalayas are the concern of Chapter Six; these include earthquakes, landslides, and torrential rainstorms. Opportunity is taken to introduce the controversy concerning construction of the Tehri Dam in relation to seismic hazard assessments, and the exaggerated claims of the dangers posed by the likelihood of catastrophic outburst of glacial lakes. Chapter Seven attempts to assess the development and importance of tourism, its positive and negative aspects, and the dangers inherent in excessive local dependency on a single development endeavour. Chapter Eight reviews the devastation being caused by accelerating violence – warfare, guerrilla activity, and unconscionable repression of mountain minority peoples. Topics range from actual warfare, as on the Siachen Glacier, Nepal's Maoist Insurgency, Bhutan's human rights abuses perpetrated on its Lhotsampa Hindu minority, Nagalim, and the oppression resulting from the imposition of mega-projects, such as the Tehri and Kaptai dams. Chapter Nine presents an overview of rural change and the challenges facing attempts to decentralize control over access to natural resources. The role of exaggeration – deliberate or unwitting distortion of events that are exasperated by news media reports – is examined in Chapter Ten. Individual case studies are presented, several of which are

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Are the Himalayas really in crisis? And if so, who's to blame?

shown as examples of distortions, even deliberate falsehoods, based in part on my experience in the field. The concluding chapter is styled: *Redefining the dilemma; is there a way out?*

The book frames the main conclusion that the *Theory of Himalayan Environmental Degradation* is not only a fallacy, but also an unfortunate impediment to identification of the real obstacles to sustainable development. These include administrative incompetence, corruption, greed, oppression of mountain minority peoples, political in-fighting, and even military and political competition for control of resources and strategic locations. The well-being of the 70–90 million mountain people has been largely neglected and so they are left with little alternative but to exert increasing pressure on whatever natural resources that are accessible, whether legally or illegally.

I have tried to make each chapter as self-contained as possible. This has led to a considerable amount of repetition. However, I believe this approach will be most beneficial for the reader who has not had direct experience of the Himalaya. None of the topics has received an exhaustive treatment. Rather, by selecting a series of issues I have tried to keep the task within reasonable limits while ensuring a broad view of this vast and complex mountain region and the challenges facing its diverse mountain peoples who deserve far better treatment than they have so far received. Without their direct involvement sustainable mountain development will remain a bureaucratic pipe dream. ■

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This account is a synthesis of the book with the same title that is due to be published by Routledge (London and New York) in August 2004.

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ANNOUNCEMENT

The Himalayan Journal of Sciences will hold a symposium to discuss issues raised by Jack Ives' forthcoming book, Himalayan Perspectives in Sept 2004. The event will be open to the public. Further details will be published on our Web site and in Mountain Forum.

SPECIAL ANNOUNCEMENT

Mountain Legacy Announces Plans

Mountain Legacy announces plans for conference on Mountain Hazards and Mountain Tourism, calls for nominations for second Hillary Medal, and proposes research and development institute in Rolwaling

One year ago, fifty-five delegates representing 15 different nations from as far away as New Zealand, Canada, South Africa, and Sweden, converged on Sagarmatha National Park for an international symposium entitled "The Namche Conference: People, Park, and Mountain Ecotourism" (May 24-26, 2003; Namche Bazar, 3350 m). The event was organized by United Nations University (UNU), Bridges: Projects in Rational Tourism Development (Bridges-PRTD), and HMG's Department of National Parks and Wildlife Conservation (DNPWC), and scheduled as part of the closing festivities marking the Mount Everest Golden Jubilee Celebration.

One of the 14 resolutions and recommendations of the Namche Conference was that a new association be established, to be called Mountain Legacy. Two immediate responsibilities were envisioned.

- First, Mountain Legacy would organize sequels to the Namche Conference — that is, international events bringing together academics, planners, commercial operators, agencies, grass roots organizations, and other stakeholders to confer with the host community in a remote mountain tourism destination. These events would be held every four years in Namche Bazaar, and every four years (at a two year off-set) in some other remote mountain tourism destination.

- Secondly, Mountain Legacy would be responsible for the presentation every two years, in the context of the Namche Conference, of the Sir Edmund Hillary Mountain Legacy Medal "for remarkable service in the conservation of culture and nature in remote mountainous regions." (The first medal was awarded to Michael Schmitz and Helen Cawley, who for the past decade have been working on keystone cultural and ecological projects in Solu-Khumbu, including the Tengboche Monastery Development Plan, the Thubten Choling Monastery Development Project near Junbesi, and the Sacred Lands Initiative.)

In addition, Mountain Legacy would undertake other projects in support of tourism and volunteerism in remote mountainous destinations.

As of April 2004, Mountain Legacy is officially registered as an NGO (HMG Regd No. 1018/060-61). The board has following members:

- Arjun Adhikari – President
- Arjun Kafle – Vice-President
- Kumar P Mainali – General Secretary
- Laxman Karki – Joint Secretary
- Geetanjali Nanda – Treasurer
- Bharat B Shrestha and Ganesh P Bhattarai – Members

Anyone interested in joining Mountain Legacy, or in collaborating on any of the projects outlined below, should contact Arjun Adhikari
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Mountain Legacy Announcements

1. From July 1 to December 31, 2004, Mountain Legacy will accept nominations for the second Sir Edmund Hillary Mountain Legacy Medal. (See Web site: www.mountainlegacy.org)

2. The second Mountain Legacy Conference will focus on Rolwaling (Dolakha District, Nepal) and will be held in October 2005. The theme will be "Mountain Hazards and Mountain Tourism."

3. Mountain Legacy is now ready to begin planning for the Rolwaling Mountain Legacy Institute. Prospective collaborators The concept and rationale for the RMLI are outlined below. (Revised from Vol 1 No 2)

Rolwaling Mountain Legacy Institute

Rolwaling Valley in north central Nepal presents an unusual combination of problems and opportunities linking cultural and natural conservation, tourism development, and scientific research.

Rolwaling's value as a biological sanctuary derives partly from its location and physical isolation. Running east-west for approximately 30 km, it is separated from Tibet by a stretch of the Himalayas that includes Gauri-Shankar (7134 m), which for some time was thought to be the highest peak in the world. The Rolwaling River flows into the Bhote Kosi (one of several rivers of the same name); this Bhote Kosi soon becomes the Tamba Kosi. Simigaon, at the confluence of the Rolwaling and the Bhote, is about 90 km east of Kathmandu, as the crow flies. It can be reached by a 4 or 5 day trek from Barabise, which lies on the

A new NGO born out of the Namche Conference ("People, Park, and Mountain Ecotourism"; May 2003), Mountain Legacy has announced a conference focusing on Rolwaling Valley to be held in October 2005. The theme will be "Mountain hazards and mountain tourism." As of July 1 2004, Mountain Legacy will be accepting nominations for the second "Sir Edmund Hillary Mountain Legacy Medal," to be awarded for remarkable service in the conservation of culture and nature in remote mountainous regions." Mountain Legacy is also planning to establish a research and development institute in Rolwaling Valley.

road to Tibet in the next valley to the west, or by a 2 or 3 day trek from Dolakha, the district administrative seat, located on a short branch off the Swiss road that connects Lamosangu with Jiri. The latter trail, the lower trails in Rolwaling itself, and particularly the steep ascent to Simigaon, are subject to frequent damage during the monsoon season, a problem that has recently been alleviated somewhat by improvements initiated by the Austrian INGO Eco Himal and by the Tsho Rolpa Glacial Lake Outburst Flood (GLOF) hazard mitigation project being carried out with Japanese and Dutch assistance. To the east of Rolwaling is Khumbu district, which in 1976 was gazetted as Sagarmatha National Park. The wall of peaks between Rolwaling and Khumbu is breached by the formidable Tashi Lapsta pass: with good weather, one can make the crossing between the last settlement in Rolwaling and the most westerly settlement on the Khumbu in about four days. Altogether, access to Rolwaling is not quite impossible, but definitely more inconvenient than the most popular trekking routes, several of which can now be approached by air.

Cultural factors have contributed to the conservation of species in Rolwaling. According to Tibetan Buddhism, about 1250 years ago Padmasambhava [aka Guru Urgyen Rinpoche] plowed the valley out of the mountains in order to serve as one of eight "beyul," refuges that were to remain hidden until, in a time of religious crisis, they would serve as sanctuaries, protecting dharma until the danger passed. The neighboring Khumbu was one such zone, and Rolwaling, in the shadow of the mountain abode of the goddess Tseringma (i.e.Gauri-Shankar), was another. Unlike Khumbu, Rolwaling remained isolated and unimpacted until the nineteenth century, and then was visited by a very few wanderers and outcasts. Due to the limited amount of arable land and the unsuitability of this east-west valley as a trade route between Tibet and India, Rolwaling's inhabitants remained poor and few, but devoutly mindful of their spiritual heritage. The Buddhist bans on hunting and slaughter, elsewhere observed less scrupulously, have protected the fauna; even plants are considered living creatures which ought not to be harmed if possible.

A third general factor that has contributed to the relatively unimpacted state of Rolwaling Valley has been the government's limitation of tourist access. Until recently, you needed both a trekking peak permit and a regular trekking permit. The trekking peak permit involved costs and other factors that essentially excluded the possibility of independent trekking. All visitors arrived in self-contained tented caravans which contributed virtually nothing to the economy of Rolwaling villages. Therefore there has been very little development of infrastructure, and not much impact on the environment.

In terms of biodiversity, Rolwaling is worthy of close attention. Janice Sacherer estimated that there are approximately 300 different plant species (Sacherer 1977, 1979). The atypical east-west orientation of the valley creates conditions unlike those in any other valley of the Himalayas. Partially shielded by its southern wall from the monsoon, Rolwaling has characteristics of the dry inner Himalaya; a good part of the flora derives from the Tibetan steppe and, in Nepal, is more typical of eastern valleys. As in other Himalayan valleys, Rolwaling's ecosystems vary dramatically from the broad glaciated valleys to the chiseled fluvial channel downstream; to a much greater extent than in other valleys, the sharp contrast between north- and south-exposed slopes affects the distribution of species. The east-west orientation of the valley also makes it a convenient corridor for mobile fauna. Rolwaling is visited by quite a few of the charismatic mammals, including wolves, fox, several species of goat, bear, jackal, langur, and several members of the cat family (including snow leopard). Every resident that we interviewed on the subject is convinced that yeti frequent the valley. In short, Rolwaling's biological assets are clearly worth studying; their conservation should also be accorded high priority as the valley's protective isolation breaks down. Furthermore, one cannot consider development scenarios in the high Rolwaling Valley without assessing the implications for the rich subtropical ecosystems of the Tamba Valley into which it feeds.

If isolation has had a benign effect on the natural ecosystem, the human residents of Rolwaling have observed the tourism boom with envy. In next door valleys, every family could throw open its doors to backpackers and cash in on the amenity values of their homeland; in Rolwaling, the stakeholders stare wistfully as organized trekking caravans deploy their tents by the river, cook up their burrito and quiche feasts, and buy nothing from the local residents. In Khumbu, their relatives enjoy the benefits of prosperity: schools, upscale monasteries, telephone, electricity, numerous clinics, a hospital, post office – even Internet, saunas, pool halls and chocolate croissants: none are available in Rolwaling. Many young men have found employment with trekking and climbing services. Such work entails extended absence from Rolwaling, and even emigration to Kathmandu or Khumbu. The result is a brain and manpower drain that leaves the villages of Rolwaling populated by women, children, and those no longer capable of strenuous labor. Agricultural fields have been abandoned, livestock ineffectively tended, trails poorly maintained. Alcohol, the only recreational option, is a serious health problem.

This disparity between the neighboring districts has created in Rolwaling (as in the access routes) an intense demand for free access to backpackers and economic opportunity. Several years ago, due to the threat of Maoist attacks, the police checkpost in Simigaon was removed. At this point, Rolwaling is officially open to general trekking, and, as the prospects for peace improve, the valley will become an important trekking destination.

Research Opportunities

At the western end of Rolwaling Valley, Tsho Rolpa, one of the largest and highest elevation lakes in the Himalayas, has been growing over the past decades due primarily to the recession of Trakarding Glacier. Attempts to mitigate the danger of a glacial lake outburst flood (GLOF) have included siphoning, installation of a warning system, and reduction of the lake level by 3 meters through an artificial drainage channel. Due to depletion of project funding, the drainage efforts have stopped far short of the recommended objective. Particularly as there is a real threat of a catastrophic GLOF, Tsho Rolpa is an appropriate place to begin long-term study of glacial melting, runoff hydrology, and moraine stability.

Rolwaling is also a good location for ecological research. Zonation is extremely compressed. The east-west orientation results in unusually sharp differences on the northward and southward facing slopes; it also means that the valley is probably an important wildlife corridor. Numerous ethnobotanical resources have been identified; now would be a good time to study them in the wild, and also to begin efforts to cultivate them as cash crops.

Serious anthropological studies by Sacherer and Baumgartner in the 1970s provide useful baseline data against which the current changes, especially the impact of tourism, can be measured and monitored. Specific studies that are urgently needed: the Rolwaling dialect of Sherpa, and Rolwaling traditions of song and dance.

RMLI Format

In the initial phase, RMLI is envisioned as an institute of opportunity rather than infrastructure. That is, researchers would use existing facilities (lodges and homes) rather than constructing new infrastructures. This would permit rapid initiation of programs, significant ongoing economic contribution to the village economy and minimization of impact on the object(s) of study.

The proposal calls for Mountain Legacy to assist researchers in recruiting volunteers. This would provide an opportunity for tourists to stay for prolonged periods, making contributions to research and practical projects, and also injecting expenditures for living expenses into the local economy. International students could be recruited either as study-abroad program participants or as interns. These students could either assist established researchers or design and implement their own programs consistent with the aims of the MLI.

The primary objective of RMLI would be to facilitate research and establish a database, while developing a special type of ecotourism in Rolwaling. RMLI would encourage long-term stays at very low per-diem rates, as opposed to so-called "quality tourism," which aims to extract the maximum profit over the course of short stays. It is expected that such an institute, well-publicized, would be a magnet not only for prospective participants but also for other tourists. Just as tourists go out of their way to visit cheese-making factories, they would visit Rolwaling to see the world-famous research center and to contribute to whatever on-going projects might need their help.

Again, Mountain Legacy invites collaboration on all of its projects.

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Quantitative analysis of tree species in two community forests of Dolpa district, mid-west Nepal

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Two community forests, Amaldapani and Juphal from Dolpa district, were selected for a study of quantitative analysis of tree flora. A total of 419 individual trees representing 16 species, 16 genera and 11 families were recorded. Total stand density and basal area were, respectively, 2100 trees ha^{-1} and 90 $m^2 \cdot ha^{-1}$ in Amaldapani and 2090 tree ha^{-1} and 152 $m^2 \cdot ha^{-1}$ in Juphal. Of the families, the Pinaceae was the most diverse, with 28 individuals representing five species and five genera, followed by the Rosaceae with three individuals representing two species and two genera. *Pinus wallichiana*, *Abies spectabilis, Quercus semecarpifolia* and *Cedrus deodara* had the highest importance value index and could therefore be considered the dominant species. Since the study area was diverse in tree population of conifers and deciduous forest tree species, it is essential to carry out further studies in order to establish conservation measures that will enhance local biodiversity.

Key words: Vegetation, tree species, *Pinus wallichiana*, community forest, Dolpa

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Human impact has, to varying degrees, led to a reduction in biodiversity in much of the forested area of Nepal (Karki 1991, Chaudhary and Kunwar 2002). Conservation of such forests requires an understanding of the composition of the particular forest, the effects of past disturbances, and the present impact of neighboring land use on that forest (Geldenhuys and Murray 1993). In order to understand the phytosociological structure of the Himalayan forests, we need studies that deal with distribution of individual plant species and of various girth classes, associations among species, patterns of dispersion and various indices of diversity (Longman and Jenik 1987). The present study therefore was designed to explain variation in vegetation composition and diversity components of tree species of Amaldapani and Juphal community forests of Dolpa district.

Materials and methods

Study area

Both Amaldapani Community Forest (ACF) and Juphal Community Forest (JCF) in Juphal Village Development Committee (VDC), Dolpa district were selected as study sites. Dolpa, in the rain shadow of northwestern Nepal, is the largest and most arid district in the country. Lying between 27°21' – 27°40' N and 84°35' – 84°41' E, it encompasses elevations between 1525 and 6883 m asl. ACF has a total area of 100 ha and 87 users, and was established in 1998 (2055 BS); JCF, with 1750 ha and has 165 users, was established in 1995 (2052 BS). Both community forests lie between 1900-2700 m asl, are situated close to agricultural lands, and are dominated by *Picea* and *Pinus* species.

Methods

Field studies were carried out in July 2001 and May 2003. Twenty plots, i.e. ten plots in each community forest, each plot measuring 10m x 10m, were randomly demarcated for study. Density, frequency, basal area and their relative values and importance value index (IVI) of tree species were calculated following Mueller-Dombois and Ellenberg (1974). Botanical name and author citation was made following DPR (2001). In addition to quantitative data, we used interviews and group discussions to collect information relating to community forest management. In order to assess the general condition and vegetation structure of the forest, we developed a density-diameter histogram. Girth of trees exceeding 10 cm diameter at breast height (dbh, at 1.37 m above the ground) was measured. The height of standing trees was measured by means of a clinometer. The species area curve of each community forests was calculated by randomly adding up the number of tree species in each quadrat. The dominance diversity curve (D-D curve) was used in order to ascertain the resource apportionment among the various species at various sites.

Jaccard's (1912) coefficient (J) was used to quantify the extent to which family and species composition overlapped between sample sites. It is defined as: J = A /(A + B + C) where A is the number of family and species found in both sites, B is the families and species in site 1 but not in site 2, and C is the families and species in site 2 but not in 1.

'S,' or species richness, was determined following Whittaker (1976) by tabulating the number of woody species in each plot. Shannon-Weiner's diversity index 'H' (Shannon and Weiner 1963), concentration of dominance 'D' (Simpson 1949) and Hill diversity numbers N0, N1 and N2 (Hill 1973) were computed.

Simpson's index 'D' was calculated using the formula

'D' = 1 - $\sum pi^2$, where pi is the relative density.

Shannon-Weiner's diversity index 'H' was calculated using the formula

'H' = - $\sum$ pi Log pi, where pi represents the proportional abundance of the i^{th} species in the community.

Hill diversity indices were calculated using the following formulae:

Number 0: N0 = S, where S is the total number of species;
Number 1: N1 = e^H, where 'H' is the Shannon's index;
Number 2: N2 = 1/D, where 'D' is Simpson's index

Results

Species area curve

The slope of the species area curve for each study site declined as sample area increased but did not approach an asymptote (**Figure 1**).

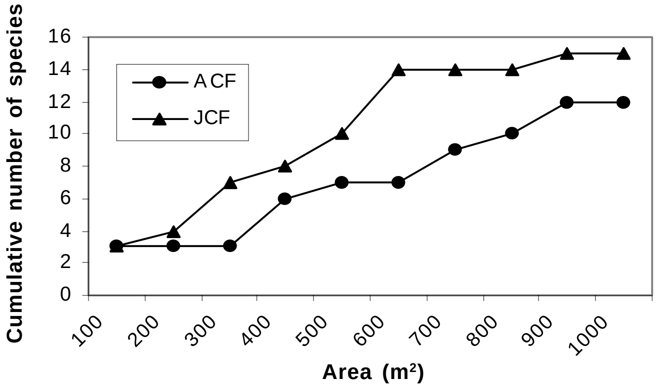

FIGURE 1. Species area curve

Vegetation composition

A total of 419 tree individuals, representing 16 species, 16 genera and 11 families, were identified within the 0.2 ha area survey (**Table 1**). *Acer caesium* (Aceraceae), *Juniperus recurva* (Cupressaceae), *Picea smithiana* (Pinaceae) and *Prunus* sp (Rosaceae) were found only in JCF and *Aesculus indica* (Hippocastanaceae) was reported only in ACF (**Table 1**).

