2017 was not a good year for planet Earth, with more record-breaking temperatures and more severe rainstorms, hurricanes, droughts and flooding than ever before. During 2017, the rate of biodiversity loss accelerated and more species than ever came under threat.

All this has consequences for the golf and turfgrass industry. Dollar spot is now quite common even in the Nordic countries, due to the milder climate. Many golf clubs are being forced to rebuild their drainage systems, due to frequent ‘thousand-year’ rain events. At the same time, the grass on other golf courses and sports fields is being killed by severe drought.

This calls for more research and knowledge building in order to conquer these challenges, but we are happy to report that STERF is very well positioned to take them on. Our four research programmes address many global challenges. During 2017, we started several projects to ensure that we have the knowledge we need to build and maintain sustainable golf courses and sports fields.

Since the climate and other conditions are changing very rapidly, it is becoming increasingly important to reach end-users with our latest findings, so that the right actions can be taken. Therefore STERF continues its focus on delivering ready-to-use results, like handbooks, factsheets and articles, which are available for free on www.sterf.org.

Enjoy reading this 2017 yearbook!

Bruno Hedlund
STERF Chairman
INTRODUCTION
STERF

COLLABORATION WITH NORWEGIAN AUTHORITIES ON PROJECTS EXAMINING PESTICIDE FATE AND BIODIVERSITY
STERF has a long tradition of collaboration with the national authorities in the Nordic countries on projects related to integrated pest management (IPM) and multifunctional golf courses. Through such projects, STERF takes responsibility for ensuring that national polices are implemented on golf courses and by the green amenity sector in general.

In 2017, two STERF-initiated projects received matching funding from the Norwegian environmental authorities. One of these projects, ‘Reduced risk of fungicide leaching and runoff from golf courses’, was co-funded by the Norwegian government’s Action Plan for More Sustainable use of Pesticides 2016-2020. The other, ‘From dense swards to biodiverse roughs’ was co-funded by the government’s Action Plan for Biodiversity and Cultural Heritage.

Both projects are described in later sections of this yearbook. STERF is very pleased to have good relations with public bodies and to be instrumental in the implementation of national and international policies. We welcome more of this type of collaborative project in the future.

IMPORTANT EVENTS IN 2017

NEW PROJECTS STARTED IN 2017
In its call for proposals in 2016 and 2017, STERF decided to prioritise research and development within four international thematic areas, according to the R&D programmes within each area. These are: ‘Integrated pest management’, ‘Sustainable water management’, ‘Winter stress management’, and ‘Multifunctional golf facilities’. STERF received 12 interesting and relevant project proposals within the four thematic areas. The amount applied for from STERF was 13 100 000 SEK, the suggested amount of matching funding was 6 700 000 and thus the total amount sought for new projects was 19 800 000 SEK.

The STERF advisory committee and its subgroups have done a very good and important job in evaluating the proposals. Especially important for the evaluation process were the sub-group coordinators, Nilla Nilsdotter-Linde, SLU, and Asbjørn Nyholt, Nyholt Consulting. In February and June 2017, and based on the recommendations of the advisory committee, the STERF board decided to prioritise seven projects for funding. The total amount of funding agreed by STERF for four years was 7 800 000 SEK and total amount of matching funding was 6 300 000 SEK. All new projects are presented in this yearbook.
SEMINAR ON TURFGRASS WINTER STRESS MANAGEMENT

Almost 100 participants from 10 different countries, including scientists, superintendents, industry representatives and consultants, participated in the STERF seminar "Winter Stress Management of Turfgrasses", arranged together with Norwegian Golf Federation, the Research Council of Norway and NIBIO in Oslo, 9-10 November 2017.

The seminar focused on the main findings and recommendations of a four-year project examining how autumn fertilisation, shade and anoxia affect winter and spring performance of cool-season turfgrasses used on golf greens. The seminar also covered many other aspects of winter stress management of turfgrasses. The invited speaker, Eric Watkins (USA), talked about breeding for winter hardiness, plant-microbe interactions, ice removal and seed germination at low temperatures. Sigridur Dalmannsdottir, originally from Iceland and now working on forage grasses in Norway, touched on issues such as day length reactions and cold acclimation in a changing winter climate. Scientists from NIBIO’s Turfgrass Research Group at Apelsvoll and Landvik presented results from earlier and ongoing projects on turfgrass winter survival and the SCANGREEN variety trials. This included full-scale trials conducted at one golf course in each of the Nordic countries during autumn/winter 2016/2017. The selected courses were Keilir GC (ISL), Roskilde GC (DK), Tapiola GC (FIN), Kungliga Drottningholm GC (SE) and Hauger GC (NO). The superintendents from these golf clubs explained how the different fertilisation practices affected the winter survival of their greens.

The need for further research regarding winter stress management was discussed in groups towards the end of the seminar. The highest priorities identified were as follows: non-pesticide control of winter diseases (6 groups), winter covers and other ice control measures (3 groups), re-establishment strategies after winter damage, notably on old greens (2 groups), moss and algae control in mild winters (2 groups) and correct use of fungicides (1 group).

THE NEW HANDBOOK ON WINTER STRESS MANAGEMENT

In 'The Golf Course Managers’ Handbook on Turfgrass Winter Stress Management', recently retired NIBIO scientist Agnar Kvalbein and his co-authors summarise results and experiences from several research projects. The handbook contains many practical recommendations, enabling golf course superintendents to find their own preferred solutions to local problems. Download the handbook at: www.sterf.org

The recommendations have been incorporated into an ‘Autumn fertilisation calculator’ that also can be downloaded.
SEMINAR ON MULTIFUNCTIONAL LANDSCAPES – NORDIC GOLF FACILITIES´ POSSIBILITIES AND CHALLENGES

The seminar ‘Multifunctional Landscapes – Nordic Golf Facilities´ Possibilities and Challenges’ was organised jointly by STERF and the Royal Swedish Academy of Agriculture and Forestry (KSLA) in Stockholm on February 7th 2017. The seminar had a Nordic focus, with speakers from Denmark, Iceland, Norway and Sweden. More than 70 people from the Nordic countries participated in the seminar, representing KSLA, research institutes and universities, local, national and Nordic authorities, landowners, the golf sector and other businesses.

The aim of the seminar was to demonstrate and discuss how multifunctional golf facilities can be used to supply a number of functions that could provide a range of important services required by society. In addition to offering a high-quality arena for golf, golf facilities could also contribute e.g. to improving biological diversity, conserving natural and cultural environments and providing recreation areas that are open to the public and to other outdoor activities. The seminar also covered challenges and potential conflicts related to land use for golf courses, especially in the urban landscape. A full report from the seminar can be found at www.sterf.org

MULTIFUNCTIONAL ACTIVITIES ON NORDIC GOLF FACILITIES – A SURVEY

Urban landscapes are now home to the majority of the world’s population and it is predicted that 66% of the world’s population will live in cities by 2050. Multifunctional urban green areas, for example golf courses, have large, mostly untapped, potential to provide ecosystem services in future cities. Thus it is important that golf courses host other activities in addition to the game of golf and that the land is used and accessible to a diversity of actors. The aim of the survey was to investigate ongoing multifunctional activities on Nordic golf facilities, which is important background information for future research and development within this area.

The survey was conducted by STERF during 2017 and had 25 questions (mostly multiple choice) divided into five sections: background information; collaboration with various groups in society; protecting natural and cultural values; accessibility to other groups in addition to golfers; and activities to improve golf club finances. In total, 745 golf clubs in Denmark, Finland, Iceland, Norway and Sweden received the survey and it was completed by 296 golf clubs. The golf federations in each country were responsible for promoting and distributing the survey and there was some variation in how this was carried out. As a result, the survey was completed by 47% of Swedish golf clubs, 39% of Icelandic clubs, 22% of Danish clubs, 11% of Norwegian clubs and 1% of Finnish clubs. A report on the survey can be found at www.sterf.org
The next International Turfgrass Research Conference will be organised by STERF in Copenhagen in 2021. The conference will include keynote speakers, oral and poster presentations, industry networking opportunities, technical tours, social events and much more. New for ITRC 2021 is a one-day programme for practitioners.

**Scientific topics of interest** may include: turfgrass establishment and management; turfgrass pests (diseases, weeds, insects etc.); turfgrass physiology; turfgrass genetics and breeding; soil biology, chemistry and plant nutrition; soil physics and rootzone construction; sustainable water management; ecosystem services and biodiversity; and information technology, education and communications.

**Technical tours** will introduce Nordic turfgrass research and development, which is focusing on internationally important key areas. These include pressure from government for greater environmental regulation, the increasing pressure on natural resources (notably water, energy and land), the emerging role of turf management in supporting ecosystem services and enhancing biodiversity, the continued need to promote integrated pest management, and the looming challenges posed by a changing climate and the urgent need to adapt.

The one-day programme for practitioners will fulfil the ambition of taking a lead in making research results and new knowledge easy accessible to end-users and providing support to implement changes, which is essential for achieving improvements in sustainable management of turfgrass.

Copenhagen is the congress capital of Scandinavia and its vibrant cultural heart. Copenhagen is also truly a green city surrounded by water and parks, with climate-friendly citizens to match. The ambitious green profile of the city has a clear goal: The City of Copenhagen aims to become the world’s first CO2-neutral capital by 2025. Experience it for yourself. Swim in the clean waters of the city’s harbour baths, stay in a sustainable hotel, eat organic and ride an electric city bike around the old maritime city.
ABOUT STERF

SCANDINAVIAN TURFGRASS AND ENVIRONMENT RESEARCH FOUNDATION, STERF

STERF is an independent research foundation that supports existing and future R&D efforts and delivers ‘ready-to-use’ research results that benefit the golf and turfgrass sector. STERF was set up in 2006 by the golf federations in Sweden, Denmark, Norway, Finland, Iceland and the Nordic Greenkeepers’ Associations. Research funded by STERF is carried out at universities or research institutes (or equivalent) where most relevant research capacity is concentrated. STERF helps to strengthen research capacity by encouraging and supporting networks and collaborating actively with international key organisations in the field of turfgrass management. STERF also arranges innovation workshops to help identify the golf and turfgrass industry’s future research needs, where researchers and industry representatives contribute to the planning process. STERF receives funding from participating golf associations, which can be complemented by funding from other sources.

STERF’s vision is to be the leading international centre of expertise in sustainable golf course management. To achieve the vision STERF focuses on:

• Ensuring that Nordic turfgrass research and development focuses on internationally important areas where concerted research and industrial efforts are required. These include the pressures generated by government demands for greater environmental regulation, the increasing pressure on natural resources (notably water, energy and land), the emerging role of turf management in supporting ecosystem services and enhancing biodiversity, the continued need to promote integrated pest management, and the looming challenges posed by a changing climate and the urgent need to adapt.

