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Research

Response of plant species to abandonment of subalpine fields, Manang, Nepal

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Abstract

Spatial dimension of abandoned fields has been expanding more in rural subalpine zones of Nepal leading to various patterns of secondary succession. The secondary succession in the subalpine Himalayas has not yet been evaluated. Here, I describe a study initiated in Manang district, Central Nepal where enough abandoned fields of different chronosequences were located. A definitive successional pattern was predicted from the data obtained from sampling 256 plots of 1 × 1 m^2 each systematically in a total of 43 abandoned fields from 1 to 55 years after abandonment. Change in composition pattern of 11 most important plant species was analyzed through the Detrended Correspondence Analysis (DCA). The first two axes of DCA explained 19.1 % of the total variation in the species composition. Early, mid and late successions were three stages distinguished each by their abundance scores and life-forms composition. *Malva neglecta, Phleum alpinum* and *Fagopyrum esculentum* were dominant at the recently abandoned fields. *Cynoglossum zeylanicum, Malaxis muscifera, Medicago falcata* and *Pennisetum flaccidum* were mid succession species, and *Thymus linearis, Tanacetum gossypinum*, *Pinus wallichiana* and *Poa annua* represented the late succession species.

Key-words: abundance value, oldfields, secondary succession, stages of succession, trans-Himalayas.

Introduction

Over the last 250 years, global change has caused large-scale shifts in the Earths' ecosystems. Global average air temperature is rising continuously (IPCC 2007). This rising temperature is much sharper at a local and regional than the global scale. Direct and indirect impacts of global change are beginning to appear in rural economies. Late start of monsoon, longer drought period, early frost and rapid spread of diseases are frequently occurring (Ruprecht 2005; Otto *et al.* 2006; Baniya *et al.* 2009). These changes have resulted in loss of biodiversity, migration of people, degradation and fragmentation of land and changing landuse patterns. At extreme cases, this leads to abandonment of cultivation. In addition, people started to colonize in such places where more opportunities and resources are available for their future generations. Out migration is a serious problem in Nepal; big population of youth is flying aboard daily for job. Young and old people living at their villages could not continue farming occupation. Hence abandonment of agricultural land is increasing. Dynamic nature does not stop its activities so does in the abandoned fields. Secondary succession is common at those abandoned fields.

Toky and Ramakrishnan (1983) have studied plant colonization pattern at abandoned fallow land in the subtropical mountains of Eastern Himalayas of north-east India and found *Imperata cylindrica* and *Chromolaena odorata* as the primary colonizers for 5 years. These species were further replaced by *Dendrocalamus hamiltonii* up to 15 years. Finally, those fallow lands were found substituted by light demanding tropical lowland forest species, such as *Bauhinia purpurea*, *Dillenia indica*, *Schima wallichii* and *Cedrela toona*.

