Influence of under-growing bamboos to the aboveground biomass in a tropical seasonal forest, Thailand

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Abstract

To make clear the contribution of under-growing bamboos to the carbon sequestration of the tropical seasonal forest ecosystem, we conducted long-term monitoring study on the tree and bamboo community dynamics in a mixed deciduous forest (MDF), Thailand. Gregarious flowering and simultaneous death of the three coexisting bamboos resulted in the significant changes in the community structure of trees, but not resulted in the prompt change in the aboveground biomass of trees. Aboveground biomass of under-growing bamboos in a mixed deciduous forest greatly fluctuated in the range of 23.7-37.1 Mg/ha according to the gregarious flowering and simultaneous death of the constituent species. Considering the low aboveground biomass of this type of forest (ca. 120 Mg/ ha), relative contribution of bamboos to the carbon sequestration of the forest ecosystem was found to be substantial and not negligible.

Key Word: Mixed deciduous forest (MDF), Bamboo, Simultaneous death, Aboveground biomass

Introduction

Seasonally dry tropical forests, which occurs in the area with several months of severe drought, covers fairly large parts of tropical and subtropical ecosystems, even larger than wet-rain forests (Murphy & Lugo, 1986, Mooney et al., 1995). Mixed deciduous forest, which is mainly composed of deciduous tree species, is a type of tropical dry forests in Thailand (Royal Forest Department 1962, Ashton 1995). This forest covers large parts of Thailand and has many variations in composition and structure (Bunyavejchewin 1983, 1985; Rundel & Boonpragob 1995). Teak (*Tectona grandis*) is usually the most important species in the mixed deciduous forest, but there are another forest type lacking teak (Smitinand 1966, Aston 1995). Bamboos characterize this forest as the dominant species in the middle layer (Whitmore 1984, Aston 1995). *Gigantochloa albociliata*, *Bambusa tulda*, and *B. nutans* are the most common among them (Kutintara, 1994). The interaction with the bamboos should be the critical factor affecting the regeneration and dynamics of the forest.

The impeding effect of undergrowing bamboos to tree regeneration is reported from several types of forests (Veblen et al. 1980; Nakashizuka 1988; Taylor & Zisheng 1992). They grow rapidly, intercept the light by the dense leaf canopy and shed deep shade on the forest floor. In Thailand, they usually form large clump and occupy on the forest floor with high density, especially, in the natural mixed deciduous forest (Smitinand & Chumsri 1985). They have long life span up to several decades (Janzen 1976), but their simultaneous death after gregarious flowering can provide a large vacant space for tree regeneration (Veblen et al. 1980; Nakashizuka 1988; Taylor & Zisheng 1992).

In spite of the ecological importance of bamboo in the mixed deciduous forests, its contribution to the carbon and biomass dynamics of the forest has not been examined yet. In this paper, we investigated the long-term interactive dynamics of trees and bamboos in a mixed deciduous forest in Thailand. Multiple flowering events of the bamboos occurred in the forest gave us the opportunities to study the effects of bamboo die-back for the carbon sequestration of the forest. The specific purpose of the paper was to make clear the relative contribution of undergrowing bamboos to the carbon dynamics of the forest ecosystem.

Study site and Methods

The study was conducted in a mixed deciduous forest (MDF, Marod et al. 1999) in Mae Klong Watershed Research Station, Thong PhaPhoom District (14’30” to 14’45” N, 98’45” to 99’ E), Kanchanaburi Province, western Thailand. Dominant tree species were *Shoreasiamensis, Dilleniaparviflora, Xyliaxylocarpa var. kerrii, Pterocarpusmacrocarpus,Vitexpeduncularis,Canariumsusbulatum,*and*Schleicheraoleosa*(Marodet al.1999).Fourbamboospecies (*Gigantochloaalbociliata, G. hasskarliana, Bambusatulda, and Cephalostachyumpergracile*) were dominant on the understory. There were no evident records of the past logging within the forest. However, the activities of local people such as selective felling of particular species or fire setting may have affected the forests surrounding the plots.