Total stand density and basal area were, respectively, 2100 trees ha^{-1} and 90 $m^2 \cdot ha^{-1}$ in ACF and 2090 trees ha^{-1} and 152 $m^2 \cdot ha^{-1}$ in JCF (**Table 2 and 3**). Girth sizes of trees at breast height (gbh) ranged from 31 to 224 cm in ACF and 31 to 440 cm in JCF. The greatest gbh of *Abies spectabilis* (440 cm) was found in JCF followed by *Quercus semecarpifolia* (400 cm). The tree species attaining the greatest heights (>20 m) were *A. spectabilis, Acer caesium, Cedrus deodara, Juniperus recurva* and *Tsuga dumosa,* all in JCF.

The highest IVI value was that of *P. wallichiana* (109.58) followed by *C. deodara* (54.22) in ACF and *A. spectabilis* (75.59) followed by *Q. semecarpifolia* (57.31) in JCF. Based on IVI values, *P. wallichiana* and *A. spectabilis* were found to be the most dominant species in the study area (**Table 2 and 3**). 4.53% of the total tree individuals were stumps: 4.05% (17) in ACF and 0.5% (2) in JCF. Of the total stumps, 52.63% (10) were *P. wallichiana,* 36.84% (7) *C. deodara* and 5.26% (1) *A. spectabilis* and *Q. semecarpifolia* each.

TABLE 1. Composition and distribution of tree species in Amaldapani and Juphal community forests (CF)

Species name	Vernacular name	Family	Amaldapani CF	Juphal CF
Acer caesium Wall. ex Brandis	Tilailo	Aceraceae		+
Betula utilis D. Don	Bhoj patra	Betulaceae	+	+
Juniperus recurva Buch.-Ham. ex D.Don	Dhupi	Cupressaceae		+
Rhododendron arboreum Smith	Gurans	Ericaceae	+	+
Quercus semecarpifolia Sm.	Khasru	Fagaceae	+	+
Aesculus indica (Colebr. ex Cambess.) Hook.	Pangro	Hippocasta-naceae	+	
Juglans regia Linn.	Okhar	Juglandaceae	+	+
Abies spectabilis (D.Don) Spach	Jhule sallo	Pinaceae	+	+
Cedrus deodara (Roxb. ex D.Don) G.Don	Deyar	Pinaceae	+	+
Picea smithiana (Wall.) Boiss.	Thingre sallo	Pinaceae		+
Pinus wallichiana A. B. Jackson	Khote sallo	Pinaceae	+	+
Tsuga dumosa (D.Don) Eichler	Gobre sallo	Pinaceae	+	+
Prunus species	Aare	Rosaceae	+	+
Pyrus species	Pande mel	Rosaceae		+
Populus ciliata Wall. ex Royle	Bhote pipal	Salicaceae	+	+
Taxus wallichiana Zucc.	Kandeloto	Taxaceae	+	+
Total			**12**	**15**

+ = presence, = absence

Size class distribution

The distribution of dbh classes conformed to an reverse 'J' shape curve, with 63.24% of individuals having dbh between 11-30 cm: 104 individuals of 11-20 cm dbh and 35 of 21-30 cm dbh in ACF; 82 individuals of 11-20 cm dbh and 44 of 21-30 cm dbh in JCF (**Figure 2**). The number of individuals with a diameter greater than 50 cm was 12 in ACF and 31 in JCF, totaling 10.26% of total species (**Figure 2**).

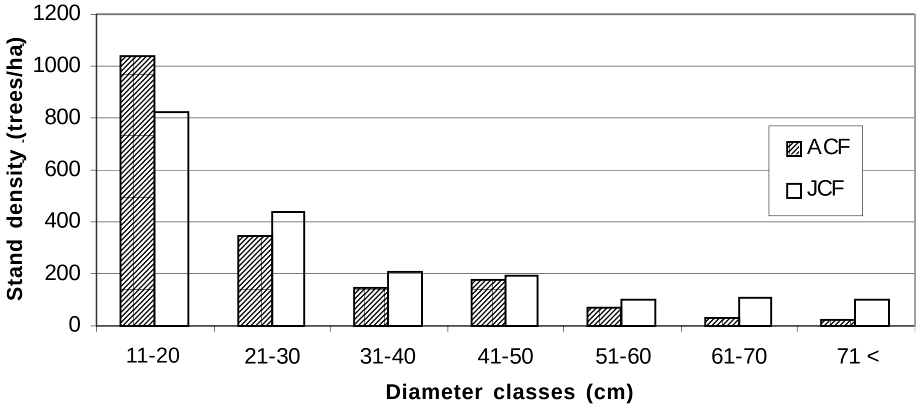

FIGURE 2. Distribution of tree in different size classes

Dominance diversity curve

Species dominance related to the availability of suitable niche and resource apportionment in a community has often been interpreted from the dominance diversity curve (D-D curve). D-D curves for ACF and JCF (**Figure 3**) were found consistent with the normal distribution model of Preston (1948), i.e., relatively few species had a high IVI. These curves illustrate resource partitioning among the various species (Verma et al. 2001).

Species diversity

Table 4 depicts the plant species richness, Shannon-Weiner diversity index, Simpson's diversity index, Jaccard's coefficient and Hill's diversity index of the two community forests. Maximum species richness (15) was observed in JCF while the minimum (12) in ACF. The Shannon-Weiner diversity index was 3.02 in JCF and 2.36 in ACF, while the concentration of dominance Simpson diversity index for JCF was 0.82 and 0.70 for ACF. Jaccard's coefficient (J) was 0.65. Hill diversity numbers N0, N1 and N2 were 12, 10.59 and 1.42 respectively in ACF.

Discussion

While square plots are usually superior for correlating plant communities with local environmental variables (Ferreira and Merona 1997), various shapes and sizes of plots have been selected for other studies (**Table 5**). In Nepal, most studies designed for the study of diversity or family/species abundance (including the present) have employed square sample plots. Comparison of quantitative data from the present study to those collected at other forest sites has been shown in **Table 5**.

For both surveyed sites, the slope of the curve relating species and area declined as sample area increased. The species area curves for ACF and JCF were more or less consistent with a gradual increase in the number of species with area, initially up to 600 m^2,

TABLE 2. Quantitative analysis of vegetation of Amaldapani community forest

Species name	D (tree/ha)	F (%)	BA (m^2 ha^{-1})	RD (%)	RF (%)	RBA (%)	Mean Ht (m)	IVI
a. *Pinus wallichiana*	1000	90	40.22	47.61	17.30	44.67	8.11	109.58
b. *Cedrus deodara*	440	90	14.38	20.95	17.30	15.97	8	54.22
c. *Abies spectabilis*	250	80	8.33	11.90	15.38	9.24	7.75	36.53
d. *Populus ciliata*	90	50	5.17	4.28	9.61	5.74	9.2	19.63
e. *Taxus wallichiana*	80	50	3.46	3.80	9.61	3.84	7.4	17.25
f. *Quercus semecarpifolia*	70	30	6.98	3.33	5.76	7.75	9	16.84
g. *Betula utilis*	60	30	3.58	2.85	5.76	3.97	9	12.58
h. *Aesculus indica*	40	40	1.48	1.90	7.69	1.64	7	11.23
i. *Tsuga dumosa*	30	20	3.55	1.42	3.84	3.94	10.5	9.20
j. *Juglans regia*	20	20	2.32	0.95	3.84	2.57	9.5	7.36
k. *Rhododendron arboreum*	10	10	0.37	0.47	1.92	0.41	6	2.80
l. *Prunus* species	10	10	0.23	0.47	1.92	0.25	7	2.64
Total	**2100**	**520**	**90.07**	**99.93**	**99.93**	**99.99**		**299.86**

D = density, F = frequency, BA = basal area, RD = relative density, RF = relative frequency, RBA = relative basal area, IVI = importance value index

TABLE 3. Quantitative analysis of vegetation of Juphal community forest

Species name	D (tree/ha)	F (%)	BA (m^2 ha^{-1})	RD (%)	RF (%)	RBA (%)	Mean Ht. (m)	IVI
a. *Abies spectabilis*	510	80	53.09	24.40	16.32	34.87	13.25	75.59
b. *Quercus semecarpifolia*	410	60	38.67	19.61	12.24	25.46	11.5	57.31
c. *Pinus wallichiana*	400	70	10.68	19.13	14.28	7.01	7.28	40.42
d. *Taxus wallichiana*	280	60	4.63	13.39	12.24	3.04	7	28.67
e. *Tsuga dumosa*	100	50	13.19	4.78	10.20	8.69	14	23.67
f. *Populus ciliata*	90	40	1.75	4.30	8.16	1.15	8.25	13.61
g. *Cedrus deodara*	60	20	8.50	2.87	4.08	5.56	14	12.51
h. *Betula utilis*	60	20	5.11	2.87	4.08	3.39	10.5	10.34
i. *Acer caesium*	50	20	6.41	2.39	4.08	4.23	14	10.07
j. *Juniperus recurva*	40	10	5.37	1.91	2.04	3.53	15	7.48
k. *Picea smithiana*	20	20	2.07	0.95	4.08	1.36	10	6.39
l. *Juglans regia*	40	10	1.88	1.91	2.04	1.23	8	5.18
m. *Pyrus* species	10	10	0.40	0.47	2.04	0.25	9	2.76
n. *Prunus* species	10	10	0.14	0.47	2.04	0.09	5	2.60
o. *Rhododendron arboreum*	10	10	0.09	0.47	2.04	0.07	4	2.58
Total	**2090**	**490**	**151.98**	**99.93**	**99.96**	**99.93**		**299.81**

and then appears to be approaching an asymptote indicating that the sampled area is adequate for this specific forest (**Figure 1**). It can be argued that, for conifer dominant forests, sample plots covering one to two hectares are adequate.

Community management of ACF was initiated in 1998, ending a period of uncontrolled exploitation; in JCF, on the other hand, management was initiated in 1995 and has been supported by the indigenous forest management. Community forest management runs under users' forest operational plan and forest act. The operational plan guides and regulates forest management. Despite the institution of community forest management, human disturbance continues in various forms, including grazing, tree felling, fuelwood collection, and encroachment on marginal land. The presence of mature trees (>50 cm dbh) is the result of prolonged forest management in JCF, while the small boles and stumps in ACF are signs of early succession and uncontrolled disturbance before 1998.

TABLE 4. Diversity indices of Amaldapani and Juphal community forests

Diversity indices	Amaldapani CF	Juphal CF	Average
Species richness (S)	12	15	13
Simpson's diversity index (D)	0.70	0.82	0.76
Shannon-Weiner's diversity index (H)	2.36	3.02	2.69
Hill's diversity number			
N0 (species richness)	12	15	13
N1	10.59	20.49	15.54
N2	1.42	1.21	1.31
Jaccard's coefficient (J)		0.65	

At the time of our survey, there were 310 mature trees ha^{-1} in JCF, as compared to 120 ha^{-1} in ACF. The reduced diversity of vegetation can be attributed to the human impact noted above, which was particularly severe due to the close proximity of agricultural lands. Disturbance has been considered an important factor structuring forest communities (Foster 1980) and different levels and types of disturbance have a differential impact on forest communities (Halpern and Spies 1995). Agricultural practices, over and premature harvesting and recreation constitute 18% of the aggregate threat to the plant diversity (Freemark et al. 2001). High human and other biotic pressures are detrimental to the vegetation structure of forests.

A total of 10 plant families were reported in JCF and nine in ACF. Among them, three families (Aceraceae, Betulaceae and Taxaceae) were identified as temperate. Pinaceae was the most diversified family with 28 individuals, five species and five genera, followed by Rosaceae, with three individuals, two species and two genera. *Pinus wallichiana* in ACF contributed the maximum stand density (1000 trees ha^{-1}), or about 50% of the total stand density. Stand density differed slightly among study sites, although there was a broad similarity in major species composition. Density is influenced by various factors, including elevation, soil type, dominant and associated species and human activities (cf. Shrestha et al. 1998). Climatic factors, environmental stability, land use and area and habitat heterogeneity are the factors often discussed as determinants of variability in species richness (Spies and Turner 1999).

In our study areas, the values for total basal area and density were higher than the values (15-60 m^2·ha^{-1} and 320-2080 trees ha^{-1}) reported by Bhandari et al. (1997) in temperate forests of the Garhwal Himalaya. As vegetation matures, total stand density tends to decrease and the stand increases in height, basal area and volume. Density and dispersion are quite sensitive to size and intensity of disturbance. The remarkable differences in stand density between ACF and JCF were due to the management history. The mean height and total basal area also differed significantly i.e. 8.20 m and 90.07 m^2·ha^{-1} in ACF and 10.05 m and

TABLE 5. Vegetation characteristics of various forest types

Forest type	Location	Study area (ha) / Plot size (m^2)	Girth size (cm)	T. stand density (trees ha^{-1})	T. basal area (m^2 ha^{-1})	Source
Temperate forests	Mid west Nepal	0.20 / (10x10)	≥ 30	2095	90-152	Present study
Shorea robusta forests	RBNP, Nepal	2.81 / (25x25)	≥ 30	333-385	32-36	Giri et al. (1999)
Shorea robusta forests	MBNP, Nepal	1.20 / (20x20)	≥ 10	1125-1174	32-35	Duwadee et al. (2002)
Castanopsis hystrix forests	MBNP, Nepal	0.60 / (10x10)	≥ 30	1921-3075	23-36	Shrestha et al. (2002)
Shorea-Castanopsis forests	MBNP, Nepal	3.84 / (20x20)	≥ 10	1425	59	Chaudhary and Kunwar (2002)
Riverine forests	KTWR, Nepal	1.84 / (20x20)	≥ 30	472-652	20-31	Karki et al. (2001)
Temperate forests	Kavre, Nepal	0.37 / (10 m radius)	-	5-132	8-19	Shrestha et al. (1998)
Himalayan forests	Nainital, India	0.10 / (10x10)	≥ 30	620	16.8	Khera et al. (2001)
Dry evergreen forests	Southern India	0.50 / (50x20)	≥ 20	280-1130	11-36	Visalakshi (1995)
Dry evergreen forests	Southern India	2.00 / (100x50)	≥ 10	453-819	11-20	Parthasarathy and Sethi (2001)
Himalayan forests	Garhwal, India	0.20 / (10x10)	≥ 10	792-1111	56-126	Pande (2001)
Semi evergreen forests	Eastern ghat, India	4.00 / (10x10)	≥ 30	367-667	26-42	Kadavul and Parthasarathy (1999)
Upland forests	Jau NP, Amazonia	4.00 / (40x10)	≥ 30	160-178	32-40	Ferreira and Prance (1998)

T = total, RBNP = Royal Bardiya National Park, MBNP = Makalu Barun National Park, KTWR = Koshi Tappu Wildlife Reserve, NP = National Park

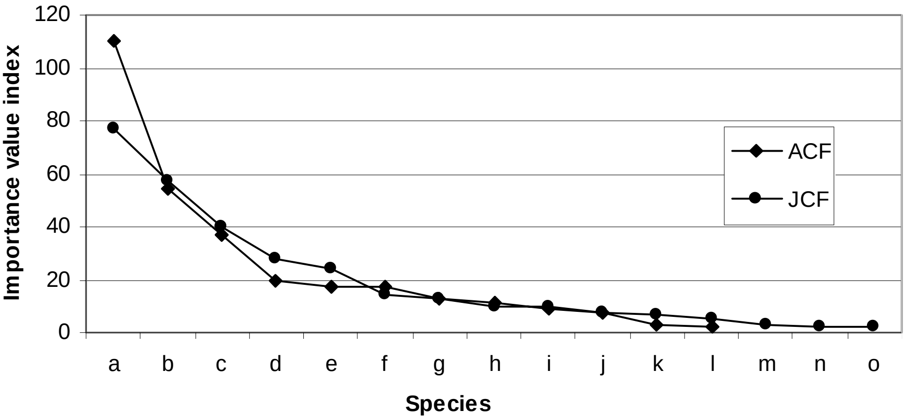

FIGURE 3. Dominance diversity curve for the tree species given in Table 2 and 3

151.98 $m^2 \cdot ha^{-1}$ in JCF, respectively. The higher total basal area in JCF was the result of the high proportion of trees of diameter greater than 50 cm (**Figure 2**). Trees with larger diameter have wider canopy cover and as canopy becomes close plant competition intensifies and slow growing trees become stunt and die. The wide range in basal area in JCF shows its heterogeneity.

The presence of a large number of trees in the 10-30 cm diameter class indicates that the study area is in mid-level succession. However, there were few trees in the small size classes (<10 cm): only 120 ha^{-1} in JCF and 260 ha^{-1} in ACF. The paucity of small trees indicates that the forest is not sustaining itself. This may be due to the recurrent human disturbance. The extent of disturbance can be attributed to easy access, inefficient management, and lack of alternative sources of forest products. Local people involved in community forestry programmes, on the other hand, generally protect their forests and access to government managed forests out of self-interest (Shrestha and Paudel 1996, Kunwar 2002). Strengthening local control and governmental oversight is urgently needed to assure long-term sustainability.

The dominance of four species (in descending order, *A. spectabilis, P. wallichiana, Q. semecarpifolia* and *C. deodara*), together with their contribution of 75% of the total stand density, 75% of frequency, 74% of total basal area and 67% of IVI, indicates that these species utilize the majority of forest space and resources (**Figure 3**). Of these four dominant species, three belongs to the Pinaceae family and one to the Fagaceae. The dominance of Pinaceae in Amaldapani and Juphal community forests of Dolpa district is one of the characteristic features of coniferous forest in temperate climate zones.

The top niches were occupied by *P. wallichiana* and *C. deodara*, in ACF, and *A. spectabilis* and *Q. semecarpifolia* in JCF. In both sites, the remaining species shared the intermediate and lower niches more or less equally. The gentle slope of D-D curve (**Figure 3**) observed in JCF indicates steady growth of trees, while sharp depression of the curve representing the small size classes of ACF trees is the result of human disturbance. The distribution pattern of tree species was similar, with the notable exceptions of *P. wallichiana* in site ACF and *A. spectabilis* in JCF. Such pattern of distribution is a general characteristic of nature (Odum 1971) while the conifer predominates the others in nutrient absorption in temperate forests (Saxena and Singh 1984).

Under severely disturbed conditions, the age class distribution of colonizers may be narrow, while individuals of diverse ages are found where disturbance is less severe (**Figure 2**). A total of seven size-classes of tree species with an interval of 10 cm dbh were recognized for each forest site; such a large number of size-classes is the result of better protection due to community forest management. The proportion of different age-classes of plant species across a landscape and over time is one of the fundamental characteristics of the vegetation mosaic (Spies and Turner 1999). The reverse 'J' shaped size-class distribution curve was obtained which is typical of all types of forests (Ferreira and Merona 1997).

If one compares the Shannon diversity values observed in the present study with the values reported (between 1.16-3.4) for temperate forests by Saxena and Singh (1982), the present study falls within the earlier reported range. Biodiversity was relatively low in ACF. The impact of human activities such as firewood collection, tree felling and cattle browsing accounts for the reduced diversity of vegetation in ACF. The similarity index of the studied sites reveals a remarkable degree of overlap in vegetation composition and structure. This may reflect the similar microclimates of the surveyed sites.

