Unpalatable perennial grass invasion in central-east Argentina native grasslands: Processes, implications and recovery

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Abstract. In temperate semiarid central-east Argentina, unpalatable perennial grasses (UPG) have been steadily invading native grasslands formerly dominated by palatable perennial grasses (PPG). The objective of this contribution is to provide a synthesis of underlying processes and implications of UPG invasion, as well as recovery strategies. Results have shown that heavy selective grazing on PPG reduces their superior competitive ability. Gaps formed due to reduced competition by PPG provide safe sites for UPG establishment. The development of large, long-lived tussock of UPG, in combination with high standing crop accumulation, impairs PPG establishment even in absence of grazing. UPG produce sclerophyllous tissues, high in fibre and lignin and low in protein and mineral content. Senesced tissues of UPG decompose and mineralize nutrients slower than that of PPG, although they show a relatively low potential to cause nutrient immobilization in soil bacteria. UPG are less productive than PPG, which in combination to their low nutritive value commonly reduce carrying capacity and secondary productivity to half or less of potential values. The analysis and interpretation of current available knowledge point out that conservative and flexible stocking, in combination with controlled grazing and fire, should be implemented to recover and maintain a sustainable use of native grasslands in central-east Argentina.

Keywords: Invasive species, perennial grass weeds, overgrazing, grazing management, controlled burning.

Introduction

Native grasslands in central-east Argentina (Lat. 36-40°S, Long. 62-66°W) experience temperate, semiarid climates. Mean annual air temperature is 15ºC, mean annual precipitation 400 mm (30% CV), and mean annual potential evapotranspiration 800 mm. Dominant soils are Complex Calciustolls, of sandy/silty loam texture. Phytogeographically, the region belongs to the Caldenal District of the Espinal Province (Cabrera 1976). Before the introduction of livestock at the beginning of last century, the physiognomy of the vegetation resembled a grassland with scattered or grouped trees and shrubs, the herbaceous layer was dominated by palatable perennial grasses (PPG; *e.g. Poa ligularis, Nassella longiglumis*) (Gallego *et al.* 2004), *Lama guanicoe* was the main large native herbivore, and natural fires return period was less than 10 years (Bóo 1990). Since then, the physiognomy has changed to shrubland, and the herbaceous layer has been frequently invaded by native unpalatable perennial grasslands (UPG; e.g. *Nassella tenuissima, N. gynerioides, N. trichotoma, N. brachychaeta*) (Fernández *et al.* 2009).

Land in the region is privately owned. Most landowners possess low level of professional knowledge, and lack a long-term management plan. Cow-calf commercial operation is the dominant production system. Average stocking rate varies between 5 and 15 ha per cattle equivalent, depending on the condition of grasslands. Weaning percentage (around 60%) and meat production (10 or less kg/ha/yr) are well below potential values (Morris and Ubici 1996).

The objective of this contribution is to provide a synthesis of underlying processes and implications of UPG invasion, as well as recovery strategies.

Methods

Information on the ecology of UPG was condensed into a synthesis of processes leading to UPG invasion in central-east Argentina native grasslands. Potential impacts of UPG invasion were evaluated, and management strategies to recover and maintain PPG dominance were proposed.

Results and Discussion

Underlying processes of UPG invasion

Native UPG were poorly represented in native grasslands of central-east Argentina that were in pristine condition, from evidence provided by soil phytoliths analysis (Gallego *et al.* 2004). Field and greenhouse studies have demonstrated the superior competitive ability of PPG (Moretto and Distel 1997), which suggests a competitive displacement of UPG by PPG in absence of livestock grazing. Badgery *et al.* (2005) reported similar results from a study on the competition for nitrogen between Australian native grasses and the UPG weed *N. trichotoma* at low nitrogen levels. However, selective defoliation of PPG by livestock depresses their competitive ability (Moretto and Distel 1999), and creates vegetation gaps of low competitive pressure that favour seedling establishment and growth of UPG (Moretto and Distel 1998). Under these conditions (low competitive pressure) UPG has shown a high growth

potential by individual plants, despite their relatively high investment in antiherbivore defences (*e.g.* structural carbohydrates, particularly lignin; Distel *et al.* 2007).