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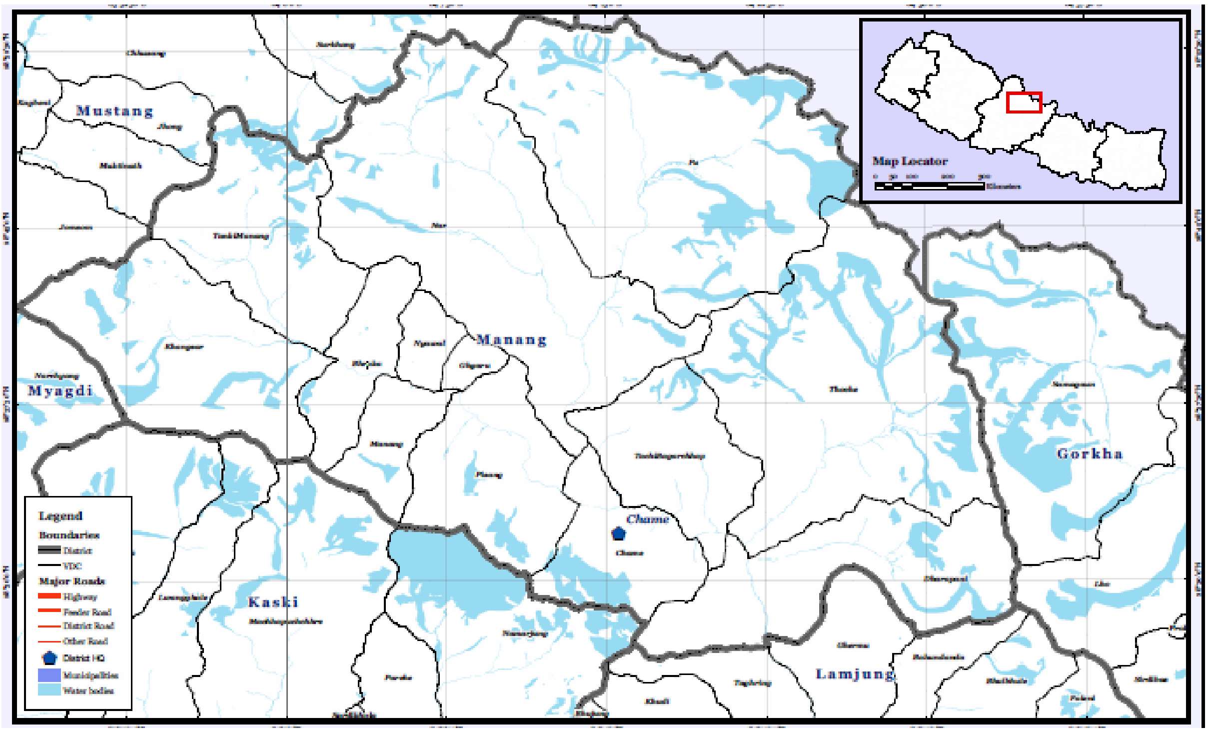

Figure 1. Map of the study area (source: http://www.un.org.np/maps/district-maps/western/Manang.pdf, accessed 1 December 2010).

Similarly, Rikhari *et al*. (1993) studied the secondary succession pattern at alpine meadows in the Central Himalayas, India. They found two seres of succession, sere I dominated by *Trachydium roylei* that also composed of *Rumex nepalensis*, *Poa pratensis*, *Plantago major* and *Danthonia cachemyriana* and sere II with *Potentilla nepalensis, Geum elatum* and *Cirsium wallichii*. Similarly, Risch *et al.* (2004) have found an early successional stage dominated by *Pinus montana* to late successional stage dominated by *Pinus cembra* and *Larix decidua* in an abandoned forest land of Swiss National Park located at subalpine zone.

No study on oldfield succession in Nepal has been undertaken. Thus this study has been aiming to assess patterns of secondary succession at different abandoned fields in the Himalayas. I expect either there might be a generally accepted certain assembly rule among vascular plant communities or just a mixture between an accepted science of secondary succession and observed real pattern at the surrounding landscape. My aim is to describe the main compositional pattern shown by chief colonizing species at different aged abandoned fields with their presence or absence data.

Materials and Methods

STUDY AREA

This study was conducted in Manang district, north-central Nepal (Figure 1). Marsyangdi River passes through this district from west to east. People are living and practicing agriculture along the Marsyangdi River since long. Manang is surrounded by Annapurna massif towards south and Tibetan Plateau in the north. The monsoon rain enters in this valley through south-east and reaches to the west. This valley is dry with 400 mm mean annual rainfall (Anonymous 1999).

Abies spectabilis and *Betula utilis* forests are found towards the north and *Pinus wallichiana* forest is found to both north and south facing slopes of Manang valley. Bushes of *Juniperus indica*, *Rosa* sp., *Berberis* sp. and *Caragana* sp. are found in the southern drier aspects.

A total of 43 abandoned fields were selected for this study. Each abandoned field was distinguished from other by their similar period of abandonment that shared a common border. I confirmed tentative period of abandonment of each field through interviews with villagers, head of the local monastery, school teachers and elderly people. Relative period

Table 1. Selected plant species with their family, short form used in response analysis and their frequency from abandoned fields of Manang, Nepal.