A 4 ha permanent plot was established in 1992 including a variety of topography (ridge, slope and valley) to monitor forest dynamics. All trees > 5 cm in dbh were identified, and their dbh was measured. Every two years until 2012, repeated tree enumeration was conducted. Survival and death of the tagged trees were checked and their dbh was measured. All the newly recruited trees (> 5 cm in dbh) were identified and their dbh was measured. At each tree census, a map of mature bamboo distribution was also checked at each 10 m x 10 m quadrat.Aboveground biomass of trees was calculated according to the allometric relationship in the literature (Ogawa et al. 1961, Ogawa et al. 1965).

Nine 20 x 20 m sub-quadrats were selected for the intensive study of bamboo clump and culm dynamics (Fig. 1). All the culms > 1 m high of the clumps were tagged, and the diameter at 1 m high was measured with caliper at the end of the growing season (late October or November) once a year from 1993 to 2006. At the first census, current year culms and older culms were specified. From the second census, newly emerged current year culms were tagged and their diameter at 1 m high were measured, while mature live culms and dead culms were checked and recorded.Allometric relationships were estimated based on the sampled individuals for each bamboo species in 1994.

Results and Discussion

The structure of this mixed deciduous forest was characterized by low stem density and BA (Table 1). This would be basically formed under the strong influence of the dominance of undergrowth bamboos. Long-term dynamics of this forest including the die-back events of dominant bamboos clearly showed the importance of the unique life history of bamboo for the regeneration of the component trees in mixed deciduous forests. Temporally concentrated recruitment patterns were observed according to the simultaneous death of bamboos (Table 1). Since the canopy gaps occupied very large area (53.7 %), the effects of canopy gaps to the recruitment were scarcely detected (Marod et al. 1999) in contrast to the other reports in closed forests with higher tree density (Nakashizuka et al. 1992) .

Aboveground biomass of trees of the plot showed a slight icrease during the study period, and wasin a range between 110-130 Mg/ha (Table 1). The value of aboveground biomass of trees in this plot is fairly low in comparison with the values of the other forests in tropical area reflecting the stand structure (Stegen et al 2009, Silk et al. 2013). Few studies on the aboveground biomass of mixed deciduous forests (Terakunpisut et al. 2007, Top et al. 2004) presented lower and higher values (96.3 and 224 Mg/ha, respectively). Tree regeneration after the three times of simultaneous death of bamboos may have contributed to this increase, but the influence was not apparent. Considering the long interval of flowering and death of bamboos, longer-term monitoring is necessary for the detection of the temporal pattern of tree aboveground biomass change.

Table 1. Change in forest structural parameters and aboveground biomass (ABG).

	1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012
BA (m^2/ha)	17.1	16.9	17.1	17.6	17.5	18.0	18.2	18.5	18.6	18.8	18.7
gain (m^2/ha)		0.5	0.8	0.7	0.9	0.9	0.6	0.8	0.8	0.7	0.6
loss (m^2/ha)		0.6	0.5	0.2	0.8	0.4	0.4	0.4	0.7	0.5	0.6
Stem No (/ha)	173	203	201	195	193	193	202	211	209	208	208
Recruit (No/ha)		37	15	12	17	22	29	24	14	12	11
Dead (No/ha)		8	18	18	19	22	19	15	17	13	12
No of SP(/4ha)	119	124	122	124	116	118	124	127	127	128	128
ABG (Mg/ha)	115.5	113.0	114.7	118.0	117.6	121.5	122.8	125.0	125.6	126.9	126.2

Aboveground biomass of under-growing bamboos in a mixed deciduous forest greatly fluctuated in the range of 23.7-37.1 Mg/ha according to the gregarious flowering and simultaneous death of the constituent species.Maximum aboveground biomass of a bamboo *Phyllostachys bambusoides* stand was estimated to be ca. 150 Mg/ha (Isagi et al. 1993). The aboveground biomass of bamboos in this forest were far less than that of the pure bamboo stands. However, relative contribution of bamboos to the carbon sequestration of the forest ecosystem was found to be high and not negligible,considering the low aboveground biomass of this type of forest.

References

ASHTON, P. S. 1995. Towards a regional forest classification for the humid tropics of Asia. In: E.O. Box et al. (eds.), "Vegetation Science in Forestry," pp. 453-464. Kluwer Academic Publishers, Netherlands.

BUNYAVEJCHEWIN, S. 1983. Analysis of tropical dry deciduous forest of Thailand. I. Characteristics of dominance types. Nat. Hist. Bull. of Siam Soc., 31:109-122.

