Urban Forestry & Urban Greening 15 (2016) 75–79

Contents lists available at ScienceDirect

Urban Forestry & Urban Greening

journal homepage: www.elsevier.com/locate/ufug

Is colourful self-sustaining forb vegetation mere fantasy?

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ARTICLE INFO

Article history:
Received 12 May 2015
Received in revised form
24 November 2015
Accepted 29 November 2015
Available online 10 December 2015

Keywords:
Design
Disturbance
Ecology
Establishment
Gaps
Management

ABSTRACT

Biodiversity in urban and suburban environments can be supported through establishment of low maintenance-requiring herbaceous vegetation types. Here, we attempt to provide a perspective on the possibilities and limitations of establishing forb-dominated vegetation to support local biodiversity and contribute to changing public aesthetics concerning green spaces. Plant ecological theories, methods and experiences are the foundation for the design and establishment of such vegetation types. We emphasise the importance of high plant density and recurrent disturbance for the maintenance of forb communities. Well-established ecological theory tells us that totally self-sustaining herbaceous vegetation is not a realistic possibility. Without intervention, herbaceous vegetation will change over time and eventually be colonized by woody species through the process of succession. However, by applying a creative and strategic approach to establishment and subsequent management involving small scale disturbances, rather than solely a uniform maintenance regime, it may be possible to maintain a colourful, aesthetically appealing and species-rich forb dominated community that will support biodiversity and increase public acceptance of alternatives to conventional lawns in urban and suburban environments.

Introduction

Forb dominated herbaceous vegetation may become important in urban planning as one way to balance the important agenda of halting the loss of biodiversity and degradation of ecosystem services (EU, 2014) with preferred nature qualities of urban dwellers (Grahn and Stigsdotter, 2010; Peschardt and Stigsdotter, 2013). It has been shown that semi-natural herbaceous vegetation may be appreciated and accepted by many lay people but the perception is influenced by factors such as gender, age and education (van den Berg and van Winsum-Westra, 2010; Petersen et al., 2011; Qiu et al., 2013; Schipperijn et al., 2013).

Compelling arguments for introducing semi-natural herbaceous vegetation types to urban green space have been the lower establishment costs by sowing seeds rather than transplanting container-grown plants, and the lower maintenance costs, since municipalities across many countries have experienced budget cuts for park management over the last decade (Hitchmough et al., 2006; Randrup and Persson, 2009).

Naturally-occurring herbaceous vegetation has been the source of inspiration for semi-natural vegetation types, since these plant communities are generally maintained with limited biotic intervention such as grazing, mowing or burning (Smith and Rushton, 1994; Hansson and Fogelfors, 2000; Socher et al., 2013). Preserving species-richness in herbaceous vegetation is a major challenge (Tilman et al., 2006).

Forb vegetation is defined as herbaceous vegetation with less than 50% graminoid cover (UNESCO, 1973). We define colourful forb vegetation as species-rich forb-dominated vegetation with visual appeal across the growing season and a long flowering period, including attractive flowering peaks. Here we attempt to provide a new perspective on the possibilities and limitations of introducing colourful forb vegetation using local occurring plants in urban and suburban environments as alternative biotopes to conventional lawns, which covers up to 80% of urban green space (Pauleit and Duhme, 2002; Ignatieva and Ahrné, 2013).

A synthesis between design and ecology

In the early 20th century a naturally-occurring plant community was considered by some ecologists to be a coevolved and highly integrated unit, which develops towards a climax community through germination, growth, flowering and seed dispersal

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http://dx.doi.org/10.1016/j.ufug.2015.11.011
1618-8667/

Fig. 1. Limestone grassland is one of the most species rich herbaceous vegetation types in Northern Europe (Poschlod and WallisDeVries, 2002; Newton et al., 2012; Redhead et al., 2014). While botanists and ecologist recognize the diversity of such a community, it may at a first glance appear as homogeneous grassland comparative to lawns to the public i.e. it is not visually diverse (Photo: Jydelejet/Møn Denmark. M.C. Bjørn).

and death of individuals (Clements, 1936). Plant communities were classified after floristic-sociological principles (Braun-Blanquet et al., 1932). In horticulture the 'Lebensbereich' planting design tool was developed to assist the designer in matching the site conditions with the ecological requirements of the species used (Hansen and Stahl, 1981; Kingsbury, 2004; Kühn, 2011). Gleason (1926) argued that specific and well-defined community types do not exist in nature, because vegetation varies continuously in response to environmental conditions. In this view species have different niches and will establish, mature and reproduce whenever environment is favourable. The weight of evidence over recent years has supported Gleason's view, so we argue that designers can use this theoretical framework to obtain persistent colourful forb vegetation along a continuum of environments (Figs. 1 and 2.). Although the factors maintaining coexistence of many plant species in a diverse community are not completely understood, we do have much applicable information about patterns of diversity (Grace, 1999; McCann, 2000; Tilman et al., 2006).