Conclusion

Differences in number of individual trees, species, families, total basal area, and vegetation composition may be due to differences in local environmental variables (disturbance gradients and vegetation characteristics). The dominance of *Pinus wallichiana, Abies spectabilis, Quercus semecarpifolia* and *Cedrus deodara*, with their major contribution to total basal area, frequency, stand density and IVI, indicates that these are frequent in the studied forests. The contribution of seven species to total species diversity and of three species to dominant species list indicated that the study area vegetation is conifer dominant. Although the forest existed in several girth classes, there was a reduced number of small tree individuals (<10 cm) which may be attributed to recurrent disturbances (marginal land encroachment, grazing and firewood collection); this dearth of immature individuals indicates impaired sustainability of the surveyed forests even though both are community managed. Better management and local control over the forests is therefore urgently needed. The present study is a modest effort focusing on a small area; large-scale studies are needed to help determine appropriate conservation and management strategies for the betterment of the existing population and biodiversity of forests. ■

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Vegetation composition and diversity of Piluwa micro-watershed in Tinjure-Milke region, east Nepal

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Comparative study of vegetation structure and composition of two forests at Tamafok (TF) and Madimulkharka (MM) villages in the Piluwa micro-watershed was undertaken. A total of 20 tree species were reported, with more species in the non-degraded TF forest than in the degraded MM forest. *Rhododendron arboreum* and *Goldfussia penstemonoides* were the dominant species in the TF forest, whereas *Quercus semecarpifolia* and *Rhododendron arboreum* were dominant in the MM forest. The total density of trees in the TF forest (756 ha^{-1}) was higher than that at MM (346 ha^{-1}). Similarly, tree basal area in the TF forest (69.8 $m^2 \cdot ha^{-1}$) was greater than at MM (56.9 $m^2 \cdot ha^{-1}$). Shrub density was also higher in the TF forest than at MM. Diversity indices for both trees (2.61) and shrubs (0.915) in the TF forest showed higher values in comparison to MM (2.4, 0.854). Concentration of dominance of the tree species was stronger in the MM forest (0.266) as compared to TF (0.258). The regeneration potential was higher in the degraded MM forest than in the relatively undisturbed TF forest. Seedling-sapling density was lower in undisturbed and mature forest which had closed canopy.

Key words: Forest structure, degradation, species richness, dominance

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The species richness of the forests of eastern Nepal has been documented in a number of studies over the past 150 years, from Hooker's initial explorations (1854) to more recent works, including Schweinfurth (1957), Hara and William (1979), Stainton (1972), Dobremez and Shakya (1975), Numata (1980), Oshawa et al. (1986) and Shrestha (1989). Eastern Nepal is rich in floral and faunal diversity (Numata 1980, DNPWC 1995, Ali 1977, and Carpenter and Zomer 1996). Extensive forest stands at late succession stage with closed canopy are present throughout Makalu-Barun Conservation Area, especially above 2000 m asl. At lower elevations, spatially limited but ecologically significant stands are found within locally protected *raniban* forest and in corridors of near-tropical riparian forest within deep river valleys that penetrate a considerable distance into the conservation area.

Forests in the Himalaya are under pressure, from both internal (e.g. over exploitation of forest resources for livelihood) and external forces (e.g. over flow of tourists), with adverse impacts on the supply of forest resources such as fuelwood, fodder, timber and non-timber forest products as well as on forest-based government revenues (Eckholm 1982, Pandey and Singh 1984, Ramakrishnan 1992). The increasing flow of tourists has further increased pressure on forest resources (Ives 1988, Thapa and Weber 1990). Studies have shown that deforestation in the Himalaya has implications for agriculture not only in the adjoining hills and mountains, but also in the plains far below (Pandey and Singh 1984, Mahat et al. 1986, Virgo and Subba 1994).

The high rate of seedling survival in the shade of late successional species and the contrasting low rate of seedling survival in the shade of early successional species are related to these species' adaptation to different light regimes in the forest community (Ramakrishnan et al. 1982). In a forest ecosystem, if a disturbance is small, suitable microclimatic conditions may remain prevalent in scattered pockets, leading to germination and establishment of large number of species (Sundriyal and Sharma 1996).

In the present study, vegetation structure and composition of two forests lying at adjacent villages, Tamafok (TF) and Madimulkharka (MM) are compared. TF forest is characterized by low intensity degradation while MM forest by high intensity degradation. The study site falls within the Piluwa watershed of Tinjure-Milke region in eastern Nepal.

Methods

Study area

The study area (27°12' N, 87°27' E), covering 24.69 km^2, represents part of the Piluwa watershed and includes the two villages (Tamafok and Madimulkharka). The land use of the study area is 41.9% forest, 54.4% agriculture land, 2.3% grassland and others 1.4% (Koirala 2002). The altitude ranges from 2200 to 3100 m asl, with slopes of 15° to 45°. The soil is dark brown to black, acidic (pH 4.3 – 5.3), with a high proportion of sand and silt, and is podzolic (Koirala 2002). The study area has three distinct seasons: a short summer (April to June), monsoonic rainy season (July to October) and cold winter (November to March). Currently, this area is under consideration as a *Rhododendron* Conservation Area (HMG/MOPE 1998). This area leads to the Makalu-Barun National Park toward the northwest and Kanchenjunga Conservation Area to the northeast (Kanchenjunga Conservation Area is closer to Qomolonga Nature Reserve in Tibet, China). For this reason, the present study area is considered a critical habitat corridor for many rare and endangered wildlife species.

Sampling

Vegetation analysis of forests in various stages of degradation was undertaken using 30 quadrats in each forest. The standard quadrat sizes were 10 m x 10 m for trees, 5 m x 5 m for shrubs and 1 m x 1 m for herbs. Frequency, density, basal area and Importance Value Index (IVI) of each species were analyzed as suggested by Mishra (1968) and Kershaw (1973). Regeneration of tree species ➜

was calculated by counting seedlings (height = 20 cm) and saplings (height > 20 cm but diameter at breast height (dbh) < 10 cm) following Sundriyal and Sharma (1996). Diversity Index (H') was calculated following Shannon and Weaver (1949) and concentration of dominance (cd) of species was calculated following Simpson (1949). The field study was conducted during January – December 2000. Since the present findings are part of an integrated study, observations were carried out over a period of 12 calendar months, with a maximum lacuna of 4 weeks during the snowfall period. Identification of plant species was carried out following the standard literature (APROSC 1991, DFPR 1993). Nomenclature followed DPR (2001).

Results

Forest structure

A total of 20 tree species were found in the study area, with higher species richness and canopy cover (>70%) in the TF forest. Nine tree species were common in both forests (**Table 1**). Density and basal area were higher in the TF forest (756 ha^{-1} and 69.8 $m^2 \cdot ha^{-1}$) than in MM (346 ha^{-1} and 56.9 $m^2 \cdot ha^{-1}$). *Rhododendron arboreum* Smith, *Goldfussia pentastemonoides* Nees and *Lyonia ovalifolia* (Wall.) Drude were dominant tree species at TF, whereas *Quercus semecarpifolia* Sm., *R. arboreum* and *L. ovalifolia* were dominant at MM. *R. arboreum* has been conserved under the management of the local Laligurans (Nepali name for *R. arboreum*) Conservation Group. The mean volume of standing trees was similar in these two forests: TF = 373.08 ± 88.9 $m^3 \cdot ha^{-1}$, MM = 371.14 ± 65.5 $m^3 \cdot ha^{-1}$ (**Table 1**).

Five species of shrubs were recorded in both forests (**Table 2**). The density of shrubs was higher in the TF forest. *Rhamnus napalensis* (Wall.) Lawson, *Daphne bholua* Buch.-Ham. ex D. Don. and *Thamnocalamus spathiflorus* (Trin.) Munro were common and dominant in both forests but at higher densities at TF. *Desmodium microphyllum* (Thunb.) DC. and species A (unidentified) were present only in the MM forest, while *Calamus acanthospathus* Griff. as well as an unidentified species were present only in TF.

Species diversity and regeneration

The diversity index for both trees and shrubs was slightly higher in the TF forest (2.61 and 0.915) than in MM (2.4 and 0.854), although the concentration of dominance was stronger in MM (**Table 3**). The diversity index of tree species was almost three times that of shrubs in the same forest. The regeneration potential (density of seedlings and saplings) was higher in the MM forest than in TF (**Table 4**). However, a few tree species were represented only by large trees without any seedlings or saplings (e.g. *Ischaemum rugosum* Salisb. and *Quercus glauca* Thunb.). Seedling and sapling distribution did not correspond to mature tree distribution. *Berberis aristata* Roxb. ex Dc. and *Viburnum continifolium* D. Don were the dominant regenerating species in the TF forest, whereas *R. arboreum* and *Symplocos pyrifolia*

TABLE 1. Density (tree ha ^{1}), basal area (m^2 ha ^{1}) and Importance Value Indices (IVI) of tree species in Tamafok (TF) and Madimulkharka (MM) forests, Tinjure - Milke region, Nepal

Species	Local name	Tamafok (TF)			Madimulkharka (MM)		
		Density	Basal area	IVI	Density	Basal area	IVI
Berberis aristata DC.	Chutro	-	-	-	3	0.23	2.9
Castanopsis indica (Roxb.) Miq	Dhalne Katus	-	-	-	3	0.03	2.5
Goldfussia pentastemonoides Nees	Angare	117	6.7	46.6	23	3.3	33.4
Ischaemun rugosum Salisb	Mallido	13	0.8	3.3	-	-	-
Loranthus adoratus Wall.	Kandeliso	3	2.7	5.5	-	-	-
Lyonia ovalifolia (Wall.) Drude	Angeri	107	6.7	39.0	60	2.1	37.2
Osmanthus suavis King ex C.B. Clarke	Shillinge	70	3.8	21.0	3	0.03	2.5
Pilea symmeria Wedd.	Kamale	-	-	-	7	0.07	3.8
Quercus glauca Thunb.	Falat	10	0.7	4. 9	3	0.97	4.2
Quercus semecarpifolia Sm.	Khasru	20	7.6	20.0	147	37.3	140.3
Rhododendron arboreum Smith	Laliguras	340	35.1	116.1	77	12.4	58.6
Rhododendron grande Wight	Guras	7	0.2	3.8	-	-	-
Rhododendron hodgsonii Hook.f.	Guras	10	0.6	4.8	7	0.1	5.5
Symplocos pyrifolia Wall.	Kholme	10	0.3	4.2	7	0.23	4.1
Symplocos ramosissima Wall.	Kharane	23	1.5	12.8	3	0.07	2.6
Taxus baccata Linn.	Dhyangre sallo	3	1.1	3.2	-	-	-
Viburnum nervosum D. Don	Asare	13	0.5	7.5	-	-	-
Viburnum continifolium D. Don	Bakalpate	-	-	-	3	0.03	2.5
Miscellaneous (n = 2)		10	1.5	7.3	-	-	-
Total		**756**	**69.8**	**300**	**346**	**56.9**	**300**

Mean ± S.E. of volume of trees (m^3 ha^{-1}): TF = 373.08 ± 88.9; MM = 371.14 ± 65.5

TABLE 2. Density (number ha^{-1}) of shrub species in Tamafok (TF) and Madimulkharka (MM) forests, Tinjure - Milke region, Nepal

Species	Local name	TF	MM
Calamus acanthospathus Griff.	Betkanda	200	-
Daphne bholua Buch.-Ham. ex D.Don	Lokta	4066	3812
Desmodium microphyllum (Thunb.) DC.	Bakhreghas	-	67
Rhamnus napalensis (Wall.) Lawson	Chillikath	32632	20222
Thamnocalamus spathiflorus (Trin.) Munro	Malingo	3146	587
Species A (unidentified)	Musakane	-	160
Miscellaneous (n = 1)		40	
Total		**40084**	**24848**

TABLE 3. Diversity and dominance of tree species in Tamafok (TF) and Madimulkharka (MM) forests, Tinjure - Milke region, Nepal

Parameters		TF	MM
Diversity Index (H')	Trees	2.61	2.4
	Shrubs	0.915	0.854
Concentration of dominance (cd)		0.258	0.266

TABLE 4. Sapling-seedling density (number ha^{-1}) of tree species in Tamafok (TF) and Madimulkharka (MM) forests, Tinjure - Milke region, Nepal

Species	TF	MM
Berberis aristata DC.	4932	1346
Castanopsis sp.	-	27
Eurya cerasifolia (D.Don.) Kobuski	-	40
Ficus neriifolia Sm.	-	27
Garuga pinnata Roxb.	-	27
Goldfussia pentastemonoides Nees	533	693
Lyonia ovalifolia (Wall.) Drude	133	866
Helixanthera parasitica Lour	13	13
Mahonia acanthifolia G.Don	67	-
Osmanthus suavis King ex C.B. Clarke	147	67
Quercus semecarpifolia Sm.	360	1280
Rhododendron arboreum Smith	80	1626
Symplocos pyrifolia Wall.	587	1586
Symplocos ramosissima Wall.	1573	387
Viburnum continifolium D. Don	2399	1067
Viburnum nervosum D. Don	-	120
Miscellaneous (n=2)	200	2026
Total	**11024**	**11198**

Wall. were the dominant regenerating species in MM. The number of regenerating species and sapling–seedling density both were higher in the MM forest. *S. pyrifolia*. and *S. ramossima* Wall. had the highest sapling-seedling/tree ratio, indicative of the highest regeneration potential (**Table 5**). The ratio was 58.7 and 226.6 for *S. pyrifolia* in the TF and MM forests, respectively. Similarly, the ratio for *S. ramosissima* in the TF and MM forests was 68.4 and 129.0 respectively. The ratio for *R. arboreum* was low (0.24) in the TF forest but it was 21 in MM.

Discussion

Forest structure

The differences in the structure and composition of the two forests arise out of differences in their disturbance regimes and ecological niche of dominant species. Forest MM, which is closer to a settlement, experiences higher pressure in the form of fuelwood and fodder collection by local inhabitants. This pressure has reduced tree density and basal area. The higher density and basal area of *R. arboreum* in TF may also be due to conservation by local Laligurans Conservation Goup. It is the national flower of Nepal. Felling the trees of *R. arboreum* was not allowed in the study area. The differences in dominant species between the two forests can more readily be attributed to the ecological specificities of the species (aspect, photoperiodism, etc.) than to the disturbance regimes. The dominance of *Q. semecarpifolia* in the MM forest may be related to high moisture content of soil at lower elevation (Koirala 2002). On the other hand, *R. arboreum* occurs at higher elevations (Shrestha 1989, Sundriyal and Sharma 1996, Chaudhary 1998). This study site showed high tree species richness, a characteristic of the eastern Himalaya (Dobremez and Shakya 1975, Shrestha 1989, Sundriyal and Sharma 1996, Carpenter and Zomer 1996). Higher diversity indices of tree species compared to shrub species in both the TF and MM forests may be attributed to the ecological succession still in the process of stabilization in both ecosystems (Sundriyal and Sharma 1996, Carpenter and Zomer 1996).

Forest regeneration

Seedling germination and establishment are related to the availability of space created through perturbation and to adaptation to particular light regimes (Ramakrishnan et al. 1982). The regeneration potential of disturbed MM forest was higher than that of relatively undisturbed TF forest. An open canopy caused by mild disturbance to the forest allows the growth of seedlings and saplings, which ensures sustainable regeneration. However, in a mature forest with closed canopy, seedling establishment is constrained by lower light intensity on the ground surface. The fact that tree species are well-represented at the

TABLE 5. Number of sapling-seedling per tree in Tamafok (TF) and Madimulkharka (MM) forests, Tinjure - Milke region, Nepal

Species	TF	MM
Goldfussia pentastemonoides Nees	4.6	30.1
Lyonia ovalifolia (Wall.) Drude	1.24	14.43
Osmanthus suavis King ex C.B. Clarke	2.1	22.3
Quercus semecarpifolia Sm.	18.0	8.7
Rhododendron arboreum Smith	0.24	21.12
Symplocos pyrifolia Wall.	58.7	226.6
Symplocos ramosissima Wall.	68.4	129.0

adult stage but not as seedlings indicates a high light requirement (Borman and Likens 1979, Sundriyal and Sharma 1996). A very old and stable climax *Rhododendron* forest community with closed canopy might be the reason for a very low sapling-seedling/tree ratio for that species. Similarly, the higher sapling-seedling/tree ratio of *Symplocos* and *Quercus* indicates that these species may replace *Rhododendron* and become dominant in future.

Conclusion

The difference in structure and composition of the two forests studied arises out of differences in their disturbance regimes and microclimatic conditions. Forest MM, which is closer to a residential area, experienced higher pressure in the form of fuelwood and fodder collection, had lower density and basal area than the relatively undisturbed TF forest. However, due to the open canopy of MM forest, the seedling-sapling growth and regeneration potential were higher. Furthermore, the higher density and basal area of *Rhododendron arboreum* in TF may be due to conservation by society, as this is the national flower of Nepal. ■

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Indigenous knowledge of terrace management in Paundi Khola watershed, Lamjung district, Nepal

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The study was carried out in the Paundi Khola watershed, Lamjung district, with the objective of evaluating the indigenous knowledge of terrace management. Various biophysical practices and land husbandry practices were recorded through field observation. A questionnaire survey and group discussions were also undertaken to acquire relevant information. It was found that terrace width and riser height correlated with slope angle negatively and positively, respectively. Outward-sloped terraces were common in the higher slope classes. Bund plantation was rarely observed in the irrigated fields. Paddy was the preferred crop wherever sufficient water was available. Paddy cultivation on unstable slopes without proper irrigation and drainage systems was the usual cause of slumping. Despite the failure of terraces or slopes in areas with deep-seated slides, farmers continued paddy cultivation by temporarily supporting and stabilizing the terraces until this was no longer feasible and major slope failure occurred. Gradual replacement of paddy by other more appropriate upland crops may sort out this problem to some extent.

Key words: Terraces, watershed management, slope failure, bund plantation, slumping

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In spite of the agrarian nature of the country and the commitment of His Majesty's Government (HMG) to support agriculture, there is an increasing concern that agricultural production is declining in Nepal. The population growth is accelerated by low literacy rate. Both the amount of arable land per capita and productivity per unit area are declining (Mahat 1987). To overcome this problem, farmers are forced to extend cultivation to marginal areas, intensify farming practices, and increasingly seek off-farm employment. Agricultural land expansion means deforestation, which leads to increased risk of natural hazards. Improper intensive agriculture practices may accelerate soil erosion. It has been estimated that as much as 1.63 mm of topsoil is washed away from the total land surface of Nepal every year (DSC 1992).

To cope with such disastrous situations, farmers have developed several techniques for maintaining and improving crop productivity through soil and water conservation. Some examples of indigenous soil fertility management in the mid-hills of Nepal are terracing, slicing the walls of terrace risers, allowing flood water into fields, *in-situ* manuring and inclusion of various legumes in crop rotations (Pandey et al. 1995). The success of a development project often depends on local participation, which in turn depends on the familiarity of the agents with the indigenous knowledge. Integration of indigenous knowledge in the development or selection of technology recommendations demonstrates sensitivity to the local culture, which facilitates the dissemination of technology (Hafeez 1998, Warren 1991). Therefore, before implementing any programme, it is essential to identify existing indigenous knowledge and to evaluate its effectiveness.

According to Pratap and Watson (1994), terrace improvement is one of the oldest indigenous conservation practices in the Hindu Kush Himalayan region. It is a package program that comprises several activities, including construction and leveling of terraces, riser trimming, construction of drainage, contour strip and grass plantation, and pond construction. The present study was carried out to identify and evaluate the indigenous knowledge of terrace management in the Paundi Khola watershed (PKW), Lamjung district, western Nepal.