BUNYAVEJCHEWIN, S. 1985. Analysis of tropical dry deciduous forest of Thailand. II. Vegetation in relation to topographic and soil gradients. Nat. Hist. Bull. of Siam Soc., 31: 109-122.

ISAGI, Y., KAWAHARA, T. AND KAMO, K. 1993, Biomass And Net Production in a Bamboo *PhyllostachysBambusoides* Stand. Ecol. Res. 8: 123-133.

JANZEN, D. H. 1976. Why bamboos wait so long to flower. Ann. Rev. Ecol. Syst. 7: 347-91.

KUTINTARA, U. 1994. Forest Ecosystem. Dept. of Forest Biology, Fac. of Forestry, K.U., Bangkok, Thailand. 442p.

MAROD, D., KUTINTARA, U., YARWUDHI, C., TANAKA, H. & NAKASHISUKA, T. 1999.Structural dynamics of the natural mixed deciduous forest, Kanchanaburi, western Thailand. J. Veg. Sci. 10:777-786.

MOONEY, H.A., BULLOCK, S.H. & MEDINA, E. 1995. An Introduction. In: S.H. Bullock, H. Mooney & E. Medina eds. "Seasonal Dry Tropical Forests," pp. 1-8. Cambridge University Press, New York.

MURPHY, P.G. & LUGO, A. E. 1986.Ecology of tropical dry forest. Ann. Rev. Ecol. Syst. 17: 67-88.

NAKASHIZUKA, T. 1988. Regeneration of Beech (Faguscrenata) after the simultaneous death of undergrowing bamboos (Sasakurilensis). Ecol. Res. 3: 21-35.

NAKASHIZUKA, T., IIDA, S., TANAKA, H., SHIBATA, M., ABE, S., MASAKI, T. AND NIIYAMA, K. 1992. Community dynamics of Ogawa Forest Reserve, a species rich deciduous forest, central Japan.Vegetatio 103: 105-112.

ROYAL FOREST DEPARTMENT. 1962. Types of Forests of Thailand. Royal Forest Department, Bullettin. No. R. 44., 12p., Bangkok.

RUNDEL, P. W. & BOONPRAGOB, K. 1995. Dry forest ecosystems of Thailand. In: S.H. Bullock, H. Mooney & E. Medina eds. "Seasonal Dry Tropical Forests," pp. 93-123. Cambridge University Press, New York.

SLIK, J. W. F. ET AL. 2013. Large trees drive forest aboveground biomass variation in moist lowland forests across the tropics. Golobal Ecology and Biogeography.

SMITINAND, T. 1966. The vegetation of Doi Chiangdao: A limestone massive in Chaingmai, North Thailand. Nat. Hist. Bull. 21: 93-128.

SMITINAND, T. AND CHUMSRI, C. 1985. Classification of Thai bamboos. In: Bamboo seminar. 6-7 June. 1985, Fac. of Forestry, Kasetsart Univ., BangKok, Thailand.

STEGEN, J. C., SWENSON, N. G., VALENCIA, R., ENQUIST, B. J. and THOMPSON, J. 2009. Above-ground forest biomass is not consistently related to wood density in tropical forests. Global Ecology and Biogeography 18, 617-625.

TAYLOR, A. H. & ZISHENG, Q. 1992. Tree regeneration after bamboos die-back in Chinese Abies-Betula forest. J. Veg. Sci., 3: 253-260.

TERAKUNPISUT, J., GAJASENI, N. and RUANKAWE, N. 2007. Carbon sequestration potential in aboveground biomass of Thong PhaPhum National Forest, Thailand.Applied Ecology and Environmental Research 5, 93-102.

TOP, N., MIZOUE, N. and KAI, S. 2004. Estimating forest biomass increment based on permanent sample plots in relation to wood fuel consumption: a case study in Kampong Thom Province, Cambodia. Journal of Forest Research 9, 117-123.

VEBLEN, T. T., SCHLEGEL, F. M. & ESCOBAR, R. B. 1980. Structure and dynamics of old-growth Nothofagus forests in the Valdivian Andes, Chile. J. Ecol., 68: 1-31.

WHITMORE, T. C. 1984. Tropical rain forests of the Far East, second edition, Oxford University Press, Oxford. p. 325.