Fig. 2. Experimental species-rich forb vegetation (2 years old) at high planting density (30 plants m^{-2}) established on inverted top/sub soil on ex-arable land. The experiment is part of a long-term study at the University of Copenhagen on plant community development after high-density transplanting of local and commonly found forbs from Northwest Europe (Bjørn, 2015) (Photo: University Research Farm in Taastrup/Denmark, M.C. Bjørn).

Coexistence of plants over time

Designed forb vegetation may include several species established from seed mixes or plantings at one point in time. The method of establishment will have a major influence on the subsequent development in the short run. Once established, the mechanisms controlling the community development depend on the survival, growth and regeneration strategies of the individual plant populations and their interactions (Wells and Richmond, 1995), with diminishing effects of the original community composition and spatial distribution created by the designer as vegetation dynamics proceed.

When establishing forb vegetation through seeding or planting, all individuals will be of similar age, and it is assumed that the environmental filtering of plants during the establishment phase is likely to be similar to the mechanisms operating in arable production systems. In agricultural systems, effective weed management can be achieved without the use of chemicals by crop rotation, weed-supressing cover crops, mowing or through a combination of high-density/high-uniformity sowing (Olsen et al., 2005a, 2005b). We therefore suggest that a combination of high-density/high-uniformity sowing or transplanting of species with high germination and survivorship rates, combined with the reduction or even elimination of the soil seed bank via establishment on subsoil (Thompson et al., 1997; Hitchmough et al., 2004), can result in the successful establishment of weed-resistant forb vegetation on previously vegetated sites (Fig. 2).

Unlike crops, which are generally monocultures, we hypothesize that colourful forb vegetation in north temperate regions such as Europe could include 15–20 species per square meter, which is similar to natural species-rich herbaceous communities such as limestone grassland (Fig. 1; Burke and Grime, 1996). Population dynamics will be influenced by numerous density-dependent and density-independent factors. Each species will respond to the environment either by increasing, decreasing or staying constant in number over time, depending in part on age, size and total number of individuals (Gurevitch et al., 2006). Designed forb vegetation must include a broad and robust mixture of species to resist small and large scale changes in the environment and prevent loss of colourful forbs.

If the species are chosen by the designer for long-term stability, vegetative reproduction and limited sexual reproduction, the dynamical change may be predictable and the relative abundance of the various species may appear evenly distributed as the individuals grow to their maximum sizes. As individual plants die, however, the resulting gaps will provide opportunities for recolonization by seeds or ramets of both desirable and undesirable species.

If, on the other hand, the majority of species in the forb vegetation are selected for sexual reproduction (i.e. flowering and seed production), a soil seed bank may be generated in a short time. This may facilitate weed resistance, maintain species diversity and accelerate a community comprising plants at various life stages, giving a more dynamic plant community, but also providing more opportunities for weeds to invade.

With time, new species will enter from the surrounding landscape, determined by propagule pressure, morphological and ecological traits of the species. Whether these species contributes positively to the community is a subjective judgment. Not all species entering the community are undesirable (which is the definition of a weed).

When choosing species for colourful forb vegetation, it may be advantageous to choose species that perform equally well under low resource-requiring maintenance such as mowing. Species selection in this perspective could be based on the concept of limiting similarity (Abrams, 1983), a concept that has been much discussed in terms of community assembly (Fox, 1987; Wilson and Whittaker, 1995; Wilson, 1999) and community invasibility (Lonsdale, 1999; Davis et al., 2000, 2005). The idea here is to choose species that fit within the ecological conditions of the habitat, but are as different as possible in their niches within the habitat. According to ecological theory, differences in niche permit coexistence among species (Chesson, 2000).

Diversity in life form, phenological and regenerative niche dimensions (Grubb, 1977; Walker et al., 2014) may be important to obtain a robust, weed-resistant community. Depending on the regenerative strategy, longevity and life history of the plant, different species will have their biomass and flowering peaks at different points in time. Our current understanding of population and community dynamics and species' life cycles clearly lead to the conclusion that fully self-sustaining herbaceous vegetation is not a realistic possibility (Persson, 1984; Hansson and Fogelfors, 2000), but that some type of disturbance is necessary.