• Establishing a successful international research and development collaboration, including research facilities and expertise in all five Nordic countries. STERF will continue to initiate inter-disciplinary and multi-disciplinary research and support collaboration in Europe, Canada, USA and China, involving both researchers and stakeholders interested in land...
• initiate inter-disciplinary and multi-disciplinary research and support collaboration in Europe, Canada, USA and China, involving both researchers and stakeholders interested in land used for managed turfgrass areas.

• Developing and expanding the STERF industrial scientific partner programme by collaborating with leading international companies within the sector to further strengthen the strategy that research and development should be integrated from producer to end-user. The STERF industrial scientific programme can be found on: http://www.sterf.org

• Taking a lead in making research results and new knowledge easily accessible to end-users and to provide support to implement changes, a prerequisite for achieving improvements in the sustainable management of golf courses and other turfgrass areas.

• Making the turfgrass industry in the Nordic countries a role model regarding responsibility for sustainable societal development, i.e. in producing managed turfgrass areas of a high standard while at the same time ensuring the sustainable use of natural resources and contributing to functioning ecosystems.

STERF BOARD
Bruno Hedlund, STERF, Chairman
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Pål Melbye, Norwegian Golf Federation
Edwin Roald, Golf Union of Iceland
Gunnar Håkansson, Swedish Golf Federation
Jerry Knox, Cranfield University
Stefan Nilsson, Swedish Greenkeeper Association
Maria Strandberg, STERF

ADVISORY COMMITTEE MEMBERS
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Peter Landschoot, Penn State University (independent international expert)
Annick Bertrand, Agriculture and Agri-Food Canada (independent international expert)
Asbjörn Nyholt (coordinator for golf course consultants/agronomists employed by the Nordic golf federations and Scandinavian greenkeeper associations)
Nilla Nilsdotter-Linde (coordinator for researchers at universities/research institutes in the Nordic countries)

Agne Strøm, Norwegian Golf Association
Peter Fjällman, The European Institute of Golf Course Architects

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Boel Sandström, Swedish Golf Federation
John Riiber, Norwegian Greenkeepers Association
Bjarni Hannesson, Golf Union of Iceland
Jan Hellström, Finnish Golf Association
Per Sørensen, Danish Golf Association
Mikael Lagerstam, Swedish Golf Association

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Sterf Director
Maria Strandberg, STERF
Managed turfgrass areas such as golf courses, sport fields, landscaped amenity areas and public parks all provide an important social, environmental and economic resource for both urban and rural communities. These areas serve a multifunctional purpose by offering valuable open spaces for recreation, helping to improve the health and quality of life for individuals and, when designed and managed appropriately, enhancing biodiversity and supporting regulatory targets for environmental protection. Conversely, where turfgrass management practices are inadequate or inappropriate, their services to society are reduced and their impacts on the natural environment can be damaging and costly.

The challenges for the future of turfgrass and golf course management are many and diverse. They include increasing demands on natural resources (notably land use, water resources and energy) driven by economic development and population growth, coupled with government demands for greater environmental protection, which are creating conflicts at the interface between land management (including turfgrass) and the environment. The situation is particularly acute in peri-urban areas where the majority of managed turfgrass facilities are concentrated. Population growth, migration and climate change will exacerbate the current situation, by increasing the competition for resources between individual sectors, including agriculture, urban development, tourism and the environment.

Many golf courses, sport facilities and stadiums are under pressure due to the financial crisis of recent years. For example, in many countries there has been a decrease in the number of registered golf players. It is common for golf courses to base their financial stability on a constant inflow of members rather than a static membership. However, they are now facing the challenge of balancing this approach against the new concept of fewer members and new conditions in a more variable and more competitive market.

The key for golf course and turfgrass management will be to increase resource use efficiency, reduce maintenance costs and minimise the environmental impact. In this context, the protection and enhancement of ecosystem services will need to be fully integrated into the planning, design, construction and management of all golf and turfgrass facilities.

The Nordic Golf Federations have approximately 900 000 members, playing golf on more than 900 courses that cover a total area of more than 60 000 hectares. Any societal activity as significant as golf must take responsibility for building knowledge through research and development (R&D). There are several important reasons why Nordic R&D is necessary. In Central Scandinavia, Oslo, Stockholm and Helsinki lie at the same latitude as the southern tip of Greenland (~60oN). This provides a unique climate resulting from a combination of factors such as light, temperature and precipitation during the playing season and particularly during the winter season. The Nordic climate creates conditions for plant growth and the construction and management of golf courses, sport fields etc. that are not found anywhere else in the world.

The financial resources allocated to R&D in each country are very limited and the number of scientists actively working within each priority R&D area is also quite limited compared with agricultural and forestry research. The financial resources and efforts of these researchers should therefore be coordinated through STERF to optimise R&D within the golf and turfgrass sector.

Sustainable golf facilities of a high standard and in establishing the credibility of golf as an environmentally friendly sport. Golf facilities that are already using new knowledge are achieving cost savings through more efficient management strategies, while also enhancing the golf course, raising the profile of their golf facility and improving the environment.
RESEARCH OBJECTIVES AND R&D SUB-PROGRAMMES

STRATEGIC RESEARCH OBJECTIVES
The golf and turfgrass industry, like other land-based industries, has to take responsibility for sustainable societal development, i.e. it must produce golf courses and other turfgrass areas of a high standard while at the same time ensuring the sustainable use of natural resources and contributing to functioning ecosystems.

The aim of STERF is to support R&D that can help the golf industry to fulfil these ambitions. The activities of STERF are intended to lead to improvements in the quality of golf courses, as well as economic and environmental gains for the industry and society as a whole.

The strategic objectives for STERF-funded R&D activities are that:

- The design, construction, management and administration of golf courses provide optimal conditions for playing quality, degree of utilisation of the course and management inputs.
- The design, construction, management and administration of golf courses are economically and environmentally sustainable, for example with respect to plant nutrient requirements, water and energy use, drainage and control of weeds and plant diseases.
- Golf courses contribute to improving the relationship between golf and ecosystems, enhance the natural and cultural values of the landscape and promote biodiversity.

R&D SUB-PROGRAMMES
It is apparent that the golf and turfgrass industry faces a number of local and international challenges, all of which will need concerted and collective solutions, underpinned by robust, applied science. To meet the challenges the sector has to face, STERF has created four international and trans-disciplinary R&D sub-programmes:

- Integrated pest management
- Sustainable water management
- Turfgrass winter stress management
- Multifunctional use of golf facilities and ecosystem services.

Progress in these programme areas will collectively lead to improvements in the quality of managed turfgrass areas, as well as economic and environmental gains for the industry. The key objectives of the pro-
grammes are to coordinate the design and running of R&D activities and to manage the effective dissemination of outputs (new knowledge) through channels and formats which are easily accessible to end-users. STERF will play a key role in expanding the programmes on international level.

**Integrated Pest Management**
New regulations at national and international level relating to the turfgrass industry are becoming more demanding. A good example is the EU Directive on Sustainable Use of Pesticides, which includes strategies for integrated pest management (IPM).

STERF, together with the Nordic park and golf sector, universities, research institutions and authorities, takes responsibility for ensuring that R&D activities important for IPM are coordinated and executed and that new knowledge is delivered.

**Sustainable water management**
Water is essential to secure the future of the turf industry and the livelihoods of many rural communities that depend upon it. Working with industry and leading research institutes, STERF’s goal is to provide science-based information to practitioners and stakeholders on integrated water management in turf. This will improve management practices relating to both irrigation and drainage systems, help protect environmental water quality and support the industry in adapting to the effects of future changes in rainfall and climate variability on water resources.

**Turfgrass winter stress management**
Winter damage is the foremost reason for dead grass, reducing the aesthetic and functional value of turf. UN-IPCC climate scenarios predict that, due to high precipitation and unstable temperature, ice and water damage will become the most important cause of winter damage in the future. This is a complex but high priority area for STERF, as it has been estimated that about 70% of Nordic golf courses suffer from winter damage each year and that the associated average annual costs per golf course are €35 000-40 000. STERF will take responsibility for developing strategic expertise and new knowledge to avoid and manage such damage.

**Multifunctional use of golf facilities and ecosystem services**
Multifunctional golf courses can contribute to increased biological diversity, conservation of natural and cultural environments, and retention and expansion of ecosystem services, and can help to improve people’s health and quality of life by providing facilities for active outdoor recreation. Through STERF’s R&D programme within multifunctional facilities, the societal benefits of golf can be improved and the Nordic area can become a model region as regards multifunctional golf courses and collaborations between different interests in society. Four central research and development areas have been identified: (1) The everyday landscape and peri-urban nature, (2) Nature and culture, (3) Dialogue and cooperation, and (4) Business promotion.

**Programme coordinators**
Programme coordinators appointed by STERF, together with the STERF board and its director, are responsible for developing STERF R&D programmes. Overarching duties to be fulfilled by the programme coordinators are:

- To be a ‘champion’ or nominal lead for their programme
- To make sure that the programme has a suitable mix of activities, not only research but also other industry-linked initiatives, including for example meetings, workshops and media outputs
- To help share programme workload
- To take ‘ownership’ of the activities/initiatives that need to be developed over the next three years.

The full R&D programmes and presentation of programme coordinators can be found at: www.sterf.org
Because STERF is working globally and launching international programmes, it has invited important companies within the sector to become involved in its Industrial Scientific Partner Programme. The aim is to increase the credibility of STERF’s research and development programme, and also to increase financial support for programmes and projects.

The involvement of leading suppliers will also strengthen the important strategy that research and development should be integrated all the way from producer to end-user.

STERF and the industrial scientific partners have had several discussions about creating combined R&D projects involving a number of different industrial partners and STERF. The aim of these projects will be to identify, explain and suggest solutions for complex problems relevant for the sector. As an Industrial Scientific Partner to STERF, companies have a whole range of benefits:

- Access to the leading research and innovation centre in the turfgrass and environmental field
- The opportunity to take part in creating STERF’s research programme through participation in the planning process
- Participation in STERF workshops and seminars
- A world-wide network of contacts with international universities and centres of research in the golf sector
- A contact day on which to present and discuss the particular company’s strategic development issues
- Information via the STERF newsletter and website
- Collaboration on research projects and product development
- Contacts with public authorities

**STERF’s partners 2017**
STERF is proud to present its current Industrial Scientific Partners:
- Aquatrols Europe Ltd.
- Botanical Analysis Group
- Melspring
- OGT
- Syngenta
SCANGREEN: TURFGRASS SPECIES, VARIETIES, SEED BLENDS AND MIXTURES FOR INTEGRATED PEST MANAGEMENT OF SCANDINAVIAN PUTTING GREENS

PROJECT PERIOD: JANUARY 2015 – DECEMBER 2018

FUNDING (kSEK)

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1) Includes an extra ear-marked grant of 78 kSEK from Norwegian Golf Federation in 2016 to write one popular article and give one additional talk on alternative seed mixtures and blends.

