MULTIFUNCTIONAL GOLF COURSES

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Background

The need for knowledge about how to plan, create and manage urban grasslands, such as golf courses, using a multifunctional approach promoting several ecosystem services, has been acknowledged, and the potential for designing golf courses to serve multiple functions has been pointed out by researchers as well as the golf associations (Colding & Folke 2009, Strandberg et al. 2012).

It is well known that different management intensities of semi-natural grasslands may affect biodiversity in different ways (Wissman et al. 2008) but the surrounding landscape may also influence the way that species are utilising habitats promoted by different management (Colding & Folke 2009). It has also been suggested that grasslands with different management have different C sequestration potential and carbon balances, especially when management intensity is included (Townsend-Small & Czimczik 2010a,b).

Appropriate management could be an important factor for mitigating climate change by increasing the carbon sink capacity of green areas (Lal & Augustin 2012), but still little is known of how this should be accomplished.

Objectives

In this project we aimed to examine how management of different areas in golf courses affect carbon sequestration and biodiversity and how these ecosystem services are related to multiple other services including, e.g., recreation and social aspects of different management strategies.

The ecosystem services were investigated in six Swedish golf courses, two courses nearby each of three cities Uppsala, Malmö and Gothenburg.

Key results

Species diversity of flowering plants as well as flower abundance and pollinator species richness was highest in least intensively managed vegetation in high rough, in average over the six golf courses. However, the diversity of plants and pollinators was not significantly related to the amount of open semi-natural habitat in the landscape surrounding the golf courses.

The results for soil organic carbon (SOC) sequestration show that plant biomass production as well as SOC contents was highest in roughs, intermediate in fairway and lowest in greens. There was no trade-off between carbon sequestration and biodiversity. Less intensive management led to both higher SOC sequestration and higher diversity of plants and pollinators. In a related project financed by Formas (a Swedish research council), social aspects of golf courses were studied at the same six golf courses.

For many players, visits to the golf course was an experience of nature and beautiful surroundings as well as a meeting place in a social context, a way to stay in shape as well as a way to relax in addition to the game. Many interviewers also stressed the importance of having golf facilities which are designed in an environmentally friendly manner. These results indicate that there is an interest in promoting biodiversity and an environmentally friendly management.

On their webbpages, several of the studied golf courses also highlight their beautiful nature and the work they do to promote the environment which indicates that this is also something they want to communicate.

Plants

High rough had very few species in common with the other two management types. The diversity of flowering plants differed significantly between the management types where rough had lower diversity than high rough and fairway had lower diversity than rough.

The number of reproductive units (buds, flowers and fruits) differed significantly between the management types where rough had lower numbers of reproductive units than high rough, but no such effect could be found between fairway and rough.

When determining the potential attractiveness to pollinators only the plant species visited by pollinators were included in the analysis. This analysis was made for the plants that were present in the 4 m^2 plots (where the pollinator observations were made). There was a significant difference in number of flowers per plot among management types.

In general, the roughs had lower number of flowers per plot than the high roughs, and fairways had lower number of flowers per plot than roughs.

The results for the golf courses Burlöv GC, Torslanda GC and Upsala GC followed the general pattern, even if the variation within golf courses in number of flowers per plot was high for the high rough at all three golf courses and for the roughs at Burlöv GC. For Delsjön GC and Sigtuna GC there was no difference in number of flowers per plot between roughs and high roughs and for Lunds akademiska GC there was no difference in number of flowers per plot between fairways and roughs.

In general, the golf courses had none or very low numbers of flowers in the fairway except Burlövs GC where it varied within the golf course and Lunds akademiska GC where it was generally relatively high. The total number of plant species found in plots in the six golf courses varied from 40 in Burlöv GC to 71 in Lunds akademiska GC.

Insects

Total number of species of pollinators varied between 8 species in Torslanda GC (honeybees, 5 species of bumble bees and 2 species of butterflies) to 18 species in Sigtuna GC (honeybees, 7 species of bumble bees and 10 species of butterflies). Honeybees were present in all golf courses, the number of bumble bee species varied between 5 and 7 species between golf courses and the number of butterfly species varied between 2 and 11 species. The highest number of butterfly species was found in Lunds akademiska GC.

There was an overall effect of management type both for number of flower visiting insect species (bumble bees, butterflies and honey bees), number of individual insects visiting flowers and number of flower visits. When comparing individual pairs of management type, number of flower visiting insect species were highest in high rough and lowest in fairway, but for number of individual insects visiting flowers and number of flower visits fairway had lower numbers while rough and high rough could not be separated.

For individual golf courses, the pattern for number of flower visiting species differed from the general pattern for Torslanda and Delsjön where there was no difference between rough and high rough. For number of flower visiting pollinator individuals there was no significant difference between fairway and rough at Lunds akademiska, whereas the other golf courses followed the general pattern. For number of flower visits per plot there was no difference between any of the management types for Torslanda and Lund, and no difference between rough and high rough at Delsjön, while the results for the other golf courses followed the general pattern.

Visiting insect individuals were dependent on number of flowers (that attract flower visiting bees and butterflies) in fairways but this relation between factors was very weak in rough and could not be detected in high rough.