Materials and methods

Study area

Paundi Khola is a tributary of the Marsyangdi River. Its watershed lies in Lamjung district, Western Development Region, between 28°05'00" and 28°12'30" N and 84°17'30" and 84°27'30" E. It covers an area of 5,877 ha and includes 12 village development committees: Sundarbazar, Tarku, Parebadanda, Chandreswar, Duradanda, Gaunsahar, Purankot, Kunchha, Dhuseni, Jita, Udipur and Sindure.

The total population of PKW in 1995 was 8,862, about 5% of the total population of the Lamjung district. The total number of households in the area was 1,774 and the population density was 150.79 inhabitants per square kilometer in the year 1998 (DSCO 1998). The majority of the inhabitants of the watershed are Gurungs, followed by Brahmins, Chhetris and Tamangs. Members of occupational castes such as Damai, Kami, and Kumal, also inhabit the area. Almost 90% of the total population depends on agriculture, while 4.5% have permanent employment outside the village. The rest of the population is either engaged in small business, wage-labor, or teaching at local schools. The number of inhabitants per hectare of agricultural and forest land is 2.18 and 4.88, respectively.

The elevation varies widely within the watershed from approximately 600 to 1,830 m asl. Land can be categorized according to slope into five different classes. PKW terrain falls within ➔

four of these slope classes, with slope class I being absent. The slope classes and their respective area in the PKW are presented in **Table 1**.

About 69% of the watershed is under cultivation, of which level and sloping terraces constitute 34% and 35%, respectively, of the entire watershed; the remaining 31% consists of forest and shrub lands (**Figure 1**). Due to the wide altitudinal variation within the watershed, variations in forest composition are marked. The southern part of the watershed is characterized by temperate forest with major species such as *Schima wallichii*, *Castanopsis indica* and *Alnus nepalensis*, while the northern part is covered abundantly with pine along with *Rhododendron*.

TABLE 1. PKW slope classes and their respective areas

Slope class	Slope %	Area (ha)	% of total area
II	3-15	605	10.30
III	15-30	69	1.17
IV	30-60	3396	57.78
V	>60	1807	30.78
Total		**5877**	**100.00**

(Source: DSCO 1998)

Methodology

Relevant biophysical and socio-economic information was collected using both primary and secondary sources. Primary data was collected through field observation, a questionnaire surveys and group discussion. During the field observations carried out in December 2000, pertinent biophysical parameters, including terrace dimension, slope, and aspect, as well as land husbandry practices, such as cropping pattern, irrigation, and drainage infrastructure, were studied and recorded.

The main patches of agricultural land in the watershed were traced from the LRMP (1986) land utilization map. By overlaying topographical and land utilization maps, we separated agricultural land slope classes. Five sample units were selected from each of the slope classes, distributing them spatially over ridge, middle and base portions of the watershed including all types of terrain, such as irrigated and non-irrigated land.

A questionnaire survey was carried out to collect information not obtainable through field observation. A total of 62 households were included in the questionnaire survey. The questionnaire was designed to elicit information on slope maintenance practices, type of terrace preferred, bund plantation, irrigation practices, crop preference, forest resource use, and indigenous knowledge regarding soil and water conservation. Separate group discussions were carried out with local leaders and innovative farmers to assess needs, interests and preferences regarding agriculture and natural resources.

Relevant secondary data and information regarding the study area were collected from the District Soil Conservation Office, Lamjung.

Results and discussion

Relation between slope and terrace dimension

The local farmers constructed terraces with narrower width in the higher slope classes than in the lower slope classes ($R^2 = -0.78$) (**Figure 2**). They were well aware of the fact that increasing the width of the terraces on steep slopes entails more effort both in construction and maintenance. Wider terrace in a given slope demands for an increased riser height. Farmers tried to keep the riser height to a minimum, because increasing the riser height leads to higher risk of terrace failure. However, riser height unavoidably increased as slope increased ($R^2 = 0.78$) (**Figure 3**).

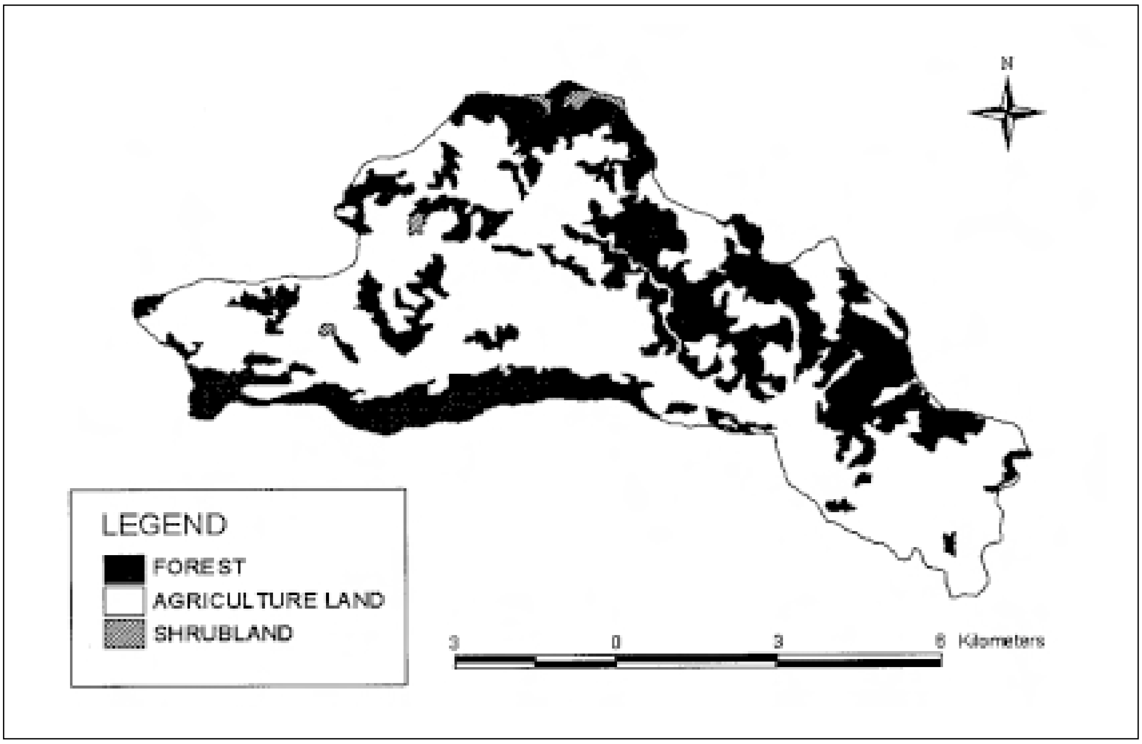

FIGURE 1. Land use distribution in Paundi Khola Watershed

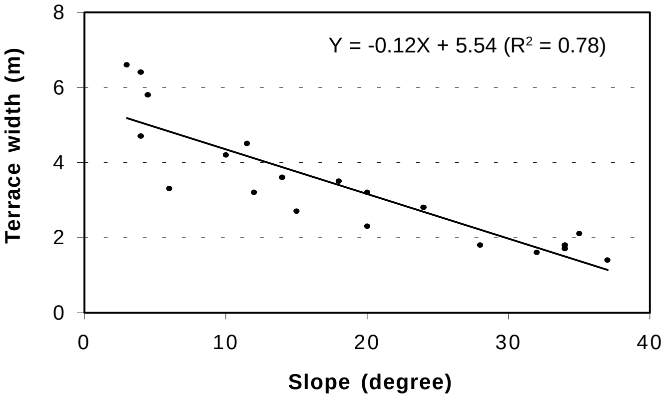

FIGURE 2. Relation between slope and terrace width

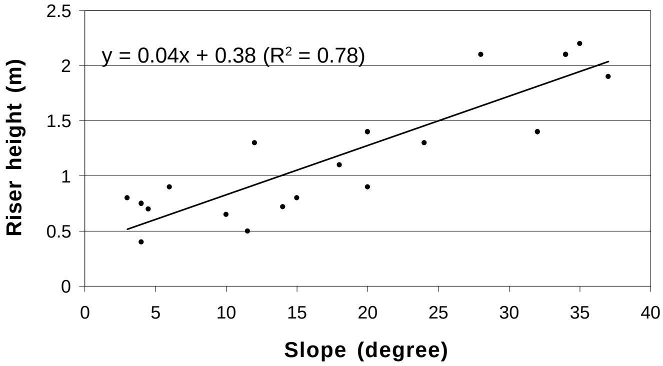

FIGURE 3. Relation between slope and riser height

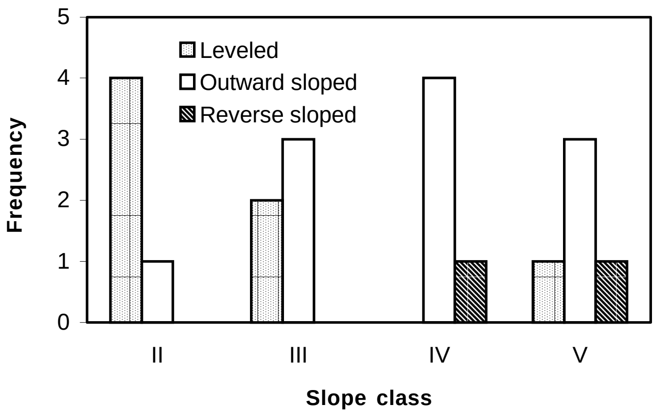

FIGURE 4. Terrace frequency in various slope classes

Types of terraces

In steeply sloping areas, farmers preferred to construct outward-sloped terraces. The construction of level or reverse sloped terraces in the higher slope classes requires more cutting and filling of earth. Outward-sloped terraces were the most common, comprising 55% of the total, followed by level terraces, with 35% of the total number of terraces. Reverse-slope terraces were least frequently observed, with only 10% of the total; they occurred only on the higher class slopes (**Figure 4**). Generally, outward-sloped terraces were common in the middle slope class while level terraces occurred primarily on lower class slopes. The results are in conformity with the statement put forward by Carver (1995) that farmers modify terrace characteristics to accommodate local slope and climate demands.

Types of riser surfaces

Most of the farmers were unaware of the importance of vegetation on the riser surface as a binding element. The natural vegetation in the riser surface was scraped every year before crop cultivation (mostly paddy cultivation). However, the scrap vegetation provides green manure for the field. Farmers believed that removing the vegetation helped control insects and other pests. The farmers' logic is in line with results reported by Tamang (1992) in a study focusing on the hills of Nepal.

According to Carson (1992), terrace risers in Nepal are commonly stone-lined, vegetated, or purposely cut to bare soil. Riser surfaces observed in the study area included natural grass or improved varieties such as Napier, stone lining and bare surface. The most common were natural vegetation (40% of the total observed), followed by bare surface (30% of the total). 20% are stone-lined while only 10% of the total was vegetated with improved varieties of grasses.

Bund plantation

Out of all observations, only 45% of the terraces had bund plantation of grasses, fruits and fodder species. The practice of bund plantation varied according to the type of land. A low proportion of planted bunds was observed on irrigated land (paddy field) in comparison to rainfed land. Only 16.67% of irrigated land had bund plantation while 57.14% of rainfed land was found to have bund plantation.

Among species most commonly planted on bunds were fodder trees such as *Artocarpus lakoocha* (badahar), *Ficus roxburghii* (nimaro), *Ficus semicordata* (khanyu), and *Melia azaderach* (bakaino). Also planted were fruit trees such as banana and orange, annual crops such as soybean and black gram, and natural grasses such as *Eulalopsis binata* (babio) and *Imperata cylindrical* (siru). Fodder trees were not planted on the bunds of paddy fields because of their shading effect, which might hinder crop growth.

Cropping pattern

Paddy, millet, maize and wheat were the major cereal crops cultivated in the PKW. The irrigated land was predominantly devoted to paddy, while either maize or wheat came afterwards to complete the rotation. On rainfed land, millet was the main crop, planted in rotation with maize and vegetables. Paddy was the preferred crop wherever irrigation was available. Even on rainfed lands, farmers were able to raise special varieties of upland paddy (ghaiya); thanks to its tolerance of moisture stress. The cropping patterns observed on irrigated lands were paddy and paddy/maize/millet, and upland paddy and millet/maize or millet and maize/vegetables or paddy/millet/maize on rainfed lands.

Irrigation practices

Irrigation systems were employed in the lower alluvial plains where paddy cultivation was practised. Farmers flooded the lowland fields excessively because they believe that more water results in higher yield. Lack of proper drainage had led to landslides and slumping where the underlying bedrock was not stable. No irrigation system existed in the mid- and higher elevations where cultivation was limited, for the most part, to millet.

Construction material

Clay and stone were the materials most commonly used in construction of terrace risers and benches. Homogenous clay was commonly used for riser construction. Stones along with clay were also used in some areas, especially in landslide-affected areas. The stones used for construction were not of uniform size and grade.

Indigenous technique for judging slope stability

People usually judged slope stability by the presence or absence of *paharo* (local term used for exposed massive base rock) at the toe of the hill slope. A slope was considered stable if such *paharo* is present; lack of *paharo* was taken to indicate instability. This criterion was taken into account when houses were constructed or settlements established. However, terraces were constructed wherever irrigation was available for paddy cultivation irrespective of slope stability.

Terrace maintenance

Farmers maintained the terrace against failure by using mud, grass, and sometimes stones to repair cracks in the paddy field. If the cracks were likely to develop further in subsequent events of mass movement, they tended to fragment the terrace. They practised cutting of earth from the elevated portions or the field and used it to fill in depressed areas. However, they continued to exploit such lands until the slope/terrace completely failed or became otherwise uncultivable.

Conclusions

There existed a high degree of negative correlation between the terrace width and slope (R^2 = -0.78), as well as between riser height and slope (R^2 = 0.78). From this, it can be concluded that the hill farmers are intentionally accommodating terrace dimensions to topography. However, the types of terraces constructed and maintained were not always adequately related to slope steepness. Outward-sloped terraces were frequently used in the higher slope classes, which can lead to increased surface run-off and downslope sedimentation. Further study of the possibility of gradually transforming of outward-sloped terraces to level or reverse-slope terracing is recommended. Immediate solutions for increased run-off and sedimentation due to outward-sloped terraces in the higher slope classes might be the adoption of supplementary soil conservation measures such as contour drainage, conservation ponds, and contour planting.

Only 45% of the observed terraces featured bund plantation. Most were in the upland areas rather than irrigated low lands. Farmers are unwilling to practice bund plantation in the paddy field because the species planted could reduce primary crop yield through above- and below-ground competition. This sort of problem might have occurred due to the selection of inappropriate species for the purpose. Conservation agents should help farmers choose the appropriate species to achieve best results.

In the uplands, no irrigation facilities were observed and rain is therefore the only source of water. Irrigation practices existed in the lower alluvial plain where paddy fields predominate. However, the irrigation practices are not sound, and poor drainage is a significant problem. Farmers practised flood-irrigation using river water conducted to the terraces through small channels. The impounding of water without regard to slope stability may be a root cause of terrace failure and may also induce landslides.

Scraping of vegetation on the risers before every cropping season was commonly practised, supposedly to provide green manure and destroy insects and pests. Although it may have benefits, this activity certainly leads to soil loss. Planting of improved varieties of grasses on the risers will not only bind the soil but also provide a rich source of fodder for the livestock. ■

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Quantitative analysis of macrophytes of Beeshazar Tal, Chitwan, Nepal

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The authors undertook a quantitative investigation of aquatic macrophytes in Beeshazar Tal (Beeshazar Lake) in summer and winter of 2002 and spring of 2003. We found a distinct seasonal variation in the distribution of macrophytes: based on importance value index, Leersia hexandra Sw., Eichhornia crassipes (Mart.) Solms, Ceratophyllum demursum L. and Trapa quadrispinosa Roxb. were dominant in the summer; E. crassipes and Hydrilla verticillata (L.f.) Royle were dominant in the winter; and Ceratophyllum submersum L., H. verticillata, E. crassipes and L. hexandra were dominant in the spring. The highest species diversity was observed in the summer, followed by winter and then spring. The luxuriant growth of aquatic macrophytes evinced the highly productive nature of the lake, while the dominance of emergents among the growth forms indicates the encroachment of littoral vegetation, indicating a successional trend toward marsh meadow.

Key words: Oxbow lake, macrophytes, importance value index, species diversity

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Aquatic macrophytes are macroscopic forms of aquatic vegetation, including macroalgae, mosses, ferns and angiosperms found in aquatic habitat. They have evolved from many diverse groups and often demonstrate extreme plasticity in structure and morphology in relation to changing environmental condition (Wetzel 1983). Aquatic macrophytes in different growth forms represent the most important biotic element of the littoral zone in a lake ecosystem (Piecznyska 1990). Two factors, number of species and importance values (numbers, biomass, productivity, and so on) of individuals, determine the species diversity of a community (Odum 1996). Importance Value Index (IVI), a quantative parameter, is useful, as it provides an overall picture of the density, frequency and cover of a species in relation to community (Curtis and McIntosh 1951).

Most of the lakes on the plains of the Terai are oxbow systems (Sharma 1973) and possess a luxuriant growth of aquatic vegetation (BPP 1995, Bhandari 1998b). Some of these lakes are already on the verge of disappearance whereas others are highly vulnerable to degradation due to physiographic features as well as anthropogenic activities (BPP 1995, Bhandari 1998b). Out of 51 wetland sites surveyed by the Biodiversity Profile Project (BPP), 10 sites were identified as meriting immediate protection (BPP 1995); Beeshazar Tal (Lake) in Chitwan District was one. However, no conservation measures have been undertaken to protect the lake. Growth of invasive species, natural eutrophication, seasonal fluctuation of water level and lack of efficient inlet and outlet are the major threats to the lake. The lake therefore demands concerted attention towards a clear understanding of its ecosystem in order to mitigate further deterioration. Though the studies on various aspects of ecology of Beeshazar Tal have been conducted by various workers (Jones et al. 1989, BPP 1995, McEachern 1996, Jayana 1997 and Bhandari 1998a), there are almost no quantitative studies of macrophytes. Hence, the objective of the present study is to assess the richness and composition of macrophytes of the lake in terms of seasonal variation. This study is expected to be helpful in designing a plan for the sustainable management of the lake.

Materials and methods

Study area

Beeshazar Tal is a shallow dissected fern-shaped oxbow lake running northeast to southwest and surrounded by the Sal (*Shorea robusta*) forest and marshy land typical of the inner Terai. Located at 27°37'19"N and 84°26'29"E, at an elevation of 183 m asl (SD 1994), the lake is situated in the buffer zone of Royal Chitwan National Park (RCNP) adjacent to Khageri Irrigation Canal, within the Barandabhar forest patch; it is a habitat corridor between RCNP and the Siwalik forests. Numerous wetlands are found along the canal. Bhandari (1998a) reported the area of the Beeshazar Tal to be 100 ha, while BPP (1995) reported that the entire area of the lake system adjacent to the Khageri Irrigation Canal covers 180 ha, of which only 5.5% is permanent lake. Beeshazar has a maximum depth of 6 m and an average depth of 3 m. The water balance of the lake was found to be determined by precipitation and ground water seepage: the lake has no proper inlet or outlet. The area is famous for its biodiversity. Altogether 21 species of mammals, 13 species of reptiles, 17 species of fishes, 37 species of aquatic insects, 273 species of birds (60 species being wetland dependent) and 131 species of plants (including 99 aquatic species) have been identified in and around Beeshazar Tal (Bhandari 1998a). Some of the more charismatic fauna in the area are the Royal Bengal tiger (*Panthera tigris*), one-horned rhinoceros (*Rhinoceros unicornis*), mugger crocodile (*Crocodylus palustris*), asiatic rock python (*Python molurus*), and the lesser adjutant stork (*Leptoptilos javanicus*, a globally threatened bird); there is also an insectivorous bladderwort (*Utricularia aurea*). In September 2003 the lake, along with its surrounding area (a total of 3200 ha), was named 'Beeshazar and Associated Lakes' as one of the new Ramsar site (RCW 2003).