Implications of UPG invasion

Once established, UPG individuals can survive for decades (personal observations), as typical for many tussock-forming grasses (Lauenroth and Adler 2008). The dominance of long-lived plants causes asymmetric competition, which limits re-establishment of PPG individuals even in absence of livestock grazing. Native UPG are less productive than native PPG, both above- and belowground (Moretto 2009). On the other hand, although in general UPG produce leaf litter and roots of lower quality than PPG, and mass loss and nutrient release through decomposition are lower in UPG, results suggest a relatively low capacity of UPG to cause nutrient immobilization in soil bacteria (Moretto et al 2001; Moretto and Distel 2002, 2003; Andrioli and Distel 2008).

Differences in plant chemistry between PPG and UPG (*e.g.* Distel *et al.* 2005) result in marked livestock preference or avoidance, respectively (Bóo *et al.* 1993; Bontti *et al.* 1999; Pisani *et al.* 2000). Moreover, the avoidance of UPG enables them to accumulate senescent biomass, which decompose slowly and further reduces nutritional value to grazers. As a result, the invasion of UPG in grasslands formerly dominated by PPG causes a drastic reduction in carrying capacity and in the production livestock products per unit of land (Morris and Ubici 1996).

Recovery strategies

In grasslands invaded by UPG, recovery strategies need to consider the expansive nature of livestock operations in central-east Argentina, and consequent high rehabilitation costs. From this perspective, appropriate fire and grazing management may represent a sound alternative for grassland improvement. The UPG are more sensitive to high fire intensity than are PPG (Peláez *et al.* 2003). Hot summer wildfires have been shown to kill much more individuals of UPG than those of PPG, and to reduce or increase basal area of surviving plants, respectively (Bóo *et al.* 1996; Guevara *et al.* 1999). Thus, appropriate timing of controlled burning may represent a low-cost management alternative to rehabilitate degraded grasslands invaded by UPG. However, successful recovery of PPG needs in addition the control of grazing in terms of both stocking rate and periods of grazing and rest.

Since moderate droughts (usually less than one year duration) occur frequently and unpredictably in central-east Argentina, a sound stocking strategy may be to adjust stocking rate of breeding cattle to available forage under moderate drought conditions (Distel 2011). In normal or wet years, the excess forage could be used for fattening culled cows, growing stockers, burning, or to improve plant vigour to better cope with future defoliations and droughts. Modelling work illustrated the potential benefits of this variable strategy in terms of maintaining grassland condition, cattle body condition, cattle survival, calf weight and weaning rate (Díaz-Solís *et al.* 2009). The proposed strategy combines elements of both "conservative" and "tracking" strategies (*sensu* Campbell *et al.* 2006). It is conservative in stocking of breeding cattle, and tracking in stocking of culled and/or stocker animals. Moreover, the strategy is adaptive in the accumulation of biomass in normal or wet periods for burning and/or for recovering of PPG vigour and density to increase their productivity and prevent UPG invasion. This conservative-tracking strategy is also less economically risky than a strict tracking strategy that attempts to follow the carrying capacity of the land by selling breeding animals during drought and buying them after drought. However, caution is needed when extrapolating stocking strategies from one context to another since the best stocking regimes is likely to vary depending on specific site conditions (Campbell *et al.* 2006).

With regard to the control of grazing and rest periods, it should be based on the maintenance of plant vigour to allow expression of productive potential, reproductive capacity and competitive ability of PPG. Increased plant vigour in turn requires the maintenance of a minimum residual biomass for plant and soil protection, and provision of appropriate rest periods for plant recovery after defoliation. This can be accomplished by the implementation of an appropriate adaptive grazing management plan (Kothmann 2009). Native Australian grasses prevented the UPG weed *N. trichotoma* from increasing in biomass, basal area and density, when rotationally grazed or when grazing was removed and fertiliser was withheld (Badgery *et al.* 2008a, 2008b).

When controlled burning and rotational grazing, in combination with proper management of breeding cows, were applied on a private ranch (3,400 ha) in central-east Argentina grasslands, weaning percentage increased from 60% to 80% and meat production from 12 to 20 kg/ha/yr, at least in part due to increasing in density and cover of PPG (Bóo and Distel 2002).

In native grasslands of central-east Argentina, heavy selective grazing on PPG reduces their superior competitive ability thereby establishing the potential for UPG invasion. Once established, UPG individuals can survive for decades, causing a drastic reduction in carrying capacity and in the production livestock products per unit of land. Appropriate fire and grazing management may represent a sound alternative for restoration of PPG in grasslands invaded by UPG.

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