PRINCIPAL INVESTIGATOR / CONTACT PERSON
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Pia Heltoft, Tatsiana Espevig, Trond Pettersen, and Jan Tangsveen, NIBIO Turfgrass Research Group, Norway

PROJECT OBJECTIVES
- To clarify which varieties of Agrostis, Festuca, Poa and Lolium are best suited for integrated pest management of putting greens at four experimental sites representing the two major climate zones in the Nordic countries
- To investigate the effect on visual quality and uniformity in space and time of using traditional and non-traditional seed mixtures and blends on putting greens
- To create meeting places for discussions between plant breeders, seed companies and greenkeepers in order to encourage variety awareness, integrated pest management and continued efforts on turfgrass breeding for high-latitude environments

TALKS AT CONFERENCES MEETINGS, SEMINARS, FIELD DAYS, ETC IN 2017
4 April: Trial at Landvik visited by Geert Grönckel, Syngenta
7 June: Trial at Apelsvoll visited by group from Denmark
19 June: Trial at Apelsvoll visited by representatives from Barenbrug seed company
21 June: Lecture and presentation of Landvik plots to 60 participants in NIBIO Turfgrass Field Day
4 Oct.: Trial at Landvik visited by 20 students from Sandmose Greenkeeper School
10 Nov.: ‘Put your bet on the winning genes’. Results from winter survival in SCANGREEN trials presented at NOBIO/STERF seminar on Winter Stress Management, Gardermoen, Norway.
Season: Trial at Sydsjælland visited by individual greenkeepers and students 5-6 times, and by the board of Maribo GC.

PROJECT SUMMARY AND STATUS BY 1 JANUARY 2018
Breeding and evaluation of turfgrass varieties is key to better turf quality. Since 2003, STERF has been testing species and varieties under realistic green conditions, including wear from pedestrian-type machines equipped with golf spikes. Results are updated annually at www.scanturf.org and www.sterf.org.

SCANGREEN 2015-2018 is being conducted at NIBIO Apelsvoll, Norway (62°N) and Korpa GC, Reykjavik, Iceland (64°N), in the northern zone and at NIBIO Landvik, Norway (58°N), and Sydsjælland GC, Denmark (56°N), in the southern zone. The trials include
25 candidate varieties and seven controls representing eight different species (Table 1). *Festuca* sp., *Lolium perenne* (Lp) and *Poa pratensis* (Pp) are mown to 5 mm, other species to 3 mm. Pesticides are never used in the trials. Unlike former test rounds, SCANGREEN 2015-2018 also includes seed mixtures and blends.

Halfway through the project period and on average for varieties, Pp had the highest quality scores, due to less winter damage and better disease resistance than in the other species. However, the leaves of Pp were coarse and stiff, and playing quality remains to be evaluated. The fine-leaved *Poa trivialis* (Pt) performed well in the north, especially when used as a nurse crop for *Agrostis stolonifera* (As), but did not thrive and was often a dark purple colour in the south. 'Two Put' showed the same poor winter hardiness and susceptibility to disease as former entries of *Poa annua*. Evaluation of seed blends of 'Musica' and 'Cezanne' (control varieties of *F. rubra* ssp. *commutata* (Frc) and *F. rubra* ssp. *litoralis* (Frl) respectively) showed the optimal ratio to be 75/25 in the north and 50/50 in the south.

Within species, the most promising entries of As, better than 'Independence', were 'Pure Distinction', 'Luminary', 'Ignite', 'Riptide' and 'Flagstick' in the south and these same varieties except for 'Pure Distinction' in the north. The most promising entries of *Agrostis capillaris* (better than 'Jorvik') were 'Heritage' and 'DLF-PS-AT 3026' (yet unnamed) in both zones. Within fescues, none of the new entries of *Frc* or *Frl* outperformed 'Musica' and 'Cezanne', respectively. All Lps had less than 10% winter survival in the north, but 'Clementine' produced significantly denser turf with 21% less height growth than 'Chardin' in the south. Within Pt, 'Sabrena 1' and, to a lesser extent, 'Qasar' were ranked higher than 'Dark Horse' in both zones.

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Varieties in SCANGREEN 2015-18 by species and by breeding/seed company. Varieties in **bold** are controls.
ENGINEERING BETTER IRRIGATION IN TURF: QUANTIFYING IMPACTS OF APPLICATION UNIFORMITY ON TURF QUALITY IN GOLF

PROJECT PERIOD: OCTOBER 2014 - MAY 2018

FUNDING (kSEK)

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PRINCIPAL INVESTIGATOR / CONTACT PERSON
Jerry Knox, Cranfield Water Science Institute, Department of Environmental Science and Technology, Cranfield University, Bedford MK43 0AL, UK
Phone: +44 (0) 1234 758365 Email: j.knox@cranfield.ac.uk

CO-APPLICANTS
Trygve S. Aamlid, NIBIO Turfgrass Research Group, Norway

PROJECT OBJECTIVES
- To assess the environmental impacts of irrigation heterogeneity on turf quality, water use and nutrient uptake.
- To evaluate irrigation management practices using two case study golf courses in Norway (Oslo GC) and Denmark (Furesø GC).
- To review current irrigation practices, scheduling methods and equipment operation and management through fieldwork and industry survey.
- To calibrate a ballistic model to simulate irrigation application (uniformity, adequacy, efficiency) under contrasting climate and turf management scenarios.

- To interview greenkeepers, irrigation engineers and representatives from the Scandinavian golf industry in order to assess turf irrigation management practices and how these relate to system design.
- To develop best management practice guidelines for the Scandinavian golf industry.

TALKS AT CONFERENCES, SEMINARS, MEETINGS ETC. IN 2017
16 June: Poster presentation at the conference Science for a Circular Economy - How to tackle the Water, Energy, Food Nexus, Cranfield University, UK (Gomez awarded the prize for best poster at the conference).

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2018
This project aims to quantify the links between irrigation heterogeneity (non-uniformity) and turf management and hence provide industry guidelines for greenkeepers and course managers to improve irrigation management and reduce environmental impacts associated with golf course irrigation. This 3-year PhD research combines fieldwork in the UK, Denmark and Norway to (i) calibrate and validate a ballistics model used to simulate sprinkler irrigation uniformity and performance, and (ii) parameterise a biophysical model (STICS) to simulate fine turf growth and development and impacts on dry matter production (clippings) and nutrient leaching risks. The research is being informed by liaison with greenkeepers and key informants from the Scandinavian golf industry.

Golf sprinkler irrigation modelling. Successful validation and calibration of a ballistics model to simulate overlapped irrigation distribution patterns and non-uniformity on golf greens under varying conditions (changing wind speed and wind direction), operating pressures and sprinkler spacings. Carlos Gómez conducted fieldwork at Furesø GC.
(Denmark) to understand sprinkler irrigation system configuration and management practices (June 2017). The preliminary findings were presented by Carlos Gómez in a poster “Simulation of irrigation heterogeneity on golf greens using a ballistics model at the Science for a Circular Economy: How to tackle the Water, Energy, Food Nexus conference held at Cranfield University, UK, on June 2017.

OPTIMAL APPLICATION OF NITROGEN AND SULPHUR IN AUTUMN FOR BETTER WINTER SURVIVAL OF PERENNIAL GRASSES – WITH EMPHASIS ON TURF

PROJECT PERIOD: MARCH 2014 - DECEMBER 2017

FUNDING (kSEK)

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PRINCIPAL INVESTIGATOR / CONTACT PERSON
Bert Sandell, Norwegian Institute of Bioeconomy Research (NIBIO), Department for Urban Greening and Environmental Engineering, Turfgrass Research Group, Landvik, Reddalsveien 215, 4886 Grimstad. Phone +47 48024078. E-mail: bert.sandell@nibio.no

CO-APPLICANTS
Wendy Waalen, Trygve S Aamlid, and Tatsiana Espevig, NIBIO Turfgrass Research Group

PROJECT OBJECTIVES

• To measure the effect of autumn application of nitrogen and sulphur on winter survival and leakage of nitrogen from two major turfgrass species on Scandinavian golf greens.
• To define effects of autumn application of nitrogen and sulphur on resistance of creeping bent grass and annual meadow grass to Microdochium nivale, and on tolerance of these species to freezing temperatures and suffocation
• To determine the impact of nitrogen fertilisation on the content of specific carbohydrates in the grass crown and to identify the relationship between carbohydrate content and resistance to winter stresses.

• To disseminate, confirm and illustrate the most significant findings

TALKS AT CONFERENCES, SEMINARS, MEETINGS ETC. IN 2017

27 January: Plant nutrients and stress resistance, Adaptation to winter stresses, Winter preparation of golf greens, Winter work and spring recovery.
A. Kvalbein, IGA, Reykjavik, Iceland

03 March: Plant nutrients and stress resistance, Adaptation to winter stresses, Winter preparation of golf greens, Winter work and spring recovery.
A. Kvalbein, DGU seminar, Roskilde GC, Denmark

30 March: Plant nutrients and stress resistance, Adaptation to winter stresses, Winter preparation of golf greens, Winter work and spring recovery.
A. Kvalbein, Estonia

09 -10 Nov.: NIBIO Winter Stress Management Seminar, Gardermoen
Securing turfgrass winter survival on golf courses: Improvements in genetics and management. Eric Watkins, University of Minnesota.
Winter survival of turf- and forage grasses. Recent advances and future prospects.
S. Dalmannsdottir.

Snow moulds. Optimal fertilisation with N and S. T. Espevig
Winter challenges at Keilir GC, Iceland. B. Hannesson
Winter challenges at Hauger GC, Norway. E. Moroney
Winter challenges at Tapiola GC, Finland. G. O’Mahoney
Winter challenges at golf courses in Denmark. A. Nyholdt
Winter challenges at golf courses in Sweden. C-J. Lönnéberg
My fight against ice encasement. O.A. Kjøsnes, Byneset GC
My winter covers. T. Petterson, Sala GC
Put your bet on the winning grass genes. T. Aamlid
Wavering turf – between growing and acclimated status. T. Espevig
Light and winter survival. W. Waalen
Anoxia, spring injuries and re-establishment challenges. W. Waalen
Green preparation. Recommended autumn fertilisation. A. Kvalbein

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2018
In 2014 and 2015, USGA greens were established with creeping bent (CB) and annual meadow grass (AMG). One was built on the lysimeter facility at Landvik. In the acclimation period, half the green at Apelsvoll was shaded to about 30% of full sunlight. In autumn, the greens were fertilised weekly at decreasing rates with liquid fertiliser. Only nitrogen (N) and sulphur (S) varied among treatments. Other elements were given at rates which, according to the STERF fertiliser handbook, were adequate for the highest N rate. Total N rates September-November were 0/2.8/5.6/8.4 g/m². The 5.6 g N/m² rate was combined with either excess sulphur (N:S = 1:1.6) or no S, giving six treatments in total. Grass plants were sampled twice in winter and tested in the lab for freezing tolerance, resistance to pink snow mould and suffocation.