Methods

We studied quantitative parameters of Beeshazaar Tal macrophytes in the littoral zone of three different sites around the lake during three seasons: summer (5-15 August 2002), winter (5-15 December 2002) and spring (5-15 May 2003). These three sites were selected for macrophyte sampling as representative of the entire lake system. To analyze the macrophytes community, we applied a random sampling method along several transects with the help of a 1m×1m light wooden quadrat. The quadrat size was determined by the species area curve method as mentioned in Zobel et al. (1987). The length of transects and number of quadrats in each transect within each sampling unit were adjusted according to the depth of the littoral zone. Each transect was taken from the shoreline itself perpendicularly towards the centre of the lake as far as the depth where submerged species were seen. The macrophytes were counted by hand picking. The centre of the lake was not covered for quadrat study because of mugger crocodile infestation. Altogether 36 quadrats in the lake were studied during each season – 12 qudrats from each sampling unit.

Importance Value Index (IVI) was calculated by totaling the relative values of density, frequency and cover (by visual estimation); and Shannon-Weiner's (1963) index of species diversity (H) were calculated following the mathematically manipulated formula (cf. Zobel et al. 1987).

The plant species were identified with the help of standard literature (Khan and Halim 1987, Cook 1996, Gurung 1991 and Press et al. 2000) and visual inspection by taxonomists. All specimens were crosschecked against specimens at Tribhuvan University Central Herbarium (TUCH). The voucher specimens were deposited at TUCH, Kathmandu.

Results and discussion

Altogether 61 species of macrophytes were recorded in the present study. The highest number of species was occupied by angiosperms (both dicots and monocots) (**Figure 1**). Lack of shady and moist habitat has limited the pteridophytes to two species.

Macrophytes in the present study were categorized into four main growth forms following Shrestha (1998). Rooted plants with main photosynthetic parts projecting above the water surface were classified as *emergents*, rooted plants with leaves floating on the water surface were classified as *rooted floating-leaved macrophytes*, rooted or floating plants completely or largely submerged were classified as *submerged macrophytes*, and plants with crown floating on the water surface were classified as *free-floating macrophytes*. In terms of the number of species, emergent species constituted the largest group, followed by submerged, rooted floating-leaved, and free-floating species (**Figure 2**). Our conclusion that emergents outnumbered submerged and floating species is substantiated by Sheerwani (1962) and Shrestha (1996 and 1998).

The number of aquatic macrophyte species was higher during the summer (39) and winter (37) and lower during the spring (29) (**Table 1**).

The dominance of species by growth forms on the basis of IVI value is presented in **Table 1**. Emergents were the most dominant form throughout the year. This can be attributed to the emergents' high tolerance for fluctuation of water level (Van der Valk and Davis 1976). Seasonally, emergents' IVI was highest in the summer, followed by winter and spring. Among emergents, *Leersia hexandra* was the most dominant in the summer and the spring, and *Cyperus alternifolius* subsp. *flabelliformis* in the winter.

After emergents, the next highest IVI values were those of free-floating species in the summer and winter, and submerged species in the spring. The dense growth of free-floating and rooted floating-leaved species prevented colonization of submerged species in the summer and the winter season (Kaul et al. 1978). Among the free-floating species, *Eichhornia crassipes* was highly dominant throughout the year. The largest IVI values for this species were found in the winter (43.5), followed by the spring (34.71) and the summer season (27.25). Lesser growth of *E. crassipes* in the spring than in the winter may be the result of human removal of this species from the canal site (which was one of the three sampling units) at the end of winter. During the summer, *E. crassipes* was found to flow with water from the lake to the adjacent canal by means of breaches in the dike between the lake and the canal due to seasonally high water levels. Consequently, the lowest IVI value for *E. crassipes* was observed during the summer. *E. crassipes* was not reported in the earlier studies of Beeshazaar Tal (BPP 1995, Jayana 1997, Bhandari 1998a). Its current dominance may be ascribed to its invasive nature and also its preference for highly eutrophic and stagnant water. Gopal and Sharma (1990) also found a similar relation between growth pattern and level of eutrophication. Beeshazaar Tal has been categorised as hypereutrophic (Burlakoti 2003) on the basis of nutrient criteria proposed by Forsberg and Ryding (1980).

Among the submerged species, *Ceratophyllum submersum*, *Hydrilla verticillata* and *C. demursum* were observed to be the most dominant species throughout the year. The vigorous year-round growth of *H. verticillata* indicates its ability to adapt in diverse conditions. Shingal and Singh (1978) also found this species in a lake area characterized by high silt load and cultural eutrophication. The silt load and the eutrophication in the Beeshazar Tal were found to be due to the transportation of silt, organic matter and litter from the catchment area at the time of flooding. Similar findings regarding *H. verticillata* are reported by Acharya (1997) and Shrestha (2000). The dense growth of *Ceratophyllum demursum* in the summer

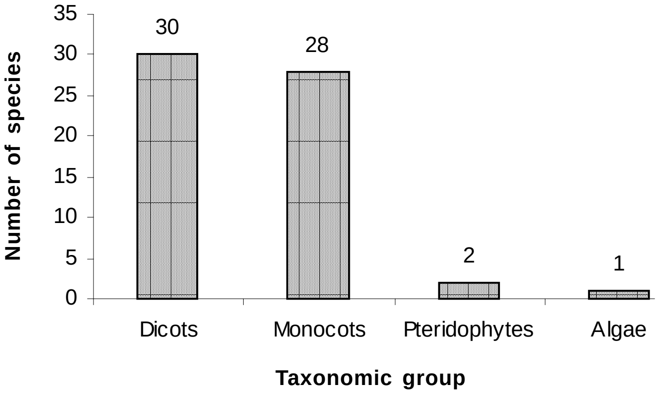

FIGURE 1. Number of species by taxonomic group

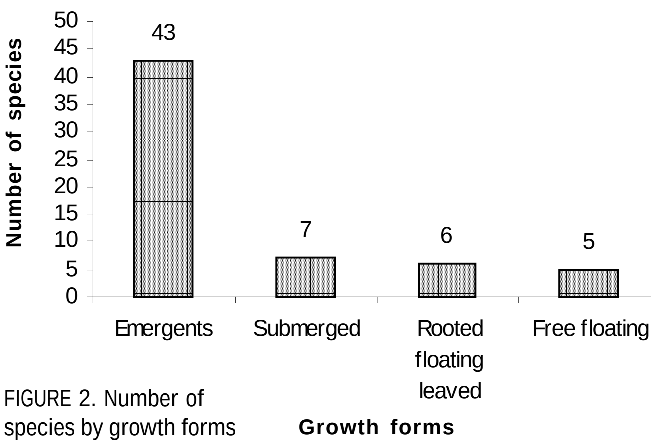

FIGURE 2. Number of species by growth forms

TABLE 1. Seasonal variation in IVI values of macrophytes by growth forms

Species, categorized by growth form	Importance value index (IVI) in			
Submerged	**Summer**	**Winter**	**Spring**	**Average**
Hydrilla verticillata (L.f.) Royle	16.37	24.9	54.54	31.94
Ceratophyllum submersum L.	12.67	23.74	55.83	30.75
Ceratophyllum demursum L.	23.61	11.56	0	11.72
Chara sp.	0	6.03	0	2.01
Potamogeton pectinatus L.	0	0	5.43	1.81
Utricularia aurea Lour.	0	0	4.18	1.39
Vallisneria natans (Lour.) H. Hara	0	3.51	0	1.17
Total	**52.65**	**69.74**	**119.98**	**80.79**
Free-floating				
Eichhornia crassipes (Mart.) Solms	27.25	43.5	34.71	35.15
Azolla pinnata R.Br.	0	21.15	0	7.05
Spirodela polyrhiza (L.) Schleid	19.41	0	0	6.47
Lemna perpusilla Torr.	12.22	6.86	0	6.36
Pistia stratiotes L.	6.04	6.29	0	4.11
Total	**64.92**	**77.8**	**34.71**	**59.14**
Rooted floating-leaved				
Trapa quadrispinosa Roxb.	19.31	0	12.19	10.50
Ipomoea aquatica Forssk.	7.69	13.11	3.05	7.95
Ludwigia adscendens (L.) H. Hara	8.75	5.34	2.78	5.62
Nymphaea stellata var. *versicolor* (Sims) Hook. f. and Thomson	2.1	3.09	0	1.73
Nymphoides hydrophyllum (Lour.) Kuntze	3.23	0	1.91	1.71
Nelumbo nucifera Gaertn.	1.5	0	1.35	0.95
Total	**42.58**	**21.54**	**21.28**	**28.47**
Emergent				
Leersia hexandra Sw.	38.97	18.56	36.83	31.45
Cyperus alternifolius subsp. *flabelliformis* (Rottb.) Kuk.	0	22.04	19.31	13.78
Persicaria hydropiper (L.) Spach	22.54	12.53	5.73	13.60
Alternanthera sessilis (L.) DC.	14.05	0	10.79	8.28
Imperata cylindrica (L.) P. Beauv.	4.87	8.16	6.91	6.65
Phragmites karka (Retz.) Trin. ex Steud.	2.82	5.29	11.28	6.46
Persicaria barbata (L.) H. Hara	0	17.29	0	5.76
Cyperus iria L.	13.8	0	0	4.60
Saccharum spontaneum L.	5.43	6.29	0	3.91
Echinochloa colona (L.) Link	4.49	6.26	0	3.58
Hemarthria compressa (L.f.) R. Br.	4.13	2.38	3.53	3.35
Pennisetum orientale Rich.	0	9.18	0	3.06
Ipomoea carnea subsp. *fistulosa* (Mart. ex Choisy) D.F. Austin	3.57	3.48	0.82	2.62
Panicum sp.	0	0	6.14	2.05

Table continued on next page...

season can be attributed to the high growth potential of this species in sedimentation-prone areas (Segal 1971) and to the eutrophic condition of lake (Zutshi and Vass 1976). The sedimentation load was high in the summer season due to flooding in the catchment.

Among the growth forms, rooted floating-leaved species were the least dominant in terms of IVI value. The dense growth of rooted floating-leaved species, especially *Trapa quadrispinosa* in the spring and summer, may be attributed to better adaptability of the rooted floating-leaved species to the stresses of water level fluctuation, to the tearing action of water turbulence, and to turbidity of water (Papastergiadou and Babalonas 1992).

Estimating annual average IVI values, we found that emergents were dominant, followed by the submerged, free-floating and rooted floating-leaved species. Previously, the lake was mostly covered by submerged and the rooted floating-leaved species (BPP 1995).

Species diversity was highest for the emergents followed by the rooted floating-leaved, submerged and free-floating species respectively (**Table 2**). This trend may be attributed to the increase in species richness with decrease in water depth (Van der Valk and Davis 1976, Handoo and Kaul 1982). The highest species diversity index for the entire community, 4.17, was found in the summer, as compared to 4.06 in the winter and 3.17 in the spring (Shrestha 2000). The seasonal variation in requirements of the diverse growth forms may cause the variation in the species diversity.

Management implications

The excessive growth of macrophytes was probably due to high nutrient level in the Beeshazar Tal. There is no outlet to flush the accumulated nutrients from the decomposed macrophytes; the consequent high rate of oxidative processes renders the lake anoxic. In addition, respiration by the *E. crassipes* (water hyacinth) roots contributes to oxygen depletion and changes the water chemistry (McEachern 1993). When a lake becomes choked by water hyacinth, the number of birds and other animals in the upper strata of the food chain decreases significantly (cf. Sah and Sah 1999).

Though Beeshazar Tal now belongs to the Ramsar Site as well as to the buffer zone of Royal Chitwan National Park, no serious steps have been taken for the sustainable management of the lake. Local people have been removing the unnecessary growth of macrophytes only at the canal site of the lake in the post-winter season for the last few years. However, as the invasive *E. crassipes* from the lake was not completely extirpated, the surface of ➜

the lake was again found to be wholly occupied by the species within a few months.

Accumulation of silt and detritus from the catchment area and decomposition of macrophytes reduces the water quality as well as the core area of the lake and promotes the encroachment of littoral vegetation, a familiar successional trend as the oxbow lake is transformed into marsh meadow (Wetzel 1983). Without inlet or outlet, the lake derives water only from subsurface seepage and precipitation, and water level fluctuation is common. The failure of the dike during the summer due to the rise in water level is also common. Recently the local Lake Management Committee drew up plans to construct a proper inlet and outlet for the lake, but work has been postponed due to the lack of adequate financial support. A sustainable management plan should be formulated and implemented soon if Beeshazar Tal's diverse ecosystem is to be preserved. The highest priority must be given to inlet and outlet construction and to removal of *E. crassipes*.

Conclusion

The luxuriant growth of the macrophytes reveals the productive nature of the lake. The dominance of emergents among other growth forms (as shown by IVI measurements) indicates the encroachment of littoral vegetation, reducing the core area of the lake and showing the trend of succession towards marsh meadow condition. The dominance of previously absent *Eichhornia crassipes* indicates its invasive nature which explains the fact that the lake is becoming anoxic. The fact that emergents have the highest species diversity and submerged species the lowest signifies the increasing richness in species with decreasing water level, a general trend during the course of succession. ■

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TABLE 1. Seasonal variation ...[continued from previous page]

Species, categorized by growth form	Importance value index (IVI) in			
Emergent	Summer	Winter	Spring	Average
Centella asiatica (L.) Urb.	2.05	1.76	2.11	1.97
Echinochloa crus-galli (L.) P. Beauv.	0	0	5.71	1.90
Agreatum houstonianum Mill.	0	1.64	3	1.55
Monochoria vaginalis (Burm. f.) C. Presl	0	2.5	2.12	1.54
Paspalum scrobiculatum L.	4.62	0	0	1.54
Persicaria lapathifolia (L.) S.F. Gray	0	0	4.16	1.39
Typha angustifolia L.	2.42	1.15	0	1.19
Persicaria glabra (Willd.) M. Gomez	0	3.56	0	1.19
Panicum repens L.	3.4	0	0	1.13
Lindernia anagallis (Burm. f.) Pennell	1.63	1.14	0	0.92
Limnophila chinensis (Osbeck) Merr.	0	0	2.75	0.92
Schoenoplectus mucronatus (L.) Palla	1.16	1.31	0	0.82
Polygonum plebeium R. Br.	2.13	0	0	0.71
Rumex dentatus subsp. *klotzschianus* (Meisn.) Rech. f.	0.9	0.75	0	0.55
Ranunculus sceleratus L.	0.96	0.61	0	0.52
Diplazium esculentum (Retz.) Sw. ex Schrad.	0.94	0.55	0	0.50
Smithia sensitiva Aiton	1.35	0	0	0.45
Paspalum distichum L.	0.56	0	0.65	0.40
Vetivaria lawsoni (Hook. f.) Blatt. and McCann	0	1.17	0	0.39
Phyla nodiflora (L.) Greene	0	1.09	0	0.36
Rotala indica (Willd.) Koehne	0	1.09	0	0.36
Cassia tora L.	1.06	0	0	0.35
Oenanthe javanica (Blume) DC.	0	0	0.98	0.33
Lindernia antipoda (L.) Alston	0	0	0.87	0.29
Eclipta prostrata (L.) L.	0	0	0.7	0.23
Axonopus compressus (Sw.) P. Beauv.	0.61	0	0	0.20
Commelina diffusa Burm. f.	0.56	0	0	0.19
Justicia procumbens var. *simplex* (D. Don) T. Yamaz.	0.56	0	0	0.19
Ottelia alishmoids (L.) Pers.	0	0.51	0	0.17
Total	**139.58**	**130.29**	**124.39**	**131.42**
Grand total	**299.73**	**299.37**	**300.36**	**299.82**

TABLE 2. Seasonal variation in species diversity index values

Growth forms of species	Shannon-Weiner's index of species diversity (H)			
	Summer	Winter	Spring	Average ± sd
Submerged	1.527	2.020	1.325	1.624 ± 0.21
Free-floating	1.862	1.656	0.000	1.173 ± 0.83
Rooted floating-leaved	2.083	1.412	1.963	1.819 ± 0.29
Emergent	3.324	3.051	3.229	3.201 ± 0.11
Community as a whole	4.170	4.060	3.170	3.800 ± 0.45

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Two new records of *Eria* Lindl. (Orchidaceae) for Nepal

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Eria concolor Par. & Rchb.f. and *Eria obesa* Lindl. are newly recorded from Nepal Himalaya. Detailed description and illustration are provided.

Key words: *Eria*, new records, orchidaceae, Nepal

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The genus *Eria* Lindl. is one of the larger polymorphic genera of the family Orchidaceae. It has about 404 species in the world (Royal Botanic Gardens, Kew 2003) which are divided into 13 to 17 sections according to the nature of pseudobulbs and leaf characters (Seidenfaden 1982, Pearce and Cribb 2002).

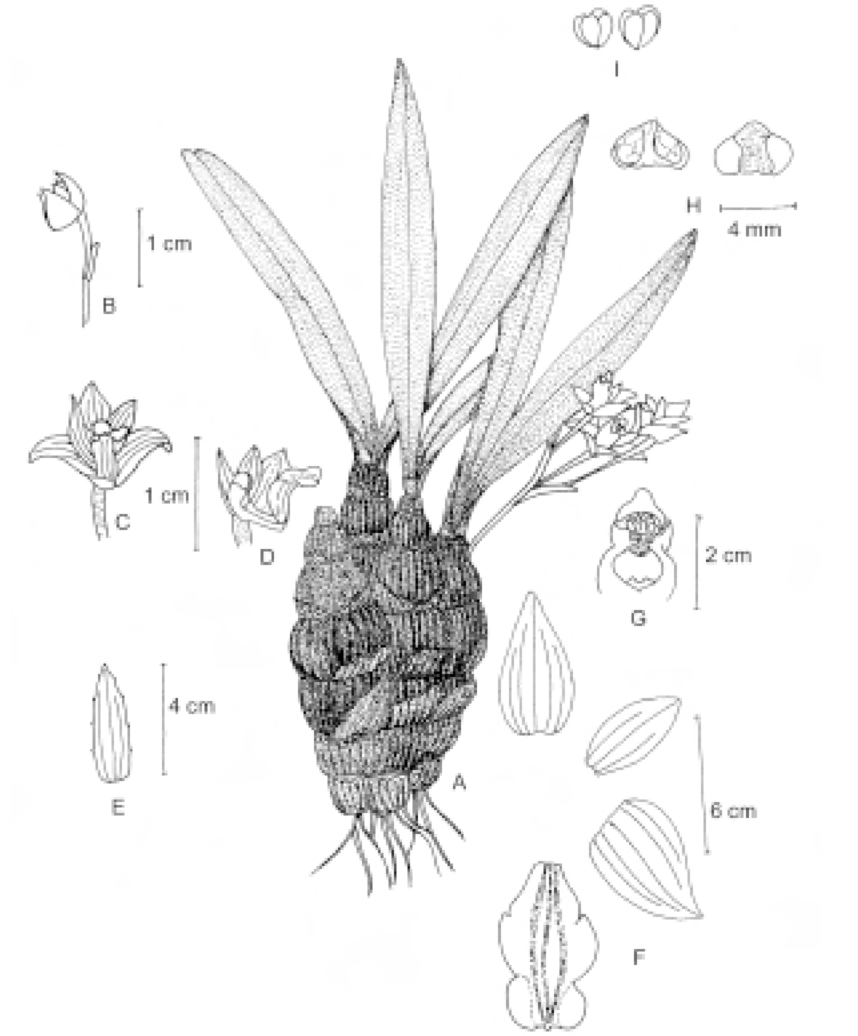
During the revisionary work on Himalayan genus *Eria* Lindl., several deposited specimens in national (National Herbarium, Department of Plant Resources, KATH and Tribhuvan University Central Herbarium, TUCH) and international (Central National Herbarium, Botanical Survey of India, CAL, The Natural History Museum London, BM, Royal Botanical Gardens, K and Royal Botanical Garden Edinburgh, E) herbaria and collected specimens from East Nepal were examined thoroughly. *Eria concolor* Par. & Rchb. f. and *Eria obesa* Lindl. were found to be new records for Nepal. King and Pantling (1898), Hara et al. (1978), Banerji and Pradhan (1984), Press et al. (2000) and Bajracharya (2001) did not mention the presence of these species in Nepal. These specimens were crosschecked with the protologue texts of *Eria concolor* Par. & Rchb.f. (1874), *Tran. Linn. Soc.* 30:148, and *Eria obesa* Lindl. (1830), *Gen & Sp. Orch.* 68. Both type specimens were collected from Burma and deposited at Orchid Herbarium, Royal Botanic Gardens, Kew. Both species are distributed in East Nepal, North East India, Burma, and Thailand.