Productivity and carbon sequestration

Above ground net primary production (NPP) was significantly affected by management intensity, with greens having the lowest, fairways having intermediate and roughs having the highest biomass production. The difference between roughs and fairways was thereby also significant. SOC concentrations in greens were significantly lower than in fairways and roughs. The difference between roughs and fairways was in the same direction as observed for NPP. On average, the soils under rough contained about 10 tones more soil carbon than those under fairways.

Landscape

The proportion of semi-open grasslands surrounding the golf courses differed widely between the golf courses but did not show any correlation with plant biodiversity, pollinator abundance, insect visiting rate or species number within the golf courses.

Methods

In this study, six golf courses, two courses nearby each of three cities in Sweden (Uppsala, Malmö and Gothenburg) were investigated. In these courses six holes was sampled for both environmental and ecological parameters. The golf courses included in the survey were: Burlöv GC and Lunds akademiska GC close to Malmö, Delsjöns GC and Torslanda GC close to Gothenburg and Upsala GC and Sigtuna GC close to Uppsala. The surveys were made in 2014 in four grassland management types: green, fairway, rough and high rough at six holes within each golf course. Biodiversity surveys were made on fairway, rough and high rough. The carbon sequestration surveys were made on the more intensively managed parts of the golf courses: green, fairway and rough.

Variables on plants and pollinators were correlated to the surrounding landscape where the amount of potentially species rich grasslands in one and six kilometre zones around the courses was used. The vegetation in the buffer zones was quantified by using the Swedish Land Cover Data (Swedish EPA, 2014).

Social aspects of golf courses were studied in a related project: Lawn as a cultural and ecological phenomenon financed by FORMAS and the results of these studies are shortly described. Managers responsible for six golf courses in three regions and a total number of 180 visitors were interviewed (30 interviews at each golf course).

Potential practical improvements

Golf courses have great potential to support multiple values, for biodiversity and carbon sequestration and social wellbeing of people. Plant biomass production and soil carbon contents were highest in roughs, intermediate in fairway and lowest in greens. Thus, there was no trade-off between carbon sequestration and biodiversity.

We have shown that there is a potential to improve the quality of habitats in golf courses for plants, pollinators and to some extent SOC sequestration through less intense management. The quality of high rough as habitat for plants and pollinators varied between sites and could probably be increased. For bees and butterflies it is important, in addition to flower resources, to also consider other factors of the environment such as availability of nesting sites and food plants for larvae. Here, we mainly encountered common and widespread butterfly and bumble bee species suggesting that the quality of the habitats for these insect groups was mediocre.

It appears that there is also a social potential in moving towards more environmentally friendly management. In the description of the different golf courses on their home pages there are often descrip-

tions of the nature of the course. For example, Delsjön golf course is described as: "..a medium difficult park- and forest course in a wonderfully beautiful and well managed nature, .." and in the description of Sigtuna golf course its old oaks, rich birdlife and the view of the lake through well managed tree curtains are mentioned as giving the course its feeling and character. It is also mentioned that the club is working for increasing biodiversity and conservation of nature. Also, other golf courses are mentioning their work for biodiversity and the environment, e.g., in Burlöv golf course ponds have been created with the intention to favor biological diversity and serve as a biological filter for water flowing into the river and both Upsala and Sigtuna golf course are GEO certified meaning that the management of the courses has been examined regarding its influence on the nature and environment. Lunds akademiska golf course mentions their unique flora in their description and also organizes guiding tours informing about plants and the birds of the area. Thus, the golf clubs value and highlight the scenery at their specific golf course, and have an interest in promoting themselves as biodiverse and environmentally friendly, but are also willing to take actions towards becoming more so. In the interviews made with golf players on the same golf courses in another study within the related LAWN-project (Ignatieva et al. 2015) also revealed an interest in promoting biodiversity and an environmentally friendly management (Eriksson et al. 2015). Given that there is a decline in meadows and other types of flower rich grasslands, due to changes in agricultural practices and that one of the most important threats towards Red Listed species in Sweden is overgrowth of open grasslands (Sandström et al. 2015), also golf courses should be considered for the conservation of grassland species. Compared with other urban grasslands many golf courses cover considerable areas and thus have the potential to create relatively big and connected habitats. Besides adding habitat for biodiversity, naturalistic golf courses may also engage people in wildlife habitat preservation issues.

Suggestions for follow-up research

1. A larger number of golf courses should be studies to reveal the key factors determining their contribution to green infrastructure in different landscapes?

2. What are the options for converting nutrient rich roughs to nutrient poor and flower rich meadow-like areas?

3. To study several of the resources that are important for pollinators in addition to flower richness, e.g., nesting sites, food plants, for identifying the most limiting factors determining species richness and abundance on golf courses.

4. How does the flora, pollinators and golf players react if the management intensity of, e.g., roughs is changed experimentally?

5. Empirial data on emissions of greenhouse gases (GHG) from golf courses are lacking. The impact of fertilization regime and the managment of grass clippings on GHG emissions (mainly nitrous oxide) should be quantified to guide greenkeepers in their decisions for developing climate-friendly golf courses.

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More information about and results from the project can be found in the final scientific report and the final popular scientific report on **www.sterf.org**