Three rates of N were used in large-scale trials at Keilir GC (ISL), Roskilde GC (DK), Tapiola GC (FIN), Kungliga Drottningholm GC (SE) and Hauger GC (NO) in autumn 2016. Major findings:

• The highest N rate significantly increased microdochium patch in AMG and CB. The low N rate resulted in less microdochium patch, better colour and better reparation capacity in spring at Landvik compared with no-N and high-N.
• The shaded green had significantly more disease and less freezing tolerance, but tolerance to suffocation was not affected.
• Freezing tolerance of AMG was not significantly affected by autumn fertilisation. In CB there was a strong negative correlation between N rate and freezing tolerance.
• Four, 20 and 43% of the N given in autumn at a rate of 2.8, 5.6 and 8.4 g N/m², respectively, was lost in drainage water.
• Sulphur generally had no effect on freezing tolerance or microdochium patch, except for Landvik where normal S gave less microdochium patch and better colour in AMG and CB compared with no-S and high-S.

Exact autumn fertiliser guidelines are difficult because conditions vary between sites and years.

Based on our data, our recommendations are:
1. Use the same balanced mix of nutrients in autumn as in the rest of the year.
2. Adjust the N rate in late August to achieve normal harvest of clippings (a rate 20-30% lower than the maximum rate in June). Rough guidelines are 7, 5 and 3 kg N/ha/week in AMG, CB and red fescue, respectively.
3. Reduce fertiliser dose every week until the turf stops growing.
4. Reduce N rate by 10-20% if the risk of winter damage (e.g. shade, disease pressure, weak turfgrass species or varieties) is high.
SUSPHOS: SUSTAINABLE PHOSPHORUS (P) FERTILISATION OF GOLF COURSES

PROJECT PERIOD: APRIL 2017 - DECEMBER 2020

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PRINCIPAL INVESTIGATOR / CONTACT PERSON  
Trygve S. Aamlid, Norwegian Institute for Bioeconomy Research (NIBIO), Department for Urban Greening and Environmental Technology, Turfgrass Research Group, Landvik, Reddalsveien 215, 4886 Grimstad. Phone: +47 90 52 83 78. E-mail: trygve.aamlid@nibio.no

CO-APPLICANTS  
Anne Falk Øgaard, NIBIO Division for Environment and Natural Resources  
Tore Krogstad, Norwegian University of Life Sciences (NMBU)  
Micah Woods, Asian Turfgrass Center, Bangkok, Thailand  
Yajun Chen, Northeast Agricultural University, Harbin, China  
Kim Sintorn, Swedish Golf Federation  
Niels Dokkuma, Netherlands Golf Federation  
Dean Cleaver, Federation of European Greenkeepers’ Associations  
Michael Bekken (Golf Environment Organization, until Aug. 2017)

PROJECT OBJECTIVES  
The principal objective is economic savings and lower environmental impact by reduced and more targeted fertilisation with phosphorus (P) according to soil analyses. Subgoals:

- To determine the need for extra P fertiliser for turfgrass establishment or re-establishment on sand-based golf greens with low soil P values and at various temperatures (WP 1)
- To determine the effect on time of green-up and turfgrass quality of foliar or granular applications of increasing amounts of P at various soil temperatures in spring (WP 2)
- To document effects on turfgrass quality and fertiliser costs of switching from conventional SLAN-based fertilisation to MLSN- or PF-based fertilisation on golf courses representing a range of climate zones, soil types and turfgrass species.

TALKS AT CONFERENCES, SEMINARS, MEETINGS ETC. IN 2017  

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2018  
Phosphorus (P) causes eutrophication of freshwater and has limited global reserves. The conventional SLAN (Sufficiency Level of Available Nutrients) recommendation for turfgrass is to maintain soil P levels >54 mg P/kg (Mehlich 3). However, MLSN theory (Minimum Level of Sustainable Nutrition) suggests a critical level of only 21 mg P/kg. MLSN usually means lower P inputs than STERF’s recommendation for PF (Precision Fertilisation), by which P is given at a constant ratio to nitrogen (N:P = 100:12), regardless of soil levels.

The background to this project is that the Golf Environment Organisation (GEO) is considering including MLSN as a criterion in its OnCourse® sustainability platform. This requires verification that 21 mg P/kg is adequate as a universal guideline across soil types, turf types and climates. For the Nordic countries, it is especially important to clarify whether low soil temperature or turfgrass re-establishment after winter damage require higher P inputs than turfgrass maintenance at higher temperature.
The project has three workpackages (WPs). In WP1, turfgrass coverage, clipping yields, root development and P uptake are being studied over a 5-week period after sowing creeping bentgrass in 40 cm deep cylinders filled with USGA-spec. sand (12 mg P/kg) at 7, 12 and 17 °C in daylight phytotrone chambers in spring 2017 and 2018. Results from 2017 showed a strong increase in turfgrass growth rate as P relative to N increased from 0 to 12 %, but no significant response to higher P rate, irrespective of temperature.

In WP2, the influence of P on spring green-up of established creeping bentgrass taken from a green (44 mg P/kg soil) is being studied in the same phytotrone chambers as in WP1. This WP is also comparing the same total amount of P given as granular superphosphate at the start of the trial or as weekly foliar applications of phosphoric acid. Results to date show no significant effect of P amount or application method on turfgrass green-up.

In WP 3, field trials comparing zero P vs. P inputs according to the SLAN, MLSN and PF models were established in May/June 2017 on putting greens with initially low soil P levels (6-35 mg P/kg) and a turf cover of annual meadow grass at Falkenberg GC, Sweden, red fescue at Princenbosch GC, Netherlands, and creeping bentgrass at Jingshan Lake GC, China, and NIBIO Landvik, Norway. These trials will be followed over a four-year period to monitor possible effects of P on turfgrass quality.
EFFECT OF IRRIGATION, FERTILISER TYPE AND SOIL AMENDMENT ON TURF QUALITY AND ORGANIC MATTER ACCUMULATION/THATCH CONTROL ON CREEPING BENTGRASS GREENS

PROJECT PERIOD: MAY 2016 - MARCH 2018

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PRINCIPAL INVESTIGATOR / CONTACT PERSON
Bert Sandell, Norwegian Institute of Bioeconomy Research (NIBIO), Dept. Urban Greening and Environmental Engineering, Turfgrass Research Group, Landvik, Reddalsveien 215, 4886 Grimstad, Norway. Phone: +47 48024078. E-mail: bert.sandell@nibio.no

CO-APPLICANTS
Trygve S. Aamlid and Trond O. Pettersen, NIBIO Turfgrass Research Group, Norway

PROJECT OBJECTIVE
To evaluate the effect of Melspring’s soil conditioners Matrix and Stor-it (containing natural zeolite) and Matrix (also containing seaweed) with an unamended control. In 2016, Matrix or Stor-it was mixed at 10% (v/v) into the top 5 cm of a USGA-spec. green with initial organic matter content 0.8% under a mobile rainout shelter at NIBIO Landvik. The green was sown with creeping bentgrass on 9 June 2016. Applications of Matrix and Stor-it continued as part of topdressing.

Once grow-in was completed on 5 August 2016, two more experimental factors were added: 1) During four weeks in 2016 and eight weeks in 2017, the rainout shelter was activated and main plots either irrigated to field capacity (FC) once a week or excess-irrigated twice a week with 50% more water than needed to replenish FC; and 2) Marathon controlled-release fertiliser applied every 4 weeks was compared with Wallco liquid mineral fertiliser applied every 2 weeks. Total N rate during the maintenance period was 10 and 18 g N/m² in 2016 and 2017, resp.. Due to its seaweed content, Matrix added a further 33 g N/m² before sowing, and 2.3 and 4.1 g N/m² in topdressing in 2017 and 2018, resp. This extra N was not compensated for on unamended or Stor-it plots.

Major findings from 2017 are:
- Matrix increased soil water-holding capacity (SWC) at both 0-38 mm and 0-200 mm. Stor-it decreased SWC at 0-38 mm, but gave the same SWC at 0-200 mm as the control
- Matrix resulted in more Microdochium nivale and thus reduced turfgrass quality in spring, but recovery from M. nivale was fast, resulting in better quality during and after the irrigation period in summer/autumn
• Stor-it resulted in lower turf quality than the control throughout the year. It seems to be more effective in wet conditions.
• Both Matrix and Stor-it gave shorter roots but harder playing surfaces than the control.
• Marathon gave equal/better turf colour than Wallco from spring to the first part of the shelter period in June. Wallco produced better turf quality than Marathon during the latter part of the shelter period in July and the two following months. However, despite more annual N being given in autumn in the Wallco than the Marathon treatment, turfgrass colour was better with Marathon than with Wallco by late October. This may be an effect of higher mineralisation of organic matter.
• Study commissioned by Melspring BV, STERF industrial partner. Final report will be made when chemical analyses are completed (Feb. 2018).
EFFECT OF FERTILISER TYPE, SILICON AND COPPER ON TURF QUALITY AND MICRODOCHIUM INFECTION ON A *POA ANNUA* PUTTING GREEN

**PROJECT PERIOD:** MAY 2016 - JUNE 2018

**FUNDING (kSEK)**

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**PRINCIPAL INVESTIGATOR / CONTACT PERSON**

Tatsiana Espevig, The Norwegian Institute of Bioeconomy Research (NIBIO), Dep. Urban Greening and Environmental Engineering, Turfgrass Research Group, Landvik, Reddalsveien 215, 4886 Grimstad, Norway. Phone: +47 406 23 778. E-mail: tatsiana.espevig@nibio.no

**CO-APPLICANTS**

Trygve S. Aamlid and Trond O. Pettersen, NIBIO Turfgrass Research Group, Norway

**PROJECT OBJECTIVES**

To determine the effect of the patented long-lasting organic mineral fertiliser Marathon and the micronutrient mixtures Melgreen Si and Melgreen Cu on microdochium patch and turf quality on an annual meadowgrass golf green.

**TALKS AT CONFERENCES, SEMINARS, MEETINGS ETC. IN 2017**


**PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2018**

A two-factor experiment on a USGA-spec. annual bluegrass golf green at Landvik research station (NIBIO) was run from August 2016.