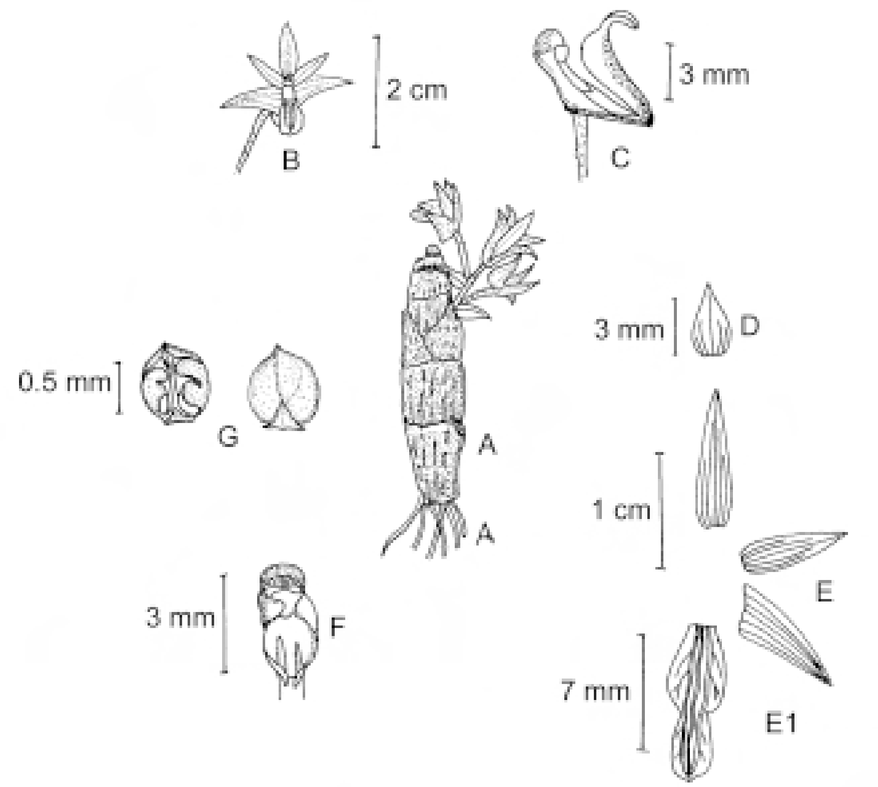
Eria concolor Par. & Rchb.f. (1874), *Tran. Linn. Soc.* **30**:148; Hooker f. (1890), *Fl. Brit. Ind.* **5**:798; Kranzlin in Engler A. (eds.) (1911), *Das Pflanzenreicn Hfl.* **50**:102; Seidenfaden (1982), *Opera Botanica* **62**:103.
Pinalia concolor (Par. & Rchb.f.) Kuntze (1891), *Revisio Gen. Pl.* **2**:679.

Epiphytic orchid 15-20 cm high. *Pseudobulbs* cylindrical, green, fusiform usually 3-5 cm high, with 4-5 internodes, often swelling between nodes, covered with bright green leaf sheath when young; older pseudobulbs with white line from the vein of old sheath. *Leaves* at top, 14 x 1.3-2 cm, linear-lanceolate, acute, very narrow membranous. *Inflorescence* raceme, sub-erect, pubescent, few flowered (2-6). *Floral bract* ovate-lanceolate, acute 5 mm, small; *pedicel plus ovary* longer than saccate mentum, more or less hairy. *Flowers* 1.5-2 mm in diameter, greenish yellow and shade of dull pink claret, membranous, glabrous. *Sepals* ovate-lanceolate, acute, 5-7.5 x 2-3 mm, glabrous, *dorsal sepal* oblong, acute, 5-6.5 mm glabrous; *lateral sepals* 3-veined, ovate-lanceolate, acuminate, falcate; *mentum* obtusely triangular. *Petals* linear, acute, ca. 5.5 mm, glabrous, 3-5 veined; *labellum* obscurely tri-lobed, small indentation in an obtuse angle between hypochile and epichile, 6-7 mm long, nearly 4 mm in width when flattened at hypochile oblong, base narrow cuneate, side lobed very narrow, disk with a thick keels merging at apex of epichile between two half-moon shaped cushion, median keel with distinct swelling at base, terminal lobe retuse, apiculate. *Column* ca. 2-3 mm, glabrous, curved, foot 5-6 mm long, distinct joint between labellum and foot; *operculum* ca. 1 mm, pea shaped; *clinandrium* collar like; *rostellum* minute and ligulate. *Pollinia* 8, obovoid, attached to caudicle; *viscidium* simple. *Stigma cavity* ca. 1-1.5 mm long laterally and two small lobed inside the cavity.
Type specimens: **Burma**: Moulmein, *Parish* 128 (K!)
Distribution: Nepal, Burma
Ecology: Epiphyte on Sal tree
Flowering: June
Specimens examined: East Nepal: Bhogatini, Raja Rani Village, Letang, Morang, 500 m., *D. M. Bajracharya, L. R. Shakya* and *A. Subedi* 424; 6 Nov 2001 (TUCH); **Burma**: Moulmein, *Parish* 128 (K!)
Etymology: Concolor refers to uniform in colour.

Eria obesa Lindl. (1830), *Gen & Sp. Orch.* 68; Lindl. (1844), *Bot. Reg.* 30 Sub. T. 29, 53; Hooker f. (1890), *Fl. Brit. Ind.* **5**:793; Grant (1895), *Orchids of Burma* 143; Kranzlin in Engler A. (eds.) *Das Pflanzenreicn Hfl.* (1911), **50**:82; Seidenfaden (1982), *Opera Botanica* **62**:105.
Eria lindleyana Griff. (1851), *Not.* **3**:300.
Eria prainii Briquet (1900), *Ann. Cons. Et. Jard. Bot. Geneve.* **4**:210.

Epiphytic herbs, 15-17 cm high. *Pseudobulbs* stoutly, clavate-ovate, 4-7 cm long, green with scarious sheath; *leaf sheath* 1-1.5 cm long, brown, scarious. *Leaves* shed before the flowering, develop in autumn, about 5-6 leaves and 12 x 1 cm appear before the pseudobulbs started swelling, lanceolate or ovate-lanceolate or glabrous (Griff. 1851); *rachis* 1 cm long. *Inflorescence* raceme, lateral sub-corymbose, 2-4 in numbers, puberulous. *Floral bract* 3 mm large, ovate, thin, entire, reflexed at the junction of the stalks, acute; *pedicel plus ovary* 1.4-2 mm long, pubescent. *Flowers* white, 2 cm across in diameter, glabrous. *Sepals* unequal, 1.0-12 cm long; *dorsal sepal* lanceolate, acuminate, entire, 1-1.2 cm x 2 mm, glabrous with 5 veins, *lateral sepals* lanceolate, slightly oblique, falcate acuminate 12 x 1.5-3 mm, entire, white, glabrous, thin, 5-veins; *mentum* 1 mm, round, curved, subcoric. *Petals*





oblong-lanceolate, obtuse, 10-12 x 2 mm, thin, glabrous, and 3 veins; *labellum* nearly as long as sepals and petals, linear-oblong, 0.8-12 mm long, 3 mm broad, entire, obscurely uniformed, thin, 3 thickened keels with lateral lobe veins, edges of lobed somewhat thin. *Column* 3-4 mm long, 2 mm in diameter, white, glabrous, curved, foot 4-5 mm long, concave; *operculum* 1 mm, sub-orbicular, thick, pappus at the upper surface, two lobed within 8 chambered; *clinandrium* collar-like, erect posterior acute, 1 dentate; *rostellum* minute and ligulate. *Pollinia* 8, obovoid, laterally compressed in appendiculate, attached to glandular caudicle; *viscidium* simple. *Stigmatic cavity* 1.5-3 mm long, curved, low stigma obscured furrow or groove, two long lobes inside the cavity.

Type specimen: **Burma**: Altran, Martabon, Wall. 1976, (K!)

Distribution: Nepal, North East India, Burma, Thailand

Ecology: Epiphyte on Sal tree

Flowering: August

Specimen examined: **East Nepal**: Bhogatini, Raja Rani Village, Letang, Morang, 500 m. *D. M. Bajracharya, L. R. Shakya* and *A. Subedi* 394, 14 Jan 2001 (TUCH); **North East India**: Palak, Lushi Hills, *Parry* (K!); *Lorrame* s.n. (K 9461!); **Burma**: Altran, Martabon, Wall 1976, (holotype K!); Moulmein, *Griff.* drawing (K!); Mergui, *Griff.* 374 (Herb. Lindl. K!); Mergui 554 type of the *E. lindleyana*, *Parish* 24 (K!); Amherest, *Lace* 4495 (K!); Amherest, *Parkinson* 5288 (K!); Moulmein, *Peche s.n.* 29 Dec. 1896 (CAL!); Kadanigh, *Meebold* 17045, 1912 (CAL!); Puge to Thagahta, *Lace* 5595, 21 Jan. 1912 (CAL!); Jaraj, *Mokim* 219, Dec. 1900 (CAL!); Paphi, *Meebold* 17044, 1912 (CAL!); Nabule valley, *Mokim* 160, Dec. 1900 (CAL!).

Etymology: Obesus refers to fat/stunt pseudobulb. ■

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Continued on page 50 ...

FIGURE 1 (top). *Eria concolor* Par. & Rcbh.f. A, habit; B, flower; C, lateral view of flower; D, bract; E, spreading of sepal, petal and labellum; F, column; G, operculum; H, pollinia.

FIGURE 2 (bottom). *Eria obesa* Lindl. A, habit; B, flower; C, lateral view of column with labellum; D, bract; E, spreading of sepal, petal; E_1, labellum; F, column; G, operculum.

Two new records of *Viola* L. (Violaceae) for Nepal

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Viola mandshurica W. Becker and *Viola odorata* L. belonging to the family Violaceae are reported for the first time from Nepal. The plants were collected along the trail between the suburbs Chovar and Jalbinayak, Kathmandu.

Key words: Herbarium, Nepal, Viola

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The family Violaceae consists of 23 genera with 830 species and the genus *Viola* alone consists of about 400 species (Mabberley 1987). In Nepal the family is represented by the single genus *Viola*, with 16 taxa in 14 species (Press et al. 2000). The Violaceae is generally characterized by simple stipulate leaves, bisexual flower borne on an axillary raceme, lower petal often spurred, 3 to 5 stamens, 3-chambered ovary in parietal placenta with numerous ovules and fruit usually in the form of a loculicidal capsule.

Previous records (Hooker 1872, Maekawa 1955, Malla et al. 1976, Hara and William 1979, Polunin and Stainton 1984, Malla et al. 1986, Koba et al. 1994, Press et al. 2000) do not reveal the existence of the species from Nepal. Morphologically, the species is often confused with other endemic species of the family.

Methodology

The present work includes the morphological variations among the taxa both in quantitative and qualitative characters such as habit, habitat, leaf size and shape, colour of flowers, spur length, size and nature of sepals, stamens, and styles. The species delimitation during this study was made from thorough examination of 300 specimens housed in National Herbarium and Plant Laboratories (KATH), 50 specimens in Tribhuvan University Central Herbarium (TUCH), 53 specimens in The Natural History Museum London (BM) and 50 specimens collected by the first author from different localities. Several photographs of type specimens were also received from different herbaria: BM, KATH, Botanical Survey of India (CAL), Royal Botanical Garden Edinburgh (E) and Royal Botanical Gardens Kew (K).

For proper identification, protologue texts, photographs of type specimens and authentic literature were used.

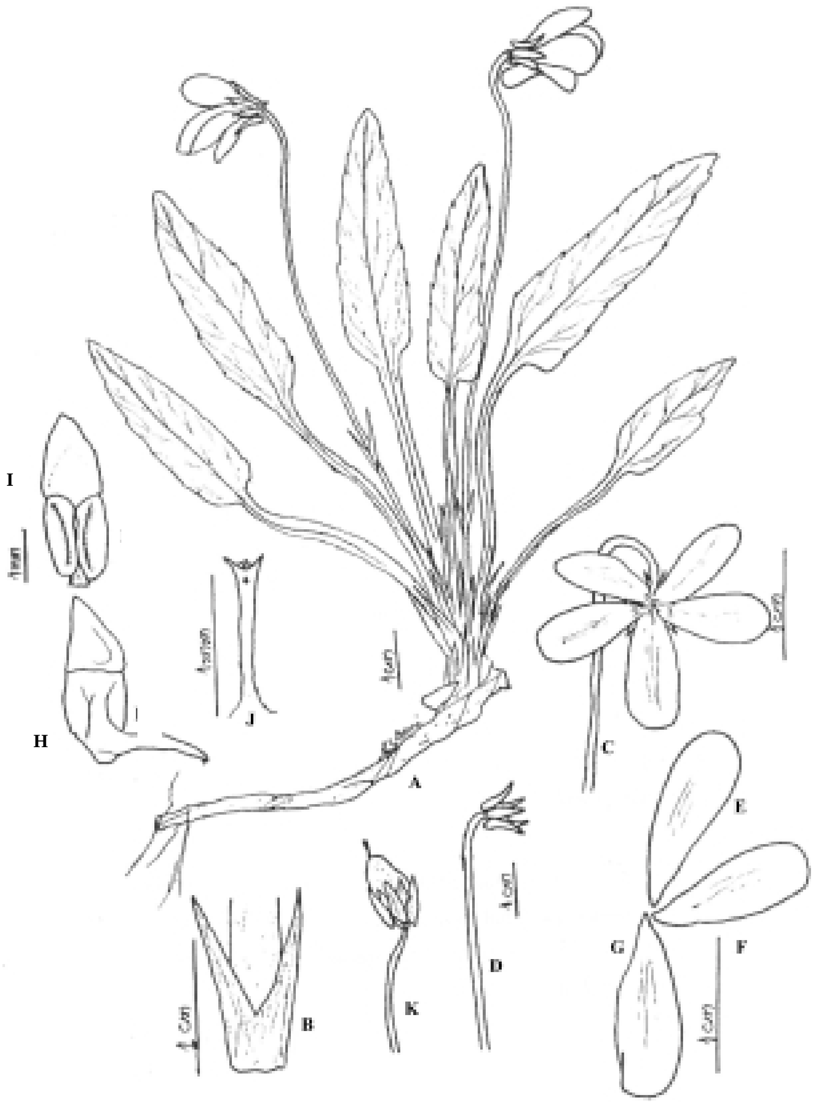

FIGURE 1. *Viola mandshurica* W. Becker. A, habit; B, stipules; C, flowers; D, calyx; E, upper petal; F, lateral petal; G, basal petal; H, basal stamens; I, other stamens; J, style (R.S. Dani, 202, TUCH)

Results

The following are recorded as new species for Nepal.

1. Viola mandshurica W. Becker in *Bot. Jahrb. 54, Beibl.* **120**: 179 (1917)

Viola mandshurica W. Becker var. *ciliata* Nakai et var. *glabra* Nakai i c **36**: 60 (1922)

Annual herbs, rarely perennial. *Rhizome* erect to ascending, rather stout. *Stem* absent. *Leaves* basal; *petiole* 2-3 (-11) cm long, glabrous, long winged (almost whole length); *leaf blade* linear-lanceolate to triangular lanceolate, 2-3 × 0.7-1.2 cm, base truncate, apex acute to obtuse, margin shallowly crenate, sometimes dentate to basal lobes, glabrous, chartaceous or subcoriaceous; *stipules* adnate to petiole more than half, lanceolate, 5-8 × 0.5-2 mm, upper 3-4 mm free, apex acuminate, margin entire or sparsely denticulate to ciliate. *Flowers* 6-9 mm across, usually dark purple to violet. *Peduncles* 2-7.5 cm long, equaling or exceeding leaves, glabrous; *bracteoles* linear, 4-5 mm long, oppositely inserted near base. *Sepal* lanceolate to ovate-lanceolate, 4-5 × 1-15 mm, apex acute, glabrous, margin entire; *appendage* 1-1.5 mm long, apex squarish to rounded. *Petal* oblanceolate to obovate, 6-7.5 × 2-3.5 mm, margin entire to undulate; *laterals* bearded; the basal apex truncate to emerginate; *spurs* 3-4 × 1-2 mm, apex rounded. *Styles* 2 mm long, slightly geniculate at base, clavate distally; *stigma* distinctly 3 lobed, terminal, with distinct anterior stigmatic beak; *fruit* loculicidal capsule (**Figure 1**).

Type: Unknown

Flowering: Mar – May

Fruiting: May – June

Distribution: 1400-1700 m Nepal (Central: Kathmandu) [China]

Specimen examined: Kathmandu, Kirtipur to Jalbinayak, 1450 m, 29.02.2000, R. S. Dani, 202 (TUCH); Kathmandu, Kirtipur, Chovar, 1500 m, 17.03.2000 (R. S. Dani, 226 (TUCH).

Note: Morphologically, *Viola mandshurica* shows close similarities to *V. betonicifolia*, however; it can be distinguished by its complete glabrous habit, shorter stipules, smaller flower (6-9 mm across), shorter peduncles, oppositely inserted bracteoles near the base, shorter spur (3-4 mm long), and distinctly trilobed stigmas. It is also similar to *Viola kunawarensis* except that the latter has spatulate leaf, pink smaller flower, style geniculation at base, stigma subterminal or lateral with anterior stigmatic beak. The *V. kunawarensis* has comparatively longer peduncle than leaf.