Name	Family	Short form	Frequency
Cynoglossum zeylanicum (Vahl ex Hornem.) Thunb. ex Lehm.	Boraginaceae	Cyno zey	180
Pennisetum flaccidum Griseb.	Poaceae	Penn fla	115
Phleum alpinum L.	Poaceae	Phle alp	66
Thymus linearis Benth.	Lamiaceae	Thym lin	66
Medicago falcata L.	Fabaceae	Medi fal	56
Malva neglecta Wallr.	Malvaceae	Malv neg	53
Fagopyrum esculentum Moench.	Polygonaceae	Fago esc	31
Tanacetum gossypinum Hook. f.	Tana gos	Asteraceae	31
Malaxis muscifera (Lindl.) Kuntze	Orchidaceae	Mala mus	27
Pinus wallichiana A. B. Jackson	Pinaceae	Pinu wal	18
Poa annua L.	Poaceae	Poa ann	2

of abandonment was reconfirmed after visiting each field with local people, direct observation of fallen stone walls and trees around such fields. These fields were found abandoned just recently (one year ago) to about 55 years ago.

This study represented abandoned fields of two villages, Pisang and Bhraka of upper Manang; separated by a distance of ca. 12 km. Abandoned fields were also available in other villages but the period of abandonment of those fields was unknown. Thus I confined this study in Pisang and Bhraka villages.

The elevation of the studied fields ranges between 3000 to 3500 m asl. Pisang lies at lower elevation (3000 m asl) than Bhraka (3500 m asl) (Figure 1). The selected fields ranged between 200 m^2 to 1.2 km^2 in size. These fields were irregular to rectangular in shape and were dispersed randomly. If abandoned fields lied closer to village they were considered as near. Both active and abandoned fields were opened for grazing after harvesting crop. Grazing was completely banned after cropping. Wheat, barley, potato and buckwheat were main crops planted in this area.

Each field was sampled systematically. A regular and systematic sampling approach was applied throughout this study. A plot of size 1×1 m^2 was chosen and laid down diagonally at the longest distance of each abandoned field at a regular space of 10 m. The plot was made always 10 m away from the closest edge of each abandoned field. Presence and absence of each species inside each plot was recorded after dividing each plot into 4 equal subplots. A total of 256 plots were sampled in 43 abandoned fields ranging in period of abandonment from 1 to 55 years.

All plants occurring inside each plot was identified by using field guides written by Polunin and Stainton (2001) and Stainton (2001). Unidentified species were collected and voucher specimens were prepared for later confirmation and identification. The nomenclature system of Press *et al.* (2000) was followed.

NUMERICAL ANALYSES

As sampling followed the chronosequence, abundance of species must resemble the successional pattern. Thus I applied Detrended Correspondence Analysis (DCA) to explore the general and compositional pattern change along the main underlying gradient. DCA orders each sample plot and their species based upon their weightage average that scaled under the beta-diversity or Standard Deviation (SD) units. All default options of DCA except downweighting of rare species were applied. After DCA, performances of 10 most abundant and one least common species were selected for the response analysis along the successional gradient. For this analysis CANOCO version 4.5 (ter Braak 2002) and its graphical program CANODRAW (Šmilauer 2002) were used.

Results

A total of 144 plant species belonging to 44 families were found in this study. Asteraceae and Poaceae were the two most dominant families with 18 species each. *Cynoglossum zeylanicum* was the most frequent species that occurred 180 times in this study. *Poa annua* was the least common species

Table 2. DCA analysis summery

Variables	Axis I	Axis II	Axis III	Axis IV
Eigenvalues	0.55	0.22	0.15	0.13
Lengths of gradient	4.8	2.6	3	2.9
Cumulative % variance of species data	13.7	19.1	22.9	26.1

occurred two times (Table 1). One ground orchid *Malaxis muscifera* occurred 27 times inside the oldest abandoned fields.

DESCRIPTIVE ANALYSIS

The length of gradient obtained after axis I of DCA was 4.8 SD. It is equivalent to a unit change in beta diversity. This DCA successfully ordered plots and species along the first axis. That means there is an almost or nearly a complete turnover. Most species showed longer length of gradient thus they showed unimodal relation with the main gradient. Almost 14 % variation in the species composition was explained by the DCA axis I. The DCA axis II explained 5% variation in the species composition. This confirmed that the DCA axis I was the strongest gradient for this study which is the successional gradient. The eigenvalue of the first axis was 0.55, which reflects the better strength of DCA in this study (Table 2).