Factor 1 consisted of two fertiliser regimes: traditional Wallco liquid mineral fertiliser at 2-wk intervals vs. long-lasting Marathon fertilizer at 4-wk intervals. The regimes started on 15 August 2016 and 7 April 2017 and lasted to October 2016 and mid-November 2017, respectively. Total N amounted to 207 and 286 kg ha-1 yr-1 in 2016 and 2017, respectively.

Factor 2 consisted of four treatments: i) negative control (no treatment), ii) positive control (fungicide treatment), iii) micronutrient mixtures (Melgreen Si and Melgreen Cu) and iv) combination of (ii) and (iii). The fungicide was applied each time microdochium patch exceeded 2%, totalling 3 times by 10 January 2017 (4 Oct. 2016, 21 Nov. 2016, 4 Jan. 2017) and 2 times by 4 Jan. 2018 (12 Oct. 2017, 6 Dec. 2017). Diseases, overall impression, density and colour were evaluated throughout the growing season at 4-wk intervals prior to Marathon application. Microdochium patch first appeared in late August 2016 and in mid-September 2017, and the disease was monitored also throughout the winter 2016-17 and 2017-18 as weather conditions allowed. By 6 April 2017, microdochium patch amounted to 2% on the plots treated with fungicides and to 27% on unsprayed plots, with no differences between fertiliser regimes or Melgreen products. On average for monthly recordings in September-November 2017, microdochium patch amounted to 1.7% and 2.5% on Marathon and Wallco plots, respectively. On average for observations from August to October, Marathon plots had better colour than Wallco plots (6.7 vs 6.0 in 2016; 7.2 vs 6.3 in 2017, scale 1-9, 9=best), but there were no differences in overall impression between Marathon and Wallco (4.8 and 4.7, respectively) (Figure 1). No differences in density were seen in 2016, but Wallco plots were somewhat denser than Marathon plots in 2017 (6.8 vs. 6.1, scale 1-9, 9=densest). This was most likely due to 23% higher N amount on Wallco plots than on Marathon plots during spring and early summer.
Figure 1. Better colour on Marathon plots than on Wallco plots on 31 October 2017, one week after Marathon and Wallco were applied. Photo: Tatsiana Espevig.
TESTING THE EFFECT OF ALGAEGREEN® ON WINTER STRESS TOLERANCE

PROJECT PERIOD: JUNE 2016 - MAY 2018

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PRINCIPAL INVESTIGATOR / CONTACT PERSON
Bert Sandell, Norwegian Institute of Bioeconomy Research (NIBIO), Dept. Urban Greening and Environmental Engineering, Turfgrass Research Group, Landvik, Reddalsveien 215, 4886 Grimstad, Norway. Phone: +47 48024780. E-mail: bert.sandell@nibio.no

CO-APPLICANTS
Trygve S. Aamlid, Tatsiana Espevig and Trond Pettersen, NIBIO Turfgrass Research Group, Norway

PROJECT OBJECTIVES
To evaluate the effect of the seaweed product AlgeaGreen® on winter stress tolerance of four turfgrass species maintained on a golf course putting green.

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2018
Seaweed or algae products have become a tool for turfgrass manager as biostimulants. One such product is AlgeaGreen® from the Irish company OGT. According to the label, this biostimulant is extracted from pure Ascophyllum nodosum at low temperature.

Plots of creeping bent (Agrostis stolonifera), red fescue (Festuca rubra), perennial ryegrass (Lolium perenne) and annual meadow grass (Poa annua) were established on a USGA green in June 2016. AlgeaGreen® was applied biweekly at a rate of 15 L/ha from mid-August to late October 2016 and 2017. Turfgrass quality was assessed regularly in autumn 2016, spring 2017 and autumn 2017 and assessments will continue in spring 2018. Plant samples for determination of freezing tolerance (LT50 lethal temperature for 50% of plants) were taken in December 2016 and 2017.

Results from winter 2016-17 showed a significant effect of AlgeaGreen® on freezing tolerance. The mean LT50 value was 1.1°C lower for grass treated with AlgeaGreen® than for the untreated control. There were no significant differences in the field regarding disease, visual performance or chlorophyll index (green colour).

Results from field observations from August to November 2017 and freezing tests in December 2017 have not yet been subjected to statistical analyses.
Recording surviving plants after freezing test. Photo: B. Sandell.
DANDELION MANAGEMENT AT VÄRPINGE GOLF COURSE

PROJECT PERIOD: APRIL 2014 - FEBRUARY 2018

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PRINCIPAL INVESTIGATOR / CONTACT PERSON  
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CO-APPLICANTS  
Anne Mette Dahl Jensen, University of Copenhagen  
Roland Andersson, Toro, Sweden  
Peter Edman, Swedish Golf Federation

PROJECT OBJECTIVES  
• To obtain knowledge regarding dandelion occurrence and dandelion morphology/appearance over the growing season and examine whether these are affected by a vertical cutting regime.  
• To obtain some indications of how dandelions appear over the entire growing season under a frequent mowing/graazing regime.  
• To evaluate the effect of the superficial verticutting on playing quality.

TALKS AT CONFERENCES MEETINGS, SEMINARS, FIELD DAYS, ETC IN 2017  
29 May: Field day at Värpinge GC.

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2018

At Värpinge GC, dandelions (Taraxacum sp.) affect playing quality. Since 2010, special vertical cutting equipment has been tested.

There has been no clear effect of superficial verticutting (of leaves) on dandelion occurrence, overall and at each treatment time. However, there seems to be a tendency for less weeds in general in 2014, compared with 2010 and 2011. The variation within season, between seasons and between the two fairways is pronounced, although the degree of cover of dandelions is generally low, often below 5%. Verticutting of dandelions may thus be a way to manage this weed in order to create a better playing surface.

In 2017, work was performed on the report and a field day was held in spring. At the field day, the project was presented together with other multifunctional initiatives at Värpinge GC. The following themes were presented and discussed:

1. Weed control of dandelion with a special vertical cutter. Weed control was discussed on-site in the trials and weed control equipment (Toro) was demonstrated.
2. Grazing with sheep of the entire course; what it does and how it is achieved in practice.
3. Organic vegetable cultivation in CSA format on golf course roughs. This is a social project in collaboration with Lund municipality.
4. Crane track - free architectural golf course for children up to 12 years. A totally unique course with reversible playing direction devised by the course architect.
Field day at Vårpinge GC. Photo: Anne Mette Dabl Jensen
SELECTION AND MANAGEMENT OF BENTGRASS CULTIVARS
(AGROSTIS SP.) FOR GENETIC AND INDUCED RESISTANCE TO
MICRODOCHIUM PATCH AND PINK SNOW MOULD CAUSED BY
MICRODOCHIUM NIVALE

PROJECT PERIOD: JUNE 2014 - APRIL 2018

FUNDING (kSEK)

\[
\begin{array}{cccccc}
\text{Year} & 2014 & 2015 & 2016 & 2017 & \text{Total} \\
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\text{STERF} & 323 & 492 & 441 & 408 & 1,663 \\
\text{Other sources} & 110 & 183 & 183 & 110 & 586 \\
\text{TOTAL} & 433 & 675 & 623 & 518 & 2,249 \\
\end{array}
\]

Total funding from Canadian sources: CDN$ 148,000/yr for three years from Jan 1 2015 to Dec 31 2017.

PRINCIPAL INVESTIGATOR / CONTACT PERSON
Trygve S. Aamlid, Norwegian Institute for Bioeconomy (NIBIO), Department for Urban Greening and Environmental Technology, Turfgrass Research Group, Landvik, Reddalsveien 215, 4886 Grimstad, Norway. Phone: +47 90 52 83 78. E-mail: trygve.aamlid@nibio.no

CO-APPLICANTS
Tatsiana Espevig, Pia Heltoft and Agnar Kvalbein, NIBIO Turfgrass Research group
Klaus Paaske, Århus University, Denmark
Oiva Niemeläinen, Pentti Ruttunnen and Auli Kedonparä, Luke, Finland
Tom Hsiang, University of Guelph
Annick Bertrand, Agriculture and Agri-Food Canada

PROJECT OBJECTIVES
Overall objective: To reduce the dependence on fungicides in controlling diseases caused by Microdochium nivale on golf courses in Scandinavia and Canada.

Subgoals (each corresponding to a subproject (SP):
- To screen in vitro top-selling cultivars of Agrostis sp. for resistance to M. nivale, with and without cold hardening and with and without application of Civitas One mineral oil, and to identify genotypes that are either resistant or show increased responsiveness to the defence activator
- To validate level of resistance and responsiveness to Civitas One in the most promising cultivars (from subgoal 1) in field trials in contrasting climates in Canada and at NIBIO Landvik and Apelsvoll, Norway.
- To determine the effect of Civitas One on microdochium patch occurring during the growing season or under snow cover in registration trials on golf courses in the Nordic countries.

TALKS AT CONFERENCES, SEMINARS, MEETINGS ETC. IN 2017
7 JUNE: Trial at Apelsvoll visited by group of Danish farmers
21 JUNE: Lecture for 60 participants at NIBIO Turfgrass Field Day
4 OCT.: Trial at Landvik visited by 20 students from Sandmose Greenkeeper School

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2018
Microdochium nivale is a serious pathogen on Nordic golf courses. Resistance to M. nivale can be present irrespective of environmental conditions, or it may require induction by defence activators. Canadian results suggest that Civitas One (CiO), a mixture of isoparaffins and a copper-containing pigment, induces resistance to M. nivale.

This project had three workpackages (WPs). In WP1 we screened 36 bentgrass cultivars, with and without CiO, for resistance to M. nivale in glass vials (Photo 1). The trial was performed three times in growth chambers. Differences in response to CiO were not significant between colonial and velvet bentgrass cultivars. In creeping bentgrass, CiO induced
resistance in Penn A4, Tiger Shark, T1 and Penn G6, but had no or negative effects in Independence, CY2, Alpha, Runner and Declaration.

In WP2, the genetic component was investigated further in field trials at Landvik and Apelsvoll, Norway, from 2015 to 2017. Bentgrass cultivars were compared on unsprayed control plots, plots receiving CiO and plots receiving conventional fungicides. CiO was equally or more efficient than fungicides in controlling *M. nivale* at both sites. The differential response in WP1 was partly confirmed at Landvik, where CiO caused a stronger reduction in *M. nivale* in Tyee, T1 and Penncross than in Declaration, Focus, Independence and 007. On the negative side, the waxy layer after repeated applications of CiO in autumn impaired natural green-up at Apelsvoll in spring 2017 (Photo 2).

In WP3, the effect of CiO was tested in five trials on golf courses in Denmark, Sweden and Finland from 2014 to 2017. In the Danish trials, which had practically no snow, CiO controlled *M. nivale* to the same level as conventional fungicides and significantly better than potassium phosphite. One of the Finnish trials confirmed that high rates of CiO in autumn could thin out the turf in spring, but the problem was overcome within a few weeks. Besides controlling *M. nivale*, an interesting feature of CO in these trials was its ability to act as a sun shield, thus reducing the need for turfgrass to produce anthocyan pigments (and possibly anti-oxidants) after snowmelt (Photo 3).