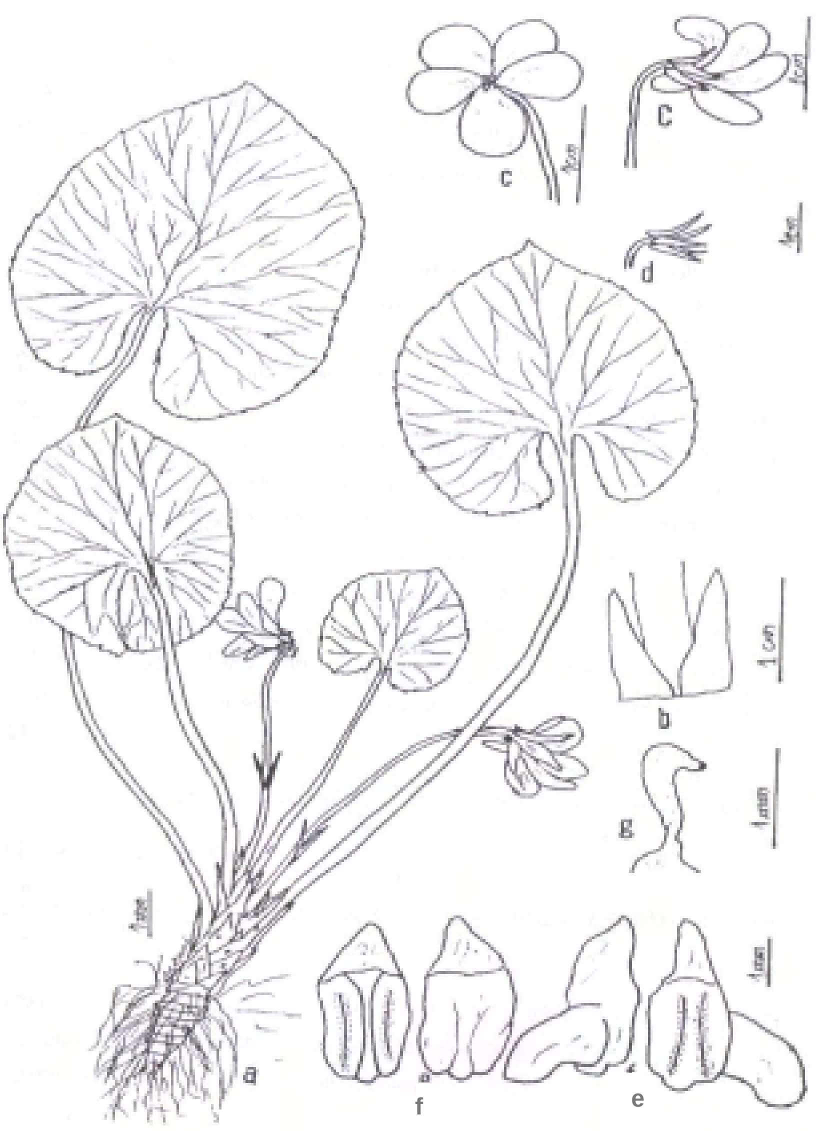

FIGURE 2. Viola odorata L. A, habit; B, stipules; C, flowers; D, calyx; E, basal stamens; F, other stamens; G, style (R.S. Dani, 205, TUCH)

2. Viola odorata L., *Sp. Pl.* 933 (1753); Hook. f. & Thomson in Hook. f., *Fl. Brit. Ind.* **1**: 184 (1975); Banerjee & Pramanik in *Fasc. Fl. Ind.* **12:** 29 (1983); Wang in *Fl. Reip. Pop. Sin.* **51**: 20 (1991).

Annual herbs. *Rhizome* erect to prostrate, rooting from rhizome and producing dense rosettes of leaves and flowers, stoloniferous. *Stem* absent. *Leaves* basal; petioles 7-14 cm long, shortly winged, glabrous; leaf blade broader ovate, 2-5 x 2.5-6 cm, base deeply cordate, acute apex, margin dentate, glabrous or sparsely pubescent; stipules almost free, membranous, 8-11 x 3-4 mm, margin shortly fimbriate. *Flowers* 1.5-2 mm across, dark purple with yellowish white at base. *Peduncle* 5-7 mm long, not exceeding the leaves, glabrous; bracteoles linear, 4-5 mm long, oppositely inserted below the middle, margin dentate, glabrous. *Sepal* broader lanceolate, l1 × 4 mm, acute apex; lateral broader than other; *appendage* 2 mm long, upper two smaller with entire margin, apex dentate. *Petal* obovate to orbicular, 17 × 9 mm, yellowish white spot on inner neck; lateral bearded; *spur* 5 mm long, cylindrical, apex obtuse. *Style* 3 mm long, geniculite at base, clavate distally; *stigma* hooked, with a conspicuous anterior stigmatic beak. *Fruit*: capsule 5 mm in diameter, globose, hirsute (**Figure 2**).

Type: *Amman*, 1052.11 (Linnaeus Botanical Herbarium, LINN - holo)

Flowering: Mar – May

Fruiting: Jun – Aug

Distribution: Cultivated in gardens, sometimes escapes from the garden; 1400-1600 m. Nepal (Central: Kathmandu) [China, India, North & West Asia; Europe; North Africa]

Specimen examined: Kathmandu, along the trail between the suburbs Chovar and Jalbinayak, 1450 m, 29.02.2000, R. S. Dani, 206 (TUCH); Kathmandu, Kirtipur, Coronation Garden, 1500 m, 29.02.2000, R. S. Dani, 207 (TUCH). ■ ➔

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Discharge and sediment loads of two streams in the mid-hills of central Nepal

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Stream flow, nutrient loading, and sediment yield closely reflect land use and management practices in relation to growing seasons in mid-hill watersheds of the central Himalaya. A preliminary study was conducted to determine approximate total water discharge and sediment yields from the Galaundi and Pokhare catchments. Mean discharge and sediment loads during the 2002 rainy season were 2.1 $m^3 \cdot s^{-1}$ and 0.9 $kg \cdot s^{-1}$ for Galaundi Khola and 0.45 $m^3 \cdot s^{-1}$ and 0.28 $kg \cdot s^{-1}$ for Pokhare Khola. Estimates of total annual discharge of water and sediment were, respectively, 27.8 million m^3 and 11,400 t (Galaundi) and 6.4 million m^3 and 3,500 t (Pokhare). These corresponded to about 71.6% and 60.4% of total rain volumes and soil loss rates of 5.18 $t \cdot ha^{-1}$ and 5.83 $t \cdot ha^{-1}$ for Galaundi and Pokhare sub-watersheds, respectively. Good correlations were observed for stream discharge vs. sediment concentration (R^2 = 0.83 and 0.94 respectively) and rainfall amount vs. discharge (R^2 = 0.94 and 0.96 respectively) for both streams.

Key words: stream flow, sediment concentration, land use, pre-monsoon, sub-watershed

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The mid-hill watersheds of central Nepal are characterized by a myriad of ephemeral and perennial streams, many with steep gradients from source areas to confluence junctions with major rivers. The seasonal nature of rainfall, being concentrated mostly within the five-month period May to September and steep terrain govern the hydrologic characteristics of these streams. Thus, many streams that run dry or dwindle to a mere trickle for much of the year are transformed into raging, torrential streams up to 2 m deep in some areas. Moreover, land use practices, seasonal paddy cropping, and diversion for irrigation all substantially influence flows and sediment concentration in the streams.

Studies in the watersheds of the Jhikhu Khola (Kavre district) and Yarsha Khola (Dolakha distric) in the mid-hills of Nepal have shown that, while major storm events are responsible for generation of the highest flows and channel scouring in the steep mountain streams, the medium-sized events are more likely to be influenced by land cover and land use (Merz et al. 2000). Furthermore, Nakarmi et al. (2000) reported that while water storage within those same watersheds was more effective on agricultural than on grazing (grass/shrub) land, erosion was higher at cultivated sites during small to medium rain events. However, in the case of high rainfall events, degraded areas were the main sources of sediment; the likely mechanism is soil compaction, which causes reduced water infiltration and storage capacity, resulting in high runoff velocities, which lead to gully erosion.

Many studies indicate that soil erosion, nutrient losses and sediment transport in mountain streams is greatest on the occasion of those few major storms that typically occur during the pre-monsoon and early growing season (Carver and Nakarmi 1995, Nakarmi et al. 2000, Atreya et al. 2002). The main reasons for this are that during this critical period soil cover is at a minimum and farming operations (tillage, planting, weeding, etc.) are in progress.

The Himalayan region in general, and the mid-hills of Nepal specifically, are faced with the conflicting needs of a growing human population on the one hand, and, on the other, natural ecosystems urgently in need of protection. This has resulted in escalating environmental degradation due to unsustainable timber, fodder, and fuel wood extraction; subsistence agriculture on marginal lands; and infrastructure development. These activities impact the hydrology of mountain watersheds, particularly with regard to flow characteristics and sediment loads, due to soil erosion and changes in water storage and runoff patterns. See Ives and Messerli (1989) as well as the Ives (2004, forthcoming) for a comprehensive assessment of these trends.

Land use changes due to forest clearing; intensification of agriculture (off-season cash crops) and diversion of stream waters for irrigation all impact stream flow, sediment content and nutrient dynamics (Carver and Schreier 1995, Schreier and Shah 2000, Sharma et al. 2002). Therefore, such land use dynamics and farming intensification will require careful balancing of water and nutrient budgets for sustainable production and environmental protection (Schreier et al. 1994).

Methods

The streams were sampled periodically (randomly) from January to September 2002, so as to obtain representative data for a range of conditions, from dry season minimum flows to rainy season high flows. Samplings were also performed in conjunction with critical events such as pre-monsoon storms, planting, and harvest, when streams carry unusually high sediment loads.

Data gathering was constrained, however, by the unfeasibility of sampling during peak flow periods, when river velocities and depths were prohibitively high. Also, it was difficult to time sampling so as to capture specific rainstorm events of high intensity, especially since these often occurred at night.

Stream velocity was determined using the floatation technique. Cross-sectional areas of each stream were determined by measuring the depth of water at 0.1 m intervals across relatively narrow and uniform segments of the streams. Sediment concentration was determined by taking one-liter grab samples from the middle depth of the stream. Water samples were allowed to settle and the residue was then oven-dried to obtain sediment weight per liter of water.

Stream discharge (Q, $m^3 \cdot s^{-1}$) and sediment delivery rate (SDR, $kg \cdot s^{-1}$) were calculated according to the following formulas:

$$Q = A * V \quad \text{[Eq. 1]}$$

where,
A = cross-sectional area of stream, m^2
V = flow velocity, $m \cdot s^{-1}$

$$SDR = Q * C \quad \text{[Eq. 2]}$$

where,
C = sediment concentration, $g \cdot l^{-1}$

Results and discussion

Stream flow measurements indicated that flow volumes in both streams are generally low (<1 $m^3 \cdot s^{-1}$ for Galaundi and <0.1 $m^3 \cdot s^{-1}$ for Pokhare). Flow increases dramatically (>4 $m^3 \cdot s^{-1}$ for Galaundi and >1 $m^3 \cdot s^{-1}$ for Pokhare) shortly after the onset of a major rainstorm, but diminishes rapidly upon cessation of the rainfall. Such quick responses and rapid fluctuations are likely due to the small size of the sub-watersheds and steep stream gradients, as observed by Merz et al. (2000).

Casual examination of the data gathered from random samplings during the rainy season of 2002 (**Table 1**) indicated high variability of both stream flow volumes (discharge) and sediment loads. Simple arithmetic means of the discharge and sediment yield rates during the rainy season were calculated to be about 2.1 $m^3 \cdot s^{-1}$ and 0.9 $kg \cdot s^{-1}$ for Galaundi, and 0.45 $m^3 \cdot s^{-1}$ and 0.28 $kg \cdot s^{-1}$, for Pokhare, respectively. These values are comparable to data from other similar sized sub-watersheds reported in the available literature (Merz et al. 2000). Taking the sub-watershed areas to be 22 km^2 and 6 km^2, we derived crude estimates of mean total water discharge and sediment yield during the rainy season of 25 million m^3 and 11,400 t for Galaundi and 5.7 million m^3 of water and 3,500 t of sediment for Pokhare, respectively (**Table 2**).

It was, however, established from both direct observation and inquiry with local residents that for about 7 months during the dry (October to April) period**,** stream flows are at a minimum and that sediment load is essentially zero. It was also noted that maximum flows and sediment loads occurred for only a few events, typically in the pre-monsoon and early rainy seasons (May-July) (**Table 1)**. At other times during the rainy season, flows and sediment concentrations were generally low to medium.

Thus, assuming that minimum flows correspond to about 0.16 $m^3 \cdot s^{-1}$ for Galaundi and 0.04 $m^3 \cdot s^{-1}$ for Pokhare, the total discharge volumes for these streams during the remaining (7 months) of the year were calculated to be 2.8 million m^3 and 0.7 million m^3, respectively. Since sediment loads during the rest of the year are negligible, total sediment yields may be taken to be those calculated for the rainy season alone. Summing the total water discharge and sediment yield values for rainy and dry seasons for each stream, estimates for the annual mean totals are shown in **Table 2**. Using the ten-year mean monthly rainfall data of Dhunbesi, Dhading, the total annual flow volumes represented 71.6% and 60.4% of the total rainfall volumes for Galaundi and Pokhare sub-watersheds, respectively (**Table 3**). The remaining water presumably percolates into the groundwater or is lost through evaporation and transpiration.

Total annual soil removal from the catchments areas, determined by dividing annual sediment yield by the total land area of each sub-watershed (approximately 600 ha for Pokhare and 2200 ha for Galaundi), was 5.83 $t \cdot ha^{-1} \cdot y^{-1}$ and 5.18 $t \cdot ha^{-1} \cdot y^{-1}$ for Pokhare and Galaundi sub-watersheds, respectively. These values fall in the lower range of observed soil loss rates reported in the literature (Chalise and Khanal 1997, Nakarmi et al. 2000, UNEP 2001) and reflect the well-managed upland terrace and forested areas over much of the two sub-watersheds. In general, soil erosion appears not to be a major problem in the study sub-watersheds. Thus, adequate management and conservation of agricultural and forest lands could lead to low overall soil erosion rates (at the catchment scale) and correspondingly low sediment loads in the streams.

TABLE 1. Stream flows, sediment yields and sediment concentration for Galundi Khola and Pokhare Khola

Sampling Date	Galundi Khola			Pokhare Khola		
	Discharge ($m^3 \cdot s^{-1}$)	**Sed. yield** ($kg \cdot s^{-1}$)	**Sed. conc.** ($g \cdot L^{-1}$)	**Discharge** ($m^3 \cdot s^{-1}$)	**Sed. yield** ($kg \cdot s^{-1}$)	**Sed. conc.** ($g \cdot L^{-1}$)
20/1/02	0.17	0.00	0.00	0.03	0.00	0.00
26/05/02†	0.57	0.75	1.30	0.27	0.03	0.12
04/06/02	0.16	0.01	0.04	0.04	0.01	0.02
02/07/02	4.60	1.41	0.54	1.16	1.08	0.93
02/07/02	4.80	1.27	0.50	1.04	0.73	0.70
02/07/02	4.24	2.48	0.30	0.83	0.50	0.60
02/07/02	3.92	2.39	0.36	0.69	0.29	0.42
13/07/02	0.30	0.03	0.10	0.08	0.06	0.07
02/08/02	0.90	0.32	0.35	0.14	0.04	0.30
30/08/02	1.00	0.19	0.19	0.11	0.02	0.14
09/08/02	0.72	0.14	0.20	0.12	0.03	0.10
Average*	**2.12**	**0.90**	**0.39**	**0.45**	**0.28**	**0.34**

† Outlier – excluded from regression analysis
* Average is for rainy season, i.e., May to September, sample size = 10

TABLE 2. Mean stream water discharge and sediment yield estimates for Galaundi Khola and Pokhare Khola (sample size = 10)

Stream	Rainy season		Dry season		Total Annual	
	Discharge volume (m^3)	Sediment yield (t)	Discharge volume (m^3)	Sediment yield (t)	Discharge volume (m^3)	Sediment yield (t)
Galaundi	25 million	11,400	2.8 million	~0	27.8 million	11,400
Pokhare	5.7 million	3,500	0.7 million	~0	6.4 million	3,500

TABLE 3. Mean monthly rainfall, mean total rain volumes and total annual rain volumes and discharge for the two sub-watersheds

Month	Mean rainfall (mm)	Total Rain Volume (X 10^3 m^3)	
		Pokhare	Galaundi
January	18.7	112.2	411.4
February	14.2	85.2	312.4
March	31.3	187.8	688.6
April	39.7	238.2	873.4
May	134.9	809.4	2967.8
June	309.2	1855.2	6802.4
July	418.1	2508.6	9198.2
August	492.2	2953.2	10828.4
September	228.9	1373.4	5035.8
October	48.4	290.4	1064.8
November	13.9	83.4	305.8
December	16.6	99.6	365.2
Total Annual Rain	1766.1	10596.6	38854.2
Total Discharge Volume ($m^3 \cdot s^{-1}$)		6400	27800
Percent of discharge to rainfall		60.40	71.55

Regression analyses

Regression plots of sediment concentration versus discharge (Q) for the streams indicated that there were good correlations between these parameters for both streams over the range of values obtained during the monitoring period. This was reflected in high R^2 values obtained for the logarithmic and linear regression functions for Galaundi ($R^2 = 0.83$) and Pokhare ($R^2 = 0.94$), respectively (**Figure 1** and **2**).

In the case of Galaundi, one outlier eliminated in the analysis. The relationships for each stream are given by the following equations:

For Galaundi

Sediment Concentration = $0.123 \ln(Q) + 0.25$; $R^2 = 0.83$ [Eq. 3]

For Pokhare

Sediment Concentration = $0.696(Q) + 0.026$; $R^2 = 0.94$ [Eq. 4]

Nearly 90% of the rainfall occurs during the months of May through September (**Figure 3**) which corresponds to the period of greatest stream flow, although the sediment concentration in stream water fluctuates greatly, being highest during the early season (May-July) and at sporadic critical periods throughout the rainy season, such as paddy planting time (**Table 1**) and during particularly intense storms, a pattern noted by other researchers (Carver and Nakarmi 1995, Nakarmi et al. 2000, Atreya et al. 2002).