The importance of disturbance

One of the most commonly cited definitions of disturbance in ecology was formulated by White and Pickett (1985): "Any relative discrete event in time that disrupts ecosystem, community or population structure and changes resources, substrate availability or the physical environment". Here we do not address disturbances at the ecosystem level but focus on populations and individuals.

In urban and suburban environments random disturbance can be caused by events such as herbivore attack, drought or flooding, which result in minor or major physical damage to plants, producing gaps in the vegetation. In nature, fires may occur as both random and cyclic disturbances having severe impact on flora and fauna. Even though burning is a common maintenance practise for preservation and restoration of herbaceous communities (Brockway et al., 2002; Halpern et al., 2012) it is not commonly used in urban and suburban areas due to the fire hazard. Burning in late winter and early spring seems to suppress the abundance of winter colonizing grasses in 'naturalistic herbaceous vegetation' (Hitchmough et al., 2006).

Mowing and grazing are important management strategies (Smith and Rushton, 1994; Hansson and Fogelfors, 2000; Socher et al., 2013); animal trampling and disturbance of the soil surface can be essential for regeneration of some forbs (Kalamees and Zobel, 2002). In urban green space, grazing is not commonly practised. Strategic implementation of small-scale soil disturbance (e.g. by creating gaps through soil inversion or thinning) at the appropriate time of the year can facilitate the emergence of flowering annuals, a phenomena well known from traditional North European agriculture and modern organic farming, where cereal fields turn red or blue due to millions of *Papaver rhoeas* L. or *Centaurea cyanus* L.

To our knowledge, the significance of disturbance of the soil for the maintenance of forb vegetation has not been investigated, but studies on germination requirements of seeds from various species show that factors such as drought, frost, moisture, and heat are important in breaking seed dormancy (Grime et al., 1988). Since germination is dependent on the season, we hypothesize that seasonal disturbance of the soil may be important to continuously facilitate germination from the soil seed bank. It has been suggested that we "garden like a cow" (or "like an elephant") as a low-resource management approach to create a garden from a wilderness through strategic, on site selective removal of undesired plants (Gerritsen, 2008). To our knowledge these ideas for facilitating regeneration of forbs from the soil seed bank have yet to be tested in controlled experiments. Gaps resulting from deliberate removal of specific plants and of litter in spring could be used

Fig. 3. It may be possible to prolong the seasonal attractiveness of herbaceous vegetation using common and locally found species, and strategic, creative and low resource management in urban and suburban environments (Bjørn, 2015). Forb vegetation can produce a visually attractive composition of dark and light colours in autumn if removal of dead biomass is postponed to the winter months. (Photo: University Research Farm in Taastrup/Denmark, M.C. Bjørn).

to facilitate seed germination and preserve species- and therefore colour diversity. Long-term studies of herbaceous vegetation tell us that species abundance and richness are often limited by recruitment (Tilman, 1997), which suggests that introduction of seeds or transplants may be necessary for preserving a colourful and species-rich forb community over time. This could be performed on a small scale and therefore be relatively inexpensive.

Based on ecological principles and experience we conclude that disturbances, both natural and applied, are necessary for the maintenance of species richness and visual quality over time (Fig. 3). Without intervention, forb vegetation will transform through the process of ecological succession, one of the most well documented processes in plant ecology, (Pickett et al., 2013) and gradually become colonised by woody species (Breckle, 2002).

Conclusion

Plants will grow, mature, reproduce and eventually die in their individual cycles over days, months, years and seasons. Each plant population responds to the environment's abiotic and biotic conditions affecting the dominance, abundance of species in the forb vegetation. Long-term studies on the successional change of grassland show that low resource requiring maintenance schemes such as mowing and grazing will prevent herbaceous communities from being colonised by woody species, but the persistence of a forb-dominated vegetation will require the development strategic disturbances to generate gaps for the regeneration of forbs from the soil seed bank while minimizing invasion by undesirable species.

Establishment of species-rich forb vegetation in high-density and high-uniformity communities comprising a mixture of species with large variation in growth form and regenerative strategies may offer the possibility of creating low maintenance requiring persistent forb vegetation for urban sites.

Ecological knowledge suggests that the possibility of developing persistent, colourful forb vegetation is not mere fantasy. Disturbance and repeated input of seeds or plants will be necessary to maintain visual quality and species richness. Short-term trials and longer-term studies on forb dominated community assembly and creative minimal management interventions are needed to achieve this goal.

Acknowledgements

We thank Niels Jacobsen for critical reading and valuable discussions. We thank two anonymous reviewers for valuable critical comments. This research was funded by a PhD stipend from the University of Copenhagen to M. C. Bjørn.

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