In summary, this project shows good prospects for CiO to become a viable alternative to conventional fungicides for control of *M. nivale* on Nordic golf courses. The legal rights to CiO in Europe belong to Intelligo (http://www.intelligro.com) and work has started on getting the product to market.
FAIRY RINGS AND THATCH COLLAPSE

PROJECT PERIOD: NOVEMBER 2016 - NOVEMBER 2017

FUNDING (kSEK)

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PRINCIPAL INVESTIGATOR / CONTACT PERSON

Tatsiana Espevig, The Norwegian Institute of Bioeconomy Research (NIBIO), Dep. Urban Greening and Environmental Engineering, Turfgrass Research Group, Landvik, Reddalsveien 215, 4886 Grimstad, Norway. Phone: +47 406 23 778. E-mail: tatsiana.espevig@nibio.no

CO-APPLICANTS

Agnar Kvalbein, NIBIO Turfgrass Research Group, before 1 September 2017
Bert Sandell (NIBIO), NIBIO Turfgrass Research Group, after 1 September 2017

PROJECT OBJECTIVES

• To identify problems on two Norwegian golf courses and test measures such as fertiliser, hand spiking and application of wetting agents.
• To write a short article providing insights into these problems based on practical tests and reports from other countries (mostly United States).

TALKS AT CONFERENCES, SEMINARS, MEETINGS ETC. IN 2017

21 June: Fairy rings. Trial presentation. NIBIO Turfgrass Field day, Landvik, Norway.

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2018

Fairy rings have long been seen as a cosmetic problem on golf courses, but in the past two years they have been reducing playing quality and killing grass on golf greens. The fungi causing fairy rings are not plant pathogens, since they do not permeate the plants. Increasing problems with fairy rings have been attributed to increased use of microbiological products, where these fungi were probably introduced.

Experiments were conducted in summer 2017 on golf greens with creeping bentgrass at NIBIO Landvik, Bjaavann GC (Kristiansand) and Gamle Fredrikstad GC, to evaluate effects of a biostimulant and the wetting agent Revolution (produced by Aquatrols) on fairy rings. At Landvik, the fungicide Amistar (azoxystrobin) was used in tank mixture with Revolution in a treatment applied only once, on 15 June. On the golf courses, Revolution was applied without fungicide monthly from July to September (3 times); on Bjaavann GC, Revolution was also applied regularly in addition to the treatment. The biostimulant was applied monthly from June at Landvik (4 times) and from July to September on the golf courses (3 times).

At Landvik, fairy rings were caused most likely by Bovista plumbea (Type 2 in June and Type 1 in August). There were generally no differences in soil moisture to 7.5 cm depth between treatments except for 2.7% higher soil moisture outside fairy rings compared with inside. Since the fairy rings grew beyond the experimental plots already in July, it was not possible to record their size and thus evaluate treatment effects. Overall impression and colour were generally better on control plots and plots treated with Amistar/Revolution than on plots treated with the biostimulant, but the differences were not significant.

At Bjaavann GK, the fungal species causing fairy rings was not identified, since no fruiting bodies were found. The fairy rings were of Type 2 in June-August and Type 3 (not visible).
early in the spring. The reduction in the size of the rings from August to September was faster on control plots and biostimulant plots than Revolution plots. On 8 August, soil moisture to 12 cm depth was 3% higher outside than inside the fairy rings on control plots, while there was no difference in soil moisture on plots treated with Revolution or the biostimulant.

The problems at Gamle Fredrikstad GK were defined as superficial fairy rings. According to Agne Strom, there were no differences between treatments (the same treatments as at Bjaavann GC).
RISK ASSESSMENT, MANAGEMENT AND CONTROL OF DOLLAR SPOT CAUSED BY SCLEROTINIA HOMOEOCARPA ON SCANDINAVIAN GOLF COURSES

PROJECT PERIOD: APRIL 2017 - OCTOBER 2020

FUNDING (kSEK)

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PRINCIPAL INVESTIGATOR / CONTACT PERSON
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CO-APPLICANTS
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Mariana Usoltseva and Åslög Dahl, Botanisk Analysgrupp /Göteborg Universitet, Sweden
Jo Anne Crouch, Systematic Mycology & Microbiology Lab, Department of Agriculture, USA
Kate Entwistle, The Turf Disease Centre, UK
Roskilde GC and Helsingør GC, Denmark, Vallda GC and Kävlinge GC, Sweden, Drammen GC, Norway

PROJECT OBJECTIVES
- To find the most efficient frequency for rolling and nitrogen rate in dollar spot control on golf greens (WP1)
- To determine the cardinal temperatures for growth of Scandinavian isolates of *S. homoeocarpa* and to assess risk of the pathogen spreading in Scandinavia (WP2)
- To screen the most widely used turfgrass species and cultivars for in vitro resistance to the Scandinavian isolates of *S. homoeocarpa* (WP3)

TALKS AT CONFERENCES, SEMINARS, MEETINGS ETC. IN 2017
04 Oct.: Problem och utmaningar i 2018. M. Usoltseva, ERFA träff SGA. Tjörn GC.
04 Oct.: Soppsykdommer på golfgress. Besøk fra Sandmoseskolen, AMU Nordjylland, Denmark. Landvik
14-15 Nov.: Dollar spot. K. Normann, DGA week.

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2018
Dollar spot was officially documented in Scandinavia in 2013 (Espevig et al., 2014. Plant Dis.) and the disease exists on more than 20 Nordic golf courses. The damage from dollar spot in Scandinavia varies and can be up to 70-80% dead turf on greens and fairways. Even when the disease pressure is low, recovery from dollar spot is very slow and the damage leads to indents on the green surface and to significant lowering of playing quality. This project is seeking to reduce the spread of dollar spot in the Nordic countries and to provide the golf sector and greenkeepers with non-chemical measures for control of this disease. The project consists of three workpackages (WP):

WP1. Effects of rolling, nitrogen (N) or rolling in combination with N are being evaluated on five Scandinavian golf courses. On average for August-September 2017, rolling 2 times...
(R2) and 4 times (R4) per week, starting in June, reduced dollar spot by 61% and 95%, respectively, on a red fescue green in Vallda GC (Fig. 1), compared with no rolling (R0) (79 individual infection centres per 1 m² on R0 plots) (Fig. 2). On a green with red fescue and colonial bentgrass as dominant species on Roskilde GC, R2 and R4 starting in June reduced dollar spot by 37% and 54%, respectively, compared with R0 (19% disease on average for September and October on R0 plots) (Fig. 3). No reduction in dollar spot diseases was found on red fescue greens from a 20% increase in N in July-August from 50 kg ha⁻¹ yr⁻¹ at Helsingør GC and from 22 kg ha⁻¹ yr⁻¹ at Kävlinge GC. No effects of rolling or interactions between rolling and N were observed at Helsingør GC. At Drammen GK, no dollar spot disease was observed in summer-autumn 2017.

WP2. Genetic analysis (ITS region of DNA) of local isolates of *S. homoeocarpa* (SH) from an earlier STERF project on dollar spot revealed that Scandinavian isolates belong to two genetic groups: the first is identical to that in the eastern and midwestern US, while the second is distinct. In an in vitro study in autumn 2017, all local SH isolates had 24°C as the optimal temperature for growth (OGT), while the abovementioned US isolates had both 16°C and 24°C as OGT. After 3 weeks at 0°C, growth of local isolates and British isolates was reduced by 7-36% and 23-38%, respectively, with no reduction in American and a Norwegian isolate.

WP3. Turfgrass resistance to different isolates of *S. homoeocarpa* will be evaluated in 2018.
RISKS OF SURFACE RUNOFF AND LEACHING OF FUNGICIDES FROM GOLF GREENS VARYING IN ROOTZONE COMPOSITION AND AMOUNT OF THATCH

PROJECT PERIOD: MAY 2016 - DECEMBER 2018

FUNDING (kSEK)  

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PRINCIPAL INVESTIGATOR / CONTACT PERSON  

Trygve S. Aamlid, Norwegian Institute for Bioeconomy (NIBIO), Department for Urban Greening and Environmental Technology, Turfgrass Research Group, Landvik, Reddalsveien 215, 4886 Grimstad, Norway. Phone: +47 90 52 83 78. E-mail: trygve.aamlid@nibio.no

CO-APPLICANTS  

Marit Almvik, NIBIO Department for Pesticides and Natural Products Chemistry.  
Agnar Kvalbein, Trond Pettersen and Tatsiana Espevig, NIBIO Turfgrass Research Group

PROJECT OBJECTIVES  

Main objective: To minimise fungicide losses from golf courses.  
Subgoals:  
- To determine sorption coefficients and thus the risk of leaching of prothioconazole, trifloxystrobin, fludioxonil, boscalid, pyraclostrobin and their metabolites  
- To determine the effect of organic matter type (peat or compost) and turf age/thatch accumulation on the risk of leaching and surface runoff of these fungicides and their metabolites

- To provide data for modelling leaching and runoff of fungicides from golf greens  
- To publish the results in ‘Journal of Environmental Technology’ or a similar peer-reviewed journal and to disseminate the findings to the environmental authorities and the golf industry in the Nordic countries and Germany.

TALKS AT CONFERENCES, SEMINARS, MEETINGS ETC. IN 2017

21 June: Preliminary results from project ‘Fungicide leaching and surface runoff from golf greens’. M. Almvik and T.S. Aamlid, NIBIO Turfgrass Field Day, Landvik.  
12 Oct.: Project Update. M. Almvik and T.S. Aamlid, Reference group meeting (Skype).  
27 Oct.: Greenkeeperverband Deutschland, Jahrestagung Potsdam, T.S. Aamlid.

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2018

STERF projects 10-15 years ago studied leaching from sand-based putting greens of azoxy strobin, propiconazole and some fungicides that are no longer permitted on Nordic golf courses. In this new project, we focus not only on leaching, but also on surface runoff of five commonly used fungicides and their metabolites after preventative applications against snow mould in late autumn. Besides STERF, the project is funded by the Norwegian Action Plan for Sustainable Use of Pesticides and by the German Greenkeepers’ Association.

The project will run from 1 May 2016 to 1 December 2018 at NIBIO Landvik, Norway. The plots have 5% slope and a turf cover of creeping bentgrass. The trial has four blocks and two factors, each with two levels:
Delaro (prothioconazole + trifloxystrobin) and Signum (bosalid + pyraclostrobin) are sprayed in late October and Medallion (fludioxonil) in early November. Each application is followed by collection of leachate and runoff until late March.