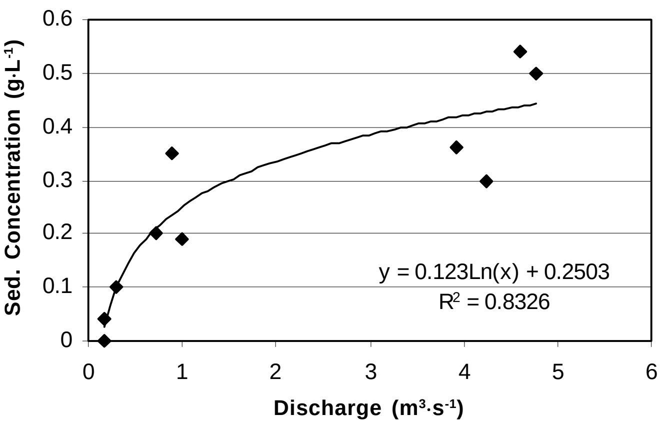

FIGURE 1. Regression plot of flow rate vs. sediment delivery for Galaundi Khola

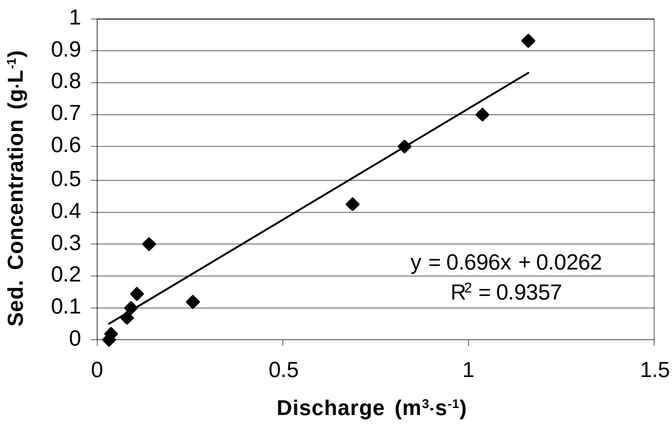

FIGURE 2. Regression plot of flow rate vs. sediment delivery for Pokhare Khola

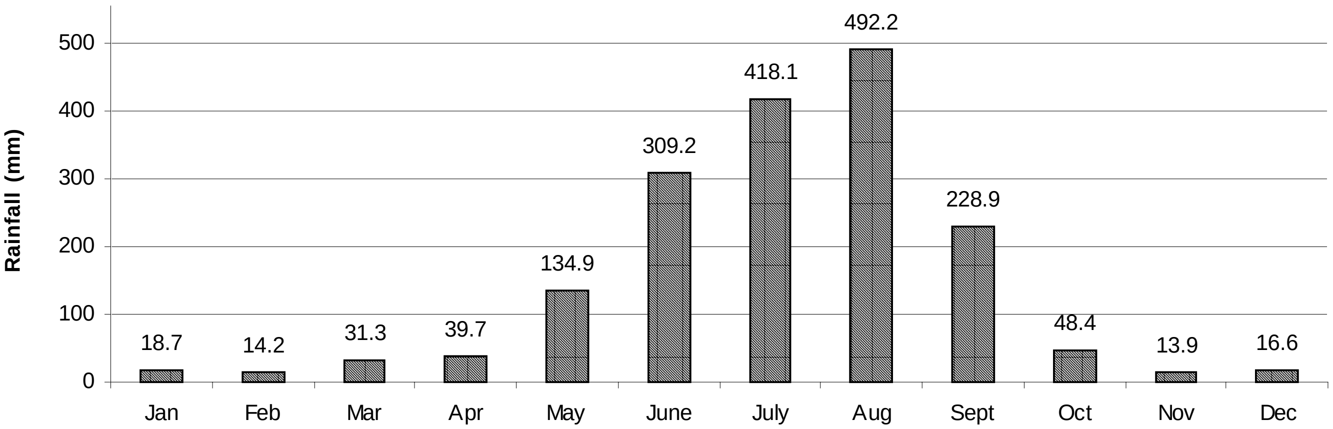

FIGURE 3. Mean monthly precipitation recorded for the study district over a ten-year period from 1991 to 2000 at Dhunbesi Station, Dhading (Source: Department of Hydrology & Meteorolgy, HMGN 1995, 1997, 1999; Climatological Records from 1987 to 1996)

Crude calculations of the total volume of precipitation falling over each sub-watershed, based upon the 10-year mean monthly rainfall and total annual stream flow volume as a percent of annual rainfall indicated that about two-thirds of the total rainfall flows out of the catchments as stream discharge (**Table 3**), the rest going to groundwater or evapo-transpiration. Moreover, stream discharge was significantly correlated with rainfall amount for the days monitored (24 h period during which sampling was done) as seen from the regression plots (**Figure 4**).

For the limited number of observations made, good correlations were seen between 24-hour rainfall totals and same-day discharge rates for both streams (**Figure 4**). This indicated that stream flow responds rapidly to rainfall due to the small size and steep gradients for both Pokhare and Galaundi sub-watersheds. Because of this fact, however, timing of stream discharge measurement is critical and pinpointing peak discharge is difficult.

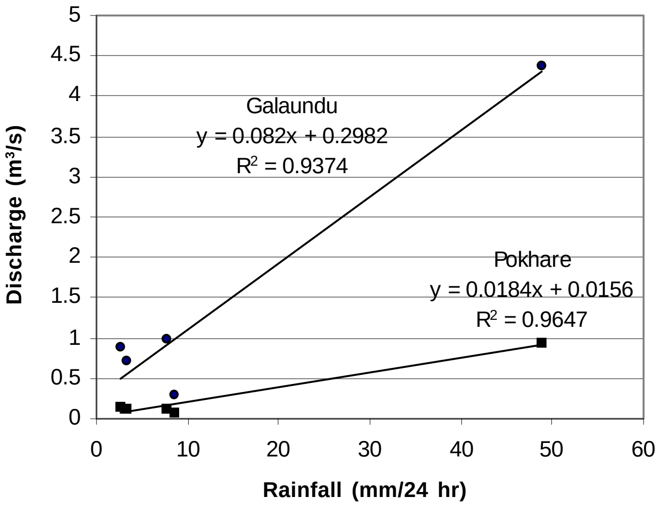

FIGURE 4. Regression plots of 24 h rainfall amount and stream discharge (flow rate, measured during the 24 h period)

Conclusions

Climatic and stream flow data revealed that most of the rainfall occurs from May to September and that during much of this period discharge from both streams is low. High flows tend to occur a few hours after heavy storms due to the steep gradients and small catchment areas of the streams. High sediment concentrations were confined to critical periods such as the pre-monsoon intense rains and during tillage/planting times when the soil is least protected and most disturbed. Soil erosion did not appear to be a major problem in the study watersheds, presumably due to adequate management and conservation practices on agricultural and forestlands. Despite limited observations, good correlations were obtained for discharge vs. sediment load and rainfall amount vs. discharge for both streams. Land use and farming practices clearly influence the nature of stream flow, as well as sediment loading in streams with steep gradients in the mid-hills. Further work is, however, needed to establish the causal relationships among land use, agricultural intensification, stream discharge, and soil and nutrient losses, in order to formulate ecologically and economically sound recommendations for sustainable land management. ■

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Ethnosilvicultural knowledge: A promising foundation for integrating non-timber forest products into forest management

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Reconciling the multiple roles of forest resources is one of the unresolved challenges for sustainable forestry, but forest management practices are still focussed on timber production. The urgent need for the integration of non-timber forest products into mainstream forestry has, however, been widely acknowledged. Ethnosilvicultural knowledge from Canadian Aboriginal communities and community forest users of Nepal is assessed in the context of multiple-product forest management. Both cases reveal a wealth of such knowledge, indicating the opportunities for integrating non-timber forest product management in mainstream forestry. It is argued that ethnosilviculture is valuable in sustaining ecological processes as well as cultural heritages and traditional rural livelihoods. Broad guidelines for acquiring ethnosilviculture knowledge are also suggested.

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Agenda 21 (UNCED 1992) highlighted major shortcomings in policies, methods and mechanisms applied in the support and development of the multiple ecological, economic, social and cultural roles of trees, forests and forest lands; subsequently, an immense need was felt for a rational and holistic approach to the sustainable and environmentally sound development of forest resources through adequate and appropriate institutional strengthening. Reconciling the multiple roles of forest resources is clearly one of the unresolved challenges facing sustainable forestry.

The uses of forest resources comprise a wide range of products and services; broadly, the products can be grouped into timber and non-timber. Non-timber forest products (NTFPs) include plant and animal products used or having a potential to be used for food, ornament, decoration, medicine, cosmetics, and other applications; they may have environmental, cultural and spiritual values. In the present paper, we focus only on plant products whose harvest does not necessitate the felling of trees.

As most of the world's forest resources are either owned by governments or influenced by their policies, governmental forestry policies play a pivotal role in the regulation of NTFPs. Governments usually regulate permits for the collection and extraction of these products depending upon the resource species and their end-uses. NTFPs with commercial value may attract some levies whereas products for subsistence uses are generally free of charges (Gautam 1991, Mahapatra and Mitchell 1997). NTFP collection and extraction involves primarily people residing within and around forests, and is undertaken for the most part at the collectors' discretion without any management guidelines. Collectors may be motivated by their objective of maximizing income without consideration of adverse effects on future yield of the target species or others in the ecosystem; such instances are common, especially when the harvesters are not assured of subsequent usufruct rights regarding these products (Gautam and Devoe 2002). The situation, thus, suggests that most of the NTFPs are still in a state of unrestricted access. Furthermore, large-scale commercial activities such as timber extraction and mining have been carried out without regard to their impact on NTFPs growing in the same forests. Nonetheless, various efforts have been initiated globally, although with inconsistent implementation, to improve the deteriorating status of NTFPs of particular importance.

Traditionally, whenever people have felt that species of local importance were disappearing from the forest or subject to intensified demand, they have domesticated those species by transplanting them into their home gardens. Such NTFPs have been cultivated primarily at a subsistence level. Some NTFPs have been commercialized as raw material for industrial uses, resulting in increased demand. Subsequently, the need to stabilize supply and increase economic return has provided a motive to undertake cultivation (Wheeler and Hehnen 1992).

'Extractive-reserve', a relatively new concept in NTFP regulation, was specifically devised to safeguard Amazonian rubber tappers when they were threatened by forest clearance in the 1980s (Brown and Rosendo 2000). It is an approach in which tracts of forests are set aside for residents to harvest NTFPs. Extractivism may promote local commitment to forest conservation, provided clear and binding management prescriptions are followed.

Recently, NTFPs have emerged as important products in community-based forest management. Waves of community forestry evolved globally and NTFP production has been the main motivation for such evolution, indicating enormous potential for integrating NTFPs into forest management. There is an urgent need to manage NTFPs in the context of sustaining ecological processes, cultural heritage, and traditional livelihoods. The management regime must integrate the economic, environmental, and cultural (including spiritual) values of NTFPs (Gautam and Watanabe 2002).

A few studies (e.g., Romero 1999, Myers et al. 2000) have considered the possibility of managing NTFPs within forest ecosystems, but they have considered only the effects of single products. Unless and until NTFP management is integrated with forest management, the sustainability of NTFPs and eventually of forests will remain threatened. Although some scientific efforts focusing on integration of NTFPs into mainstream forestry have ➔

been initiated (Salick et al. 1995, Gautam 2001), the NTFPs are so vast and diverse that merely waiting for scientific results may entail delays that preclude sustainable management. On the other hand, undocumented ethnosilvicultural knowledge gleaned in the course of many generations is vanishing. The present paper, based on studies in two distinct contexts (Canada and Nepal), argues that ethnosilviculture is a prospective base for integrating NTFP management into mainstream forestry.

Source of information

As the present study is based on primary and secondary information including a review of earlier studies, the methodology is broad-based. The Nepalese case study draws on information collected from two community-managed forests in Dang district in the course of doctoral research conducted by one of the authors (KHG) from 1997 to 1999 (Gautam 2001), whereas the Canada case study is based mainly on earlier research (Marles 2001, Turner 2001), supplemented by information from a field visit to Nipissing First Nation Ontario in September and October 2002. The steps followed for acquiring ethnosilvicultural knowledge are summarised in **Table 1**.

Origin of conflicts in Canadian forestry

At the Earth Summit (UNCED 1992) Canada announced its commitment to sustainable forestry and acknowledged the forest's multiple roles - environmental, commercial, and cultural. Since then, efforts have been made to incorporate consideration of forests' multiple benefits into management strategies, mainly through the amendment of provincial policies (NRCan 2002). Canada holds 10% of the world's forests, and 94% of its forests are publicly owned; forests under provincial and federal jurisdictions are 71% and 23%, respectively. Out of 417.6 million hectares of forest, 235 million hectares are categorised as commercial forests. However, forests are predominantly managed for timber despite the fact that the public values forests primarily for non-timber uses (WRI 2000).

Over 80% of Canadian Aboriginal Communities (CACs) are living in productive forest areas, and large tracts of forests may revert to their control through the adjudication of outstanding land claims (Quaile and Smith 1997). The CACs are struggling to maintain their traditional values. Timber harvesting is threatening the subsistence of many communities in the far north, and aboriginal interests are poorly represented in forest management decisions throughout Canada (WRI 2000). Thus, Canadian government's timber-biased attitude often conflicts with CAC's rights and traditional respect for the sustainability of forests (WRI 2000).

Although Canada has launched a First Nation Forestry Program (1996), and a few other pilot projects have been designed with the goal of increasing CAC involvement, the communities' feeling of marginalization has not yet abated (Jaggi 1997, KHG's personnel communication with First Nation in Ontario 2002). Accordingly, the National Aboriginal Forestry Association (NAFA) recently proposed a separate aboriginal criterion for sustainable forest management (NAFA 2002). According to the proposal, Canadian forests need to be managed for multiple products and values with proper appreciation of traditional knowledge and active participation of the CACs (and not simply as stakeholders). Thus, Canadian forestry is at a crossroads: timber-biased industrial forestry evolved over the past 100 years is pitted against CAC forestry practices evolved over several centuries. The value systems of these two approaches are radically different, and such differences may result in an unwanted outcome. As the industrial forestry development has not been able to accommodate the values of CACs, it may be an appropriate juncture to assess the key elements of CAC's traditional forestry practices.

TABLE 1. Comparison of methods for acquiring ethnosilvicultural knowledge in Canada and Nepal

Canada	Nepal
Consent from Band Council and elders (Band Council is a quasi-governmental institution of the aboriginal community)	Explanation of study objectives to Community Forest User Groups (CFUGs), and request for consent
Approval from appropriate institutional ethics committee	Informal discussions to identify key informants
Formation of advisory committee of elders to supervise work	Meetings with key informants
Involvement of young people from the community	Participatory meetings of each subgroup and class
Regular reporting to the Band Council	General meeting (presentations from each subgroup and class)
Compilation of information from community and literature	Forest transect with key informants
Communication of research results to the community	Outputs: identification of NTFPs, silvicultural characteristics of NTFPs, key informants
Arrangements to safeguard intellectual property rights	Communication of results to users

Ethnosilviculture from CACs

Traditional ecological knowledge, which not only assesses physical environmental relationships but also considers cultural factors, may be able to assemble the requisites for multiple-product management (Gliddon 2000). North American native communities have extensive ethnobotanical knowledge (Davidson-Hunt et al. 2001). Marles (2001) noted that Canadian forests have been meeting the multiple subsistence needs of CACs for millenia. Survival pressures have produced not only indigenous knowledge but also indigenous institutions such as '*hahuulhi*', a system that accords community chief's hereditary power along with the responsibility to manage resources with the involvement of the entire community (Turner 2001).

Turner (2001) noted the following elements in ethnobotanical knowledge and practices, indicating the scope of such knowledge that could be available upon intensive exploration for forest management.

- Replanting propagules, including cuttings; Transplanting valuable plants
- Pruning and coppicing to improve quality and quantity
- Thinning of density-dependent species to enhance growth
- Partial harvesting of bark, branch or root
- Selective harvesting of medicinal plants
- Controlled burning in order to enhance growth of desired species

From conflict to reconciliation in Nepali forestry

Nepal, with an area of 147,181 square km, was once rich in forest resources; timber export was one of the main revenue sources until the 1970s. Until the 1950s, when they were opened for settlement, forests in the Tarai were intact. Industrial forestry intervened through enactment of Private Forest Nationalization Act 1957; although this was mainly intended to nationalize the forest owned by earlier ruling classes, it affected the forests throughout the country by promoting the conversion of forest to cropland (Gautam 1991). The act had a negative impact on traditional forestry, and Nepal's forests became fodder for the 'Theory of Himalayan Environmental Degradation' (Ives and Messerli 1989), which highlighted the gathering crisis in mountain region though the theory, in itself, was not supported by reliable data.

Forest policy makers responded by amending the legislation and introducing a community forestry development programme in 1977. Since then policy has increasingly emphasized the involvement of local communities in forest management, and the focus has shifted from timber to multiple uses. The response from communities and concerned organizations has been overwhelmingly positive, and, as of November 2002, management of a million hectares of government forest had been transferred to more than 12000 CFUGs comprising approximately 1.3 million households (personal communication, Department of Forest, Nepal).

FUG's Ethnosilvicultural knowledge

Because integrated management of timber and NTFPs had not been adequately addressed by earlier forestry, most CFUGs were practicing "passive management", simply protecting the forest. Community forestry programmes, however, created opportunities to investigate the usefulness of local knowledge on various aspects of forest management. Utilization of local knowledge has proven to be not only beneficial but also essential for the active management of community forests (Gautam 1991).

A detailed study (Gautam 2001) on ethnosilvicultural knowledge in two community-managed sal (*Shorea robusta*) forests was conducted in Dang district of Nepal. Besides their knowledge regarding use of more than 200 plant species of different life-forms, users demonstrated their awareness on the silvicultural characteristics of 97 of these species. Ethnosilvicultural knowledge embraced: phenology, abundance and distribution, ecological associations, propagation, microclimatic constraints, and dispersal mechanisms.

Discussion

The cases showed that CACs in Canada are still struggling for their traditional tenure of land, including forests, whereas similar issues created by nationalizing private forests in Nepal have been resolved with the transfer of forest management to CFUGs. Nepal had very bitter experiences with marginalized local communities; in Canada, we have seen the creation of similar situations, which, if not handled promptly, may affect the sustainability of Canadian forests.

Forest management focusing on a single product (timber) may frustrate users of other products, resulting in conflicts among interest groups within a community. By the early 1970s, struggle in Nepal between an economic elite interested in timber extraction, on the one hand, and others with broader-based subsistence interests quickly resulted in degraded hills. In Canada, too, diverging economic priorities of CACs and other stakeholders may have the same effect on forests. In many regions timber-biased management has resulted in extreme ecological damage (Roberts and Zhu 2002, Marchak and Allen 2003). In both developed nations such as Canada and developing countries like Nepal, forests must be managed with an eye to optimizing return on timber as well as non-timber forest products.

Turner (2001) found that some species had disappeared after the disruption of indigenous management, indicating that a two-way relationship exists between indigenous knowledge and species diversity. Since many NTFPs species are ecologically dependent on a diverse forest environment, disappearance of one or more species may affect the survival of other species. CACs have understood these linkages, and therefore emphasize the importance of developing mechanisms to utilize aboriginal forest-based traditional knowledge in forest management (NAFA 2002). Both CACs and CFUGs are aware that ethnosilviculture ensures NTFP productivity. Other cases where local people have applied such knowledge are well documented (Salick et al. 1995, Emery and Zasada 2001). Thus ethnosilviculture could be an effective basis for developing silvicultural regimes.

The transfer of knowledge to new generations was an established part of the cultures perpetuated by CACs and CFUGs. Language, food, artefacts, and beliefs are important in this process, and any change in such factors could constitute a threat to continuity. Collecting such information from indigenous communities must be carried out carefully so that the process neither disrupts the tradition nor embarrasses people by casting them as "primitive" informants. Davidson-Hunt et al. (2001) have presented approaches and methodologies for collecting indigenous knowledge on plant use and management. Furthermore, Marles (2001) has developed protocols for ethnobotanical research, which may be useful in documenting silvicultural information. Acquiring ethnosilvicultural knowledge has involved long effort on the part of CACs and CFUGs. In both cases establishing a rapport seems to have been the necessary first phase in acquiring information from local people. (For example, offering tobacco when meeting with community elders is an established tradition in CACs). It is necessary to piece together information from different sources. Information can be collected from gatherers, loggers, ground-managers, crafters, artisans and their families and friends (Emery and Zasada 2001). Within a community, all groups (whether categorized by gender, age, profession, or ethnicity) hold some sort of knowledge; so the participation of all will be beneficial. Civic events such as fairs, churches, and temples, could be very important venues for the acquisition of such information. Multiple meetings with resource persons may be useful in triangulating and verifying information. Walking forest transects in the company of local users has been very useful in identifying species, uses and habitats in Nepal. Although research protocols may vary, the informants must be convinced that the information shared will not be used against their interests.

Conclusion

We offer the following recommendations concerning the integration of NTFPs in mainstream forestry.

- Tenural or proprietorship rights need to be safeguarded.
- NTFPs management must be considered an integral part of forest management.
- An ethnosilvicultural knowledge database must be prepared for the smallest stands or sites as well as for larger forests. This information could become a good basis for scientific investigation for ecosystem-based forest management.
- Strengthening traditional and indigenous institutions is essential. Such institutions may be capable of monitoring the ecological condition of the forest as well as implementing management strategies. ■

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