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Research Letters

Burning management mediates the coexistence of plant species in a semi-natural grassland



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ABSTRACT

Miscanthus sinensis-dominated semi-natural grassland is one component of a typical Satoyama landscape. *M. sinensis* most notably forms ring patches as a result of human management, which includes the removal of aboveground stems by burning. In this study, I hypothesized that *M. sinensis* aids the coexistence of several plant species under managed conditions because of its notable ring patches. To test this hypothesis I monitored the richness of plant species inside and outside *M. sinensis* ring patches for 5 years, which included one non-managed year, and compared richness between managed and non-managed years. Results showed that species richness was higher inside than outside patches in all cases, but that this effect was more prominent in managed years than in the non-managed year. Consequently, human management is promoting the coexistence of plant species in *M. sinensis*-dominated semi-natural grassland. Human management will likely play an important role in conserving plant species diversity in semi-natural grasslands by changing relationships among plants.

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Introduction

Plants that co-occur can interact both positively and negatively (Callaway, 1994; Brooker et al., 2008; Kikvidze et al., 2009). Positive interactions can increase species survival and diversity when the presence of one species modifies the environment so as to reduce the frequency of some disturbance or stress, allowing less stress-tolerant species to survive (Hacker and Gaines, 1997; Cavieres and Badano, 2009). However, these plant-to-plant interactions can alternate between positive and

negative effects, when plants change their growth forms or patterns (Armas and Pugnaire, 2005; Ervin, 2005; Miriti, 2006; Osawa, 2011; Estape et al., 2013). For example, Ervin (2005) showed that only collapsed culms on *Juncus effusus* L. contributed to neighboring plants in wetland. Armas and Pugnaire (2005) showed that such plant interactions could alter with life stage or environmental variability.

Human management activities such as controlled burning and mowing may alter the growth forms or patterns of some plants. Semi-natural grasslands, which are maintained by continuous human management, are decreasing

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in several regions (White et al., 2000; Kitazawa and Ohsawa, 2002; Kawano et al., 2009; Koyanagi et al., 2009; Koyanagi and Furukawa, 2013). In Japan, semi-natural grasslands dominated by *Miscanthus sinensis* are a component of the typical Satoyama landscape, which has long been developed and maintained by continuous human management (Yasuda and Programme, 2001). *M. sinensis* is a clonal perennial plant that forms ring patches, a common behavior among clones of tussock grasses (Kobayashi and Yokoi, 2003). Notably, ring patches form under human management activities such as burning and mowing (Osawa, 2011; Fig. 1A).

One study found that plant species richness was higher inside than outside *M. sinensis* ring patches in semi-natural grassland dominated by *M. sinensis* (Osawa, 2011). The present study suggests that human management alters interactions between *M. sinensis* and other plant species, which can range from negative or neutral to positive through the changing forms of *M. sinensis* ring patches because ring patches are notable under management (Fig. 1A and B). In other words, *M. sinensis* ring patches might facilitate the establishment of coexisting plants under management. Thus, I hypothesized that human management enhances the coexistence of *M. sinensis* and other species in *M. sinensis*-dominated semi-natural grasslands. Should this hypothesis be supported, it would provide new evidence in support of traditional grassland management that not only maintains the semi-natural grassland itself but also biodiversity conservation.

In this study, I examined the hypothesis that human management, i.e., the removal of aboveground *M. sinensis* by burning in early spring, mediates plant coexistence between *M. sinensis* and other plant species. To test this, I monitored plant species richness both inside and outside of *M. sinensis* ring patches generated by 5 years of annual burning, which included one non-managed year (see *Materials and methods* section). I predicted that plant species richness would be higher in managed years than in the non-managed year, especially inside *M. sinensis* regimes because of the notable ring patches formed in this human-managed semi-natural grassland. Based on the results, I discuss the significance of burning management in semi-natural grassland from the perspective of biodiversity conservation.

Materials and methods

Study area

This study was conducted at Sengokuhara in Hakone, Kanagawa Prefecture, Japan (35°13.3' N, 139°2.5' E). The climate is warm-temperate with a mean annual precipitation of 3228 mm and a mean annual temperature of 16.1 °C (Osawa and Inohara, 2008). There are approximately 13-ha of *M. sinensis*-dominated semi-natural grassland on the slope of Mt. Daigatake.

This semi-natural grassland has been maintained by annual burning every March since 1989 (Osawa, 2007). Although this area was maintained as *M. sinensis*-dominated semi-natural grassland for the use of grasses as building material historically, the management work was stopped



Fig. 1 – Forms of *M. sinensis* growth in Sengokuhara grasslands: (A) a notable ring patch found under management and (B) a *M. sinensis* patch without management. Aboveground stems remain. (C) *M. sinensis* 2 months after the management activity.

in the 1950s because of decreasing material needs. As a result, several shrubs grew in the grassland before 1989 (Toyama, 1990). In 1989, burning management was reintroduced to restore the historical *M. sinensis*-dominated landscape (Toyama, 1990). Currently, burning is conducted by a local fire company annually.

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