During the mild winter 2016-17, the mostly unfrozen green had very high infiltration rates: 91% of rainfall from 25 October to 20 March was collected as drainage water and only 3% as surface runoff. Fungicide detections in drainage water were very low, but in runoff water from the soil surface, the environmental safety limits for trifloxystrobin, pyraclostrobin, fludioxonil and the metabolite prothioconazole-desthio were exceeded in water collected 3-4 weeks after application. These findings shows the importance of complying with the minimum distances to open water when spraying fungicides before winter.

The sorption studies showed that the fungicides sorbed strongly to the sodded thatch layer, as expected from the high content of organic carbon in the thatch. Nevertheless, the surface runoff of fungicides was higher from sodded than from sown plots. This could be an effect of water repellency of the thatch layer and/or runoff of soilbound fungicides (erosion). Our results suggest that the risk of surface water contamination will increase as greens become older and accumulate more thatch.

![Tubes filled with methylene-blue used to indicate frost at different soil depths. Photo: Trond Pettersen.](image)
SUCCESSFUL REESTABLISHMENT OF GOLF GREENS FOLLOWING WINTER DAMAGES

PROJECT PERIOD: JULY 2014 - JULY 2017

FUNDING (kSEK)

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1) SEK 20, as in-kind contributions from machine companies and golf courses, was omitted from the budget in 2014 as the demonstration sites were not established until 2015.

PRINCIPAL INVESTIGATOR / CONTACT PERSON

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CO-APPLICANTS

Trygve S. Aamlid and Agnar Kvalbein, NIBIO Turfgrass Research Group Norway
Carl-Johan Lönnberg, Swedish Golf Federation, Sweden
Boel Sandström, Swedish Golf Federation, Sweden

PROJECT OBJECTIVE

The project aims to provide new knowledge that can help greenkeepers achieve faster re-establishment of turf after winter kill. Specific objectives were:

- To give species-specific guidelines for re-seeding after winter kill caused by anoxia
- To investigate how sowing techniques influence the rate of success
- To provide golf clubs with useful information on deciding the optimal time for re-seeding
- To disseminate research-based recommendations to the golf industry

TALKS AT CONFERENCES, SEMINARS, MEETINGS ETC. IN 2017

09 Nov.: Winter challenges at golf courses in Sweden. C.J. Lönnberg, SGF, NIBIO/STERF winter stress conference, Oslo
10 Nov.: Anoxia, spring injuries and reestablishment challenges. W. Waalen, NIBIO/STERF winter stress conference, Oslo

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2018

This project examined some important factors that can influence the success rate in re-establishing golf greens following winter kill.

Work package 1 examined how phytotoxic metabolites, which can be produced during long-lasting ice cover, affect the establishment of different grass species used on golf greens. One field experiment was run at the NIBIO research facility at Apelsvoll in southern Norway in 2015 and 2016. Soil water extracts taken following ice encasement did not negatively affect germination of the various grass species tested in either year compared with saline water or soil water extracts taken from an area that had been killed with glyphosate. This experiment should be repeated on an older green with a higher level of organic matter, as this is expected to aggravate anoxic conditions. Furthermore, seedling root growth and the impact of germination temperature on the re-establishment capacity of the most common turfgrass species were investigated. Rate of germination and seedling root growth have important implications for competition between species on a golf green. *Poa annua* is a very competitive species, due to faster germination at lower temperatures, especially compared with *Agrostis stolonifera* and *Festuca rubra ssp. commutata*. Root growth of *P. annua* was also significantly faster than for the *Agrostis* species tested. Seedlings of *Agrostis*...
species and *F. rubra ssp. communtata* that germinate in close proximity to *P. annua* seedlings run a high risk of being choked out. In order to reduce competition with *P. annua*, early sowing should be avoided. Early sowing and soil disturbance encourage establishment of *P. annua*. Covers should also be used to increase the germination temperature, especially when sowing *F. rubra ssp. communtata* and *A. stolonifera*.

In **Work package 2**, trials were established on ice-damaged greens in Northern Sweden in spring 2015 and 2016, using four different sowing machines. The results showed that sowing techniques which bury the seed and create good seed-soil contact (slit and spike machines) result in more even and dense plant cover than seed drop methods. Moisture and soil temperature must be favourable for good establishment, and covers can be used to speed up re-establishment.

The experimental work was finished in 2016. Project work in 2017 included statistical analyses, publications in Nordic greenkeeper magazines and scientific publications.
PRACTICAL RE-ESTABLISHMENT OF GOLF GREENS FOLLOWING WINTER DAMAGE - A FIELD STUDY

PROJECT PERIOD: APRIL 2017 - JULY 2018

FUNDING (kSEK)

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PRINCIPAL INVESTIGATOR / CONTACT PERSON
Carl-Johan Lönnberg, Svenska Golfförbundet, Box 11016, SE-100 61 Stockholm, Sweden
E-mail: carl-johan.lonnberg@golf.se

CO-APPLICANTS
Boel Sandström, Svenska Golfförbundet

PROJECT OBJECTIVES
• To explore the differences between slit, spike and drop sowing technology and the impact on germination
• To compare two different grass species (rough meadow grass and creeping bentgrass) in terms of germination
• To examine use of wetting agents. Is there any difference in green sward establishment during spring for the two species? Will treatment with wetting agents give more moisture in the top of the green and better and smoother establishment?

TALKS AT CONFERENCES, SEMINARS, MEETINGS ETC. IN 2017
25 Sept.: Successful re-establishment of golf greens following winter damage - a field study. C-J Lönnberg, SGF, Elmia Park & Golf industry show, Jonkoping.


PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2018
The project is being carried out on naturally winter-damaged golf greens in central Sweden. In 2017, the research sites were Surahammars GC and Leksands GC. Four different golf greens were divided into two blocks, with rough meadow grass used in one block and creeping bentgrass in the other. Across the blocks, one half was treated with wetting agent (Primer Select, 20 L/ha) and the other half was left untreated.

Each block was divided into four plots, with replicates:
• Control (no seed)
• Vertical cutting + drop sowing,
• Slit sowing
• Spike sowing.

The results from the trial varied depending on weather and how the spring developed. A significant factor in 2017 was low ground temperature, which impeded establishment. The results showed that the seed must have good contact with soil for establishment to be successful. In 2017, the slit sowing method was clearly the best, compared with drop sowing, spike sowing and the control treatment. Rough meadow grass germinated faster and there was a large difference between the species. The wetting agent had no effect on germination.
May 2nd, Surahammars GK.

May 23rd, Surahammars GK.
WINTER DAMAGE TO GOLF GREENS IN THE NORDIC COUNTRIES: SURVEY OF CAUSES AND ECONOMIC CONSEQUENCES (PART II)

PROJECT PERIOD: JANUARY 2017 - JULY 2018

FUNDING (kSEK)

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PRINCIPAL INVESTIGATOR / CONTACT PERSON

Tatsiana Espevig, Norwegian Institute of Bioeconomy Research (NIBIO), Dept. Urban Greening and Environmental Engineering, Turfgrass Research Group, Landvik, Reddalsveien 215, 4886 Grimstad. Phone: +47 406 23 778. E-mail: tatsiana.espevig@nibio.no

CO-APPLICANTS

Trygve S. Aamlid, NIBIO Turfgrass Research Group

PROJECT OBJECTIVES

- To publish a final report from Survey 2015 about winter damage to Nordic golf courses
- To analyse the remaining 11 questions (of 24) on common practices for preparing golf greens in autumn, including autumn fertilisation practices, use of fungicides, mechanical treatments, common winter work on golf greens including winter covers, snow and ice removal
- To bring new information about the economic consequences of winter damage related to number of holes, grass species and geography.

TALKS AT CONFERENCES, SEMINARS, MEETINGS ETC. IN 2017


PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2018

It has long been claimed that turfgrass winter damage is a significant economic burden for golf courses in the Nordic countries. To confirm this claim, in 2015 NIBIO and NGF, with the support of STERF, conducted an internet-based survey about winter damage in the five Nordic countries (Denmark, Finland, Iceland, Norway and Sweden). More than 300 golf courses participated. These data gave solid information about the type and severity of winter damage on golf greens and factors affecting this (Kvalbein et al., 2016). The comprehensive survey also showed that the total costs of repair of winter-damaged greens and fairways, together with lost revenue from players in the Nordic countries, amount to at least €14 million. In a year with significant winter damage, the average cost to repair the turf was between €3000 and €12,000 on 88% of the courses. The revenue loss after a winter with considerable damage was less than €6000 on 50% of the courses, while 25% of the courses reported a loss pf between €6000 and €12,000.

The causes of winter damage varied depending on geography. Biotic factors played a major role in southern Scandinavia, while ice and water damage were most devastating north of 60°N. The answers from the respondents were analysed in relation to dominant grass species.
As for autumn fertilisation practices, the Nordic survey 2015 showed that autumn N application is common practice on several golf courses in Scandinavia. In particular, in Sweden, Norway, Iceland, Finland and Denmark, 54%, 52%, 30%, 17% and 11%, respectively, of golf courses are fertilised until frost comes.

There are still 10 of 24 questions that have not been analysed. The remaining data deal with aspects such as fungicide use, winter covers, mechanical treatments, snow and ice removal, other winter management actions, and economic impacts of winter damage in relation to golf course size. Mapping winter problems and the factors affecting them in the Nordic countries will contribute to identification of areas for new research.
FROM DENSE SWARDS TO BIODIVERSE ROUGHS

PROJECT PERIOD: JUNE 2017 - DECEMBER 2020

FUNDING (KSEK)

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1) Reserved, but not granted

PRINCIPAL INVESTIGATOR / CONTACT PERSON
Hans Martin Hanslin, Norwegian Institute of Bioeconomy Research (NIBIO), Dept. Urban Greening and Environmental Engineering, Særheim Research Centre, Postvn. 213, N-4353 Klepp St., Tel: + 47 90 50 12 79, hans.martin.hanslin@nibio.no

CO-APPLICANTS
Trygve Aamlid, NIBIO Turfgrass Research Group
Johannes Kollmann, Technical University Munich
Tommy Lennartsson, Swedish Biodiversity Centre, SLU
Ellen Svalheim and Eveliina Kalloniemi, NIBIO Turfgrass Research Group

PROJECT OBJECTIVES
Main objective: To provide knowledge of management strategies to enhance diversity of flowering plants and pollinators in roughs to be used in further development of multifunctional golf courses.
Specific objectives:
• To study specific effects of sward cutting frequency, biomass removal and soil carbon addition on rough productivity and establishment of sown target species
• To critically test the use of hemiparasitic Rhinanthus minor as a method to diversify roughs
• To assess whether cutting combined with temporal nitrogen immobilisation by incorporating carbon sources in soil improves establishment of seeded species relative to cutting only
• To quantify the effects of diversification measures on pollinator visiting rates and composition of the pollinator community, and relate these to provision of resources for pollinators
• To evaluate filtering effects of management treatments on sown species depending on their specific germination and establishment traits
• To explore the effect of management regimes on the playability of roughs

TALKS AT CONFERENCES, SEMINARS, MEETINGS ETC. IN 2017
21 Sept.: Field day, Royal Castle Park, Oslo (Aamlid, Svalheim, Hanslin).

