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Cattle grazing facilitates tree regeneration in a conifer forest with palatable bamboo understory

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Abstract

In a temperate mixed conifer forest in the Bhutan Himalayas, we investigated the effects of cattle grazing on conifer (*Tsuga dumosa*, *Pinus wallichiana*, *Picea spinulosa*, *Abies densa*) seedling density, growth and microsite of recruitment under dense cover of the bamboo *Yushania microphylla*, using exclosures over a period of 9 years after group selection harvest. Increasing bamboo competition over time following canopy opening successfully prevented seedling recruitment in ungrazed plots, while recruitment in grazed plots was continuous. Reduction of bamboo height through grazing facilitated recruitment of all tree species, particularly *T. dumosa*, mainly through increased light interception on the forest floor. Tree species composition of seedlings and the overstory did not differ in ungrazed plots, while in grazed plots we observed a shift towards dominance of *T. dumosa*. Growth rates of *T. dumosa* and *P. spinulosa* were higher in grazed plots as compared to ungrazed plots. In grazed plots, recruitment of *T. dumosa* was concentrated on moss, which might have prevented desiccation of the small-seeded species after germination. We propose that controlled grazing might facilitate natural regeneration after logging in mixed conifer forests of central Bhutan with dense *Y. microphylla* bamboo understory.

Keywords: Cattle grazing; Bamboo; Forest regeneration; Facilitation; Arrested succession; Bhutan Himalayas

1. Introduction

Large herbivores exert considerable influence on dynamics of ground vegetation (Milchunas and Lauenroth, 1993) and tree regeneration (Ross et al., 1970; Linhart and Whelan, 1980). Large herbivores can affect establishment and survival of tree seedlings either directly through browsing (Gill, 1992), trampling (Mitchell and Kirby, 1990), zoochorous seed dispersal and dispersal of mycorrhiza, or indirectly through soil compaction (Mitchell and Kirby, 1990), nutrient removal or input (Gill and Beardall, 2001), increased susceptibility to drought (Peterson and Pickett, 1995), change of competing understory vegetation (Kirby, 2001; Rossell et al., 2005), and possible resulting increases in rodent densities (Evans et al., 2006). With all other factors having mainly negative effects on tree seedling recruitment, changes in competing vegetation can be both, negative through increased dominance of non-palatable competitors (de la Cretaz and Kelty, 1999; Royo and Carson, 2006), or positive through reduction of palatable competitors (Miles and Kinnaird, 1979). This indirect positive effect can outweigh direct negative effects on establishment and survival of tree seedlings and saplings (Gill and Beardall, 2001; Itô and Hino, 2005). The effects of large herbivores on tree regeneration can differ with understory type (Peterson and Pickett, 1995; Nomiya et al., 2002; Kramer et al., 2006), herbivore density (Horsley et al., 2003; Mayer et al., 2006) and site conditions (Horsley et al., 2003). While no clear-cut recommendations exist for most forest types, moderate grazing has been proposed to facilitate tree regeneration under certain palatable understory vegetation types inhibiting tree regeneration (Kuiters et al., 1996; Miller and Wells, 2003; Mountford and Peterken, 2003; Pollock et al., 2005).

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Dense understorys of bamboo species often create strong competition for light (Nakashizuka, 1988; Taylor and Qin, 1988; Cao, 1995), water (Takahashi et al., 2003), and nutrients (Numata, 1979), provide shelter for rodents resulting in increased seed predation and seedling damage (Wada, 1993; Abe et al., 2001; Iida, 2004) and thereby temporarily suppress tree regeneration in several locations world wide, e.g. Bhutan (Gratzer et al., 1999), China (Taylor and Qin, 1988; Wang et al., 2006), Japan (Nakashizuka and Numata, 1982; Nakashizuka, 1991), Chile (Veblen, 1982), Thailand (Marod et al., 1999), Costa Rica (Widmer, 1998), and Brazil (Guilherme et al., 2004). As a result of vegetative spread, fast growth response to increasing light, considerable tolerance against browsing, and depleting soil water resources, several bamboo species appear to form persistent understory layers, leading to delayed succession (Nakashizuka and Numata, 1982; Griscom and Ashton, 2003; Taylor et al., 2006; Royo and Carson, 2006). These understory layers act as a selective ecological filter, differentially affecting the regeneration of certain tree species (George and Bazzaz, 1999a; Wang et al., 2006). In the temperate zone of Bhutan, *Yushania microphylla* (Munro) R.B. Majumdar is a dominant and widespread, frequently browsed bamboo species, which is often associated with regeneration failure in harvested areas (Rosset, 1999).