SPECIES RESPONSE THROUGH SUCCESSION

Most species showed a distinctive successional pattern among abandoned fields. It seems that there are three stages of succession: short living annuals, long living perennials and shrubs or trees. Successional responses of 11 plant species selected for this study (Table 1) can be grouped into three successional stages. *Malva neglecta, Phleum alpinum* and *Fagopyrum esculentum* exhibited as the primary colonizing short growing annual stage (Figure 2). Their abundances were found decreasing with increasing age of the abandoned fields. Long growing perennials comprising *Cynoglossum zeylanicum, Malaxis muscifera*, *Medicago falcata* and *Pennisetum flaccidum* represented as the mid successional species. Their abundance peaked at the mid stage of abandoned fields. The last stage of succession was represented by *Thymus linearis, Tanacetum gossypinum*, *Pinus wallichiana* and *Poa annua* showing their increasing abundance towards oldest abandoned fields (Figure 2).

Discussion

Abundance pattern of plant species with different age of abandonment in the subalpine *trans*-Himalayan zone of Upper Manang, Nepal signified a clear successional pattern. Species appeared at different chronosequences showed their distinctive abundance value with their community progression. Early, middle and late are three probable successional stages each represented by their distinct life-form and species composition patterns which is similar in literatures.

Species such as *Malva neglecta, Phleum alpinum* and *Fagopyrum esculentum* seemed early successional ruderals, opportunistic, short lived, survived as long as there is an available nutrients from previous years. Importance of left over nutrients was highlighted by Toky and Ramakrishnan (1983). Occurrence and ecological importance of annual herbs and grasses at early stages of secondary succession were commonly discussed by other researchers (Pickett 1982; Bartha *et al*. 2003; Bonet and Pausas 2004; Ruprecht 2005; Otto *et al*. 2006; Baniya *et al*. 2009). These studies may justify the present findings. These species represents common agricultural weeds and crop seedlings from active fields. Their greater abundance at recently abandoned fields may indicate their easy dispersal from nearby open active fields or germination of seeds from the upper most horizon of previous year seed-bank. As time passes, abundance of early succession species decreased but abundance of mid and late succession species increased and competition among them has also increased (Grime 1977). Both above and below ground competition might have increased during the course of succession. Hence nutrition might be depleted at first as well as availability of light decreased and resources might be partitioned among newly established species. At such successional phases less adapted species seemed easily substituted by better adapted species. Environmental space created by early succession species may not fit for them but facilitates to colonize by newly established species and will be successful at later successional stage. This can be equivalent to inhibition model of succession at first and facilitation model in the middle as purposed by Connell and Slatyer (1977).

High abundance of nitrogen fixing species such as *Medicago falcata* at the mid successional stage may facilitate nitrogen loving species to establish at late successional stage. *Pennisetum flaccidum* is one of the most preferable grasses by cattle. All above ground parts of this grass are heavily grazed. Regeneration of this species may facilitate after

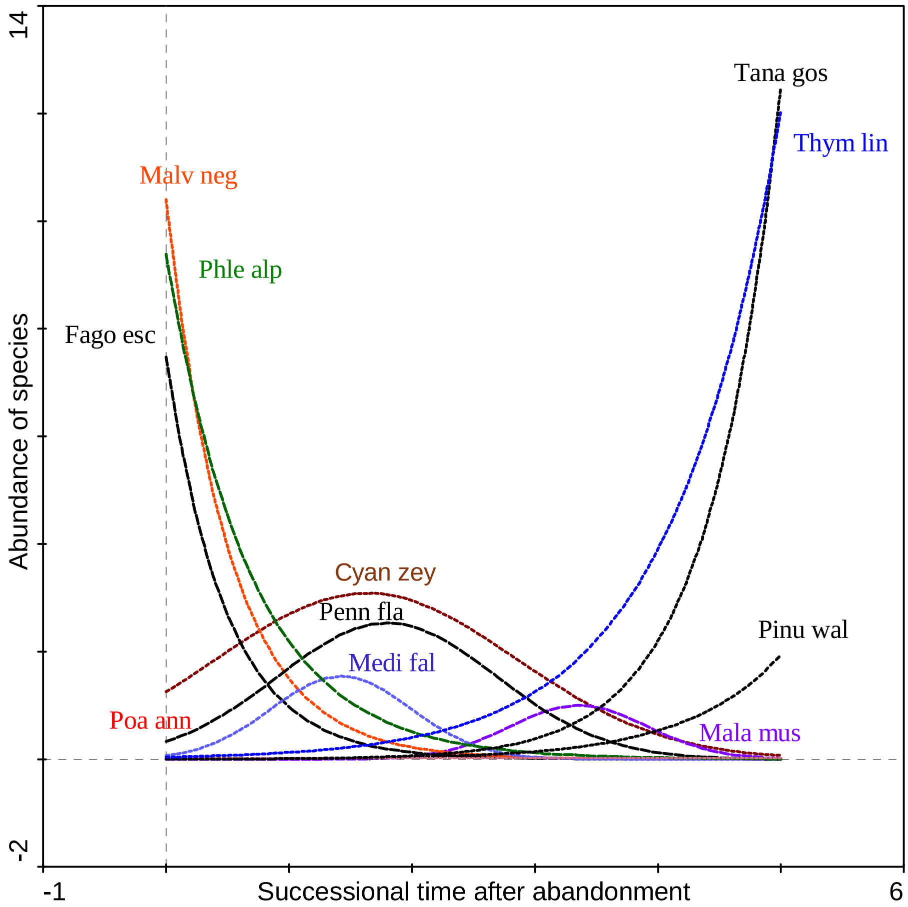

Figure 2. Species responses with age of abandoned field analysed through DCA. Full form of species is given in Table 1.

grazing. Abundance of this species was high at the mid succession stage. Similarly, *Malaxis muscifera* is a ground orchid with the highest abundance at mid succession stage. Grasses and orchids are better representatives of mid succession species as reported earlier (Bartha *et al*. 2003; Ruprecht 2005; Schiffers *et al*. 2010).

Higher abundance of *Thymus linearis, Tanacetum gossypinum*, *Pinus wallichiana* and *Poa annua* towards oldest abandoned fields signified late colonizers. These species may be better competitors and stress tolerant. Their increased occurrence towards the oldest abandoned field justifies the deterministic model of succession (Connell and Slatyer 1977; Grime 1977).

Pinus wallichiana has high chances to be colonized as its' forest lies near the abandoned fields. But their abundance was high only at old abandoned fields. This may be due to negative impact of grazing. Seedlings might have been grazed from the recent abandoned fields. But some healthy *Pinus wallichiana* saplings appeared nucleated inside thorny bushes of *Berberis* and *Caragana*. These may turn to trees in the future. Appearance *of Pinus wallichiana* at early stages of succession has also been mentioned from the glacier foreland succession of Manang (Mong and Vetaas 2006) but true establishment was not that early. This finding is further supported by the report of early occurrence of tree species during secondary succession elsewhere (Bonet and Pausas 2004; Ruprecht 2005).

There are also evidences of changing pasture land quality after grazing and increasing abundance of unpalatable species at high alpine pastures due to land use change as well as due to present rise in temperature (IPCC 2007; Klein *et al*. 2007). Likewise, an opinion of no grazing impact in the secondary forest land succession has been purposed (Risch *et al*. 2004). Rising temperature may facilitate succession, but I have no evidence to support this. Thus it is harder to project temperature, grazing and succession scenarios here.

In conclusion, subalpine abandoned fields in upper Manang have been responding a deterministic secondary succession as predicted. This succession is leading towards the *Pinus wallichiana* forest in future. Succession processes have highly been influenced by grazing. Plant species have a characteristic role in this subalpine *trans*-Himalayan secondary succession. An individual characteristic of species is playing a key role in progressing succession ahead.

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