Virtually the entire forest area of Bhutan is grazed by domestic livestock, mostly through migratory herds of cattle and yaks (Gyamtsho, 2000; Norbu, 2002). The lack of forest regeneration in harvested areas in the country has mostly been attributed to the detrimental effects of cattle grazing, irrespective of understory type and grazing pressure (Miller, 1986; van Ijssel, 1990; Wangda and Ohsawa, 2006). Steps towards discouraging traditional grazing practices have met strong resistance from farmers, who heavily rely on livestock productivity (Ura, 2002). Roder et al. (2003) documented that without additional input of chemical fertilizers in agriculture, forest grazing is essential to maintain production levels through direct nutrient transfer from the forests to agricultural land, most notably of P. The reduction of bamboo height through moderate grazing was found to promote forest regeneration through increased light availability on the forest floor (Gratzer et al., 1999; Itô and Hino, 2005). Therefore, moderate forest grazing by domestic herbivores might be beneficial in Bhutan, wherever justified from the silvicultural point of view (Gratzer et al., 1999).

We conducted an experimental study comparing grazed and ungrazed plots over a period of 9 years to clarify the effects of cattle grazing on conifer regeneration under dense *Y. microphylla* bamboo understory in small size group openings in a temperate mixed conifer forest in central Bhutan. We had the specific objectives to (1) assess the impact of grazing on bamboo height and cover, (2) evaluate the tree species-specific effects of bamboo height reduction through grazing on tree seedling density, size distribution and growth, and (3) assess differences in site conditions affecting tree seedling establishment between grazed and ungrazed plots.

2. Methods

2.1. Study area

The study was conducted at two sites in East-Central Bhutan in the Chumey valley of Bumthang district on rather gentle, east facing slopes at altitudes of 3225 m (Hurchi) and 3060 m (Domkhar) (Fig. 1). The area is dominated by meta-sediments and gneisses of the main crystalline belt of the high Himalaya (Gansser, 1983). Based on records of a nearby weather station (Hurchi, 3400 m), annual precipitation is 1300–1500 mm, the vast majority of which falls during monsoon from May to early October. The mean annual temperature is +4.6 °C, with the mean maximum temperature of +14.6 °C in July and the mean minimum temperature of −8.3 °C in January (Dorji, 2001; Bürgi, 2002). The vegetation period (definition see Rinchen and Rosset (1996)) is approx. 200 days with early frost starting from the second week of October and late frost ending by May (Tenzin and Rinzin, 2003). The forest in the research area is dominated by *Tsuga dumosa* (D. Don) Eichler (Himalayan Hemlock) and *Pinus wallichiana* A.B. Jackson (Blue Pine), with the almost continuous presence of *Picea spinulosa* (Griff.) Henry (East Himalayan Spruce). *Abies densa* Griff. (East Himalayan Fir) occurs scattered in the research area, which is part of the transitional belt towards mono-specific fir forests occurring at higher altitudes. Stands, especially the ones dominated by pine are fairly young, without considerable amount of coarse woody debris. The understory is almost exclusively dominated by the bamboo *Y. microphylla* (Munro) R.B. Majumdar, sometimes mixed with *Arundinaria racemosa* Munro, another bamboo species. The biomass and height of both bamboo species are considerably reduced by cattle grazing. Shrubs, mostly *Berberis aristata* D.C., frequently occur in the area (Grierson and Long, 1983).

Both, sedentary and migratory livestock graze in the study area. Migratory cattle, representing 50–70% of the livestock population in Chumey, are present for about 5 months every year during the summer. They migrate to lower lying areas in the south for winter and are replaced by a lower number of migratory yaks coming from pastures above the timberline. A livestock survey showed that Hurchi and Domkhar are grazed by comparable numbers of domestic ungulates (168 versus 194), with the numbers of sedentary livestock being virtually equal between the two locations (25 versus 23) (Dorji, 1997). Besides domestic ungulates, sambar (*Cervus unicolor*), wild boar (*Sus scropha*), and barking deer (*Muntiacus muntjak*) are common in the study area. Based on visual investigation of droppings, domestic livestock is present at higher densities than wild herbivores, on whose density no objective assessment has been carried out.

2.2. Experimental design and data recording

In both locations, Hurchi and Domkhar, five pairs of plots were established in late 1996 in small group openings along cable line corridors created a few months earlier. Each pair of adjacent plots, representing a block, consisted of a randomly