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2018
Golf courses have high potential to support biodiversity and ecological functions in the landscape while maintaining high-quality playing conditions. As many courses are located on fertile soils, management of soil fertility is the key to supporting more diverse vegetation and to providing resources for pollinators. This project is examining how to use cutting regimes, soil amendments, seed addition and hemiparasitic plants to reduce grass dominance and improve biodiversity on roughs. A field experiment will be conducted at Oslo GC and demonstrations at Sigtuna GC and Herning GC from 2017 to 2020. Local wild flower mixtures will be sown and the development of botanical composition and pollinators...
monitored. The knowledge generated will enable golf clubs to decide how to enhance biodiversity under their particular conditions. Results will be disseminated through field days, two popular articles and a fact sheet, an information video and a scientific paper.

Locations were selected and experimental treatments started 2017 for all eight locations, including the two demonstration fields. Pollinators and vegetation were recorded according to plan and soil samples collected for chemical analyses. A test of the relationship between standing vegetation biomass and playability was run at Oslo GC. Raw material for a video was also recorded. This video will be edited early 2018 and made available at sterf.se. The information posters planned at participating golf clubs will be changed to outdoor information boards by the experimental plots. Herning GC already has one installed.
GOLF CLUBS AS LANDSCAPE PLAYERS
– ESTABLISHMENT OF COLLABORATION NETWORKS IN THE
LANDSCAPE FOR ENHANCED CONTRIBUTION TO THE 2030 AGENDA
ON SUSTAINABLE DEVELOPMENT

PROJECT PERIOD: AUGUST 2017 - JUNE 2018

FUNDING (kSEK) 2017 2018 Total
STERF 281 368 649
Other sources 0 0 0
TOTAL 281 368 649

PRINCIPAL INVESTIGATOR / CONTACT PERSON
Phone: +46 070-273 09 45. Email: anders@mannature.se

CO-APPLICANTS
Malena Heinrup, Project manager, Man & Nature AB

PROJECT OBJECTIVES
To investigate how golf courses can contribute to enhanced multifunctionality on landscape level, thus advancing their contribution to the 2030 Agenda implementation process in the Nordic countries. Subgoals are:
• To identify existing or potential functions/values on golf courses, apart from golf playing, that could benefit from collaboration on landscape level. The values/functions should contribute to multifunctionality of the landscape and not only matter for the course and club members (e.g. outdoor recreation, cultural history, biodiversity, education)
• To determine the global goals to which the identified functions contribute
• To identify actors in the surrounding landscape that would benefit from collaborating with the golf club and other relevant actors when developing the identified values/functions. The collaboration should also benefit the golf club in a win-win relationship
• To examine how long-term collaboration between golf clubs and actors in the surrounding landscape can be developed to advance the contribution to the 2030 Agenda implementation process and enhance multifunctional values in the landscape.

TALKS AT CONFERENCES, SEMINARS, MEETINGS ETC. IN 2017
10 Oct.: Golf clubs as landscape players. Project presentation. M. Heinrup, Assarbo GC.
2 Nov.: Golf clubs as landscape players. Project presentation. M. Heinrup, Larvik GC.
13 Nov.: Golf clubs as landscape players. Project presentation. M. Heinrup, Linköpings GC.
Nov.-Dec.: Presentation of the project orally and by mail to all landscape actors interviewed (37 so far). These landscape actors represent different organisations (departments at the municipality, sports clubs, local associations) working closely with the project golf clubs and many have spread information about the project within their respective organisations.

ONGOING: Information about the project in the Facebook group “Turfgrass”, which has 595 members (Dec 2017) and is directed at greenkeepers, and pictures from our visit at Asserbo GC. Torben Kastrup Petersen (DGU).

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2018
Multifunctional golf facilities can contribute a multitude of societal benefits, such as biodiversity and outdoor recreation. Today, the work to implement the UN’s 2030 Agenda for Sustainable Development and the 17 global goals are gaining attention world-wide. The cross-sectoral and cross-scale nature of the goals, spanning issues such as health, food
production and climate change, stresses the relevance and importance of viewing the landscape through a multifunctional lens.

This project is investigating how golf clubs can contribute to enhanced multifunctionality on landscape level by collaborating with other actors, thereby advancing their contribution to the 2030 Agenda implementation process in the Nordic countries. At three sites, we will carry out social-ecological inventories to identify key collaboration partners in the landscape. A workbook will be produced to inspire collaborative processes between golf clubs and other actors in the landscape.

During 2017, we recruited three courses to participate in the project: Asserbo GC (Denmark), Larviks GC (Norway) and Linköpings GC (Sweden). We made our first visits to the clubs (second visit will be for the workshops in spring 2018), met club representatives and interviewed them about existing/potential values and previous/ongoing/potential collaborations. Identification of landscape actors is finished in Sweden and Norway. So far, we have interviewed 16 landscape actors in Norway (we will add a couple more in January) and 21 in Sweden. These landscape actors, representing different perspectives on and knowledge about the development of the landscape, will meet at workshops in 2018. They can assist in, and benefit from, development of one or more of the values to be discussed at the workshop. Examples of landscape actors included in the study are: municipal departments (sports & recreation, nature, culture, health etc.), local business associations, local branches of national associations working with e.g. trekking and tourism, outdoor recreation, art and nature conservation; schools, museums, and organisations for people with disabilities.

Visit at Linköpings GC. Photo: Anders Esselin
GO OUTDOORS AND USE THE GOLF COURSE IN AN EDUCATIONAL WAY – CREATIVITY, LEARNING AND HEALTH IN THE UNLIMITED CLASSROOM

PROJECT PERIOD: MAY 2017 - DECEMBER 2018

FUNDING (kSEK)

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PRINCIPAL INVESTIGATOR / CONTACT PERSON
Anders Szczepanski, Spetsa AB (Linköping University Holding AB, Linköping University)
Teknikringen 10, 583 30 Linköping, Sweden, E-mail: anders.szczepanski@liu.se

CO-APPLICANTS
Helene Nord, Spetsa AB, Linköping University

PROJECT OBJECTIVES
• Investigate the most suitable methods for outdoor learning on golf courses during all four seasons
• Identify themes and subjects based on the curriculum for primary schools (LGR 11) that are suitable for outdoor learning on golf courses
• Develop a pilot model and practical guidelines for outdoor teaching on golf courses in compulsory school years 1-6
• Connect the outdoor learning activities to the norms and value in the Swedish (LGR 11) guidelines and curriculum and to the Swedish right and public access to nature
• Evaluate the ways of learning and experiences by teachers and pupils through interviews and open questions in a phenomenographical study over time 2017-2018

TALKS AT CONFERENCES, SEMINARS, MEETINGS ETC. IN 2017
Ongoing:
Articles in local newspapers, website and local TV
Project presentation by A. Szczepanski

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2018
This project is part of STERF’s programme Multifunctional use of golf facilities and ecosystem services focusing on the golf course as a teaching facility/outdoor classroom. Golf courses could contribute to improved teaching by offering a variety of green areas for outdoor teaching. Using golf course land as outdoor classrooms could become particularly important since the majority of the world’s population now live in urban landscapes and local areas suitable for outdoor activities are getting scarce.

In this proof-of-concept study, one pilot school, Smedsbyskolan, with 15 teachers has been part of an outdoor education intervention and training at Motala golf club. In close collaboration with teachers and golf course staff, we have investigated the most suitable methods for outdoor teaching on golf courses and the most suitable areas of the golf
course to be used as an outdoor classroom. A training course for participating teachers was carried out in autumn 2017. We have developed learning tools and implemented knowledge and skills connected to the Swedish curriculum and subjects like geography, languages, mathematics, technology, ecology and biology. The activity and reflection have been documented by the teachers in a school blog. There are also documents at the primary school in Motala from the outdoor course that we initiated and which was implemented by the teachers in their classes. In the coming spring, the children will visit their new classroom at the golf course.

The first survey with open questions about the teachers’ experience in the area of outdoor education has been carried out. Preliminary results from the study show that teachers can see the advantage of the outdoor learning situation to support the indoor learning in the classroom. However, it takes time for some teachers and also for pupils to understand that the outdoor environment is their new classroom. This phenomenographical study will be conducted with interviews and research questions after we have finished the training in June 2018.
COMPLETED PROJECTS

The projects listed below were funded by STERF during the period 1999-2017. More information about the projects can be found on the STERF website www.sterf.org


27. **Nordic cooperation between authorities and non-governmental organisations for creating multifunctional golf courses and healthy ecosystems.** Maria Strandberg, Scandinavian Turfgrass and Environment Research Foundation. January (2010–2011)


29. **Optimal maintenance for hardening and early spring growth of green turfgrass.** Karin Blomback, Department of Soil and Environment, Swedish University of Agricultural Sciences (2006-2013)

30. **Development of methods for non-pesticide weed control on golf fairways.** Anne Mette Dahl Jensen, Forest & Landscape, University of Copenhagen-LIFE (2008-2013)

31. **Preservation of cultural landscapes and cultural heritage elements on golf courses.** Ole R. Sandberg, Department of Landscape Architecture and Spatial Planning, Norwegian University of Life Sciences (2009-2013)

32. **Interactive map with navigation to learn and understand environmental work and impacts at a golf course.** Magnus Enell, Enell Sustainable Business AB (2011-2013)

33. **Integrated pest management - communication project within the park and golf sector.** Maria Strandberg, Scandinavian Turfgrass and Environment Research Foundation (2011-2013)
34. Evaporative demands and deficit irrigation on sand-based golf greens. Trygve S. Aamlid, Norwegian Institute for Agricultural and Environmental Research (2008-2014)


38. Effects of mowing height, N-rate and P-rate/mycorrhiza on quality and competition against annual meadowgrass on putting greens with red fescue as predominant species. Tatiana Espevig, Norwegian Institute for Agriculture and Environmental Research (2011-2015)


42. A comparison of the soil surfactant Qualibra and Revolution on creeping bentgrass greens varying in water availability. Trygve S. Aamlid, Norwegian Institute for Agricultural and Environmental Research (2014-2015)


44. FESCUE-GREEN: Best management of red fescue (Festuca rubra) golf greens for high sustainability and playability. Trygve Aamlid, NIBIO (2011-2016)

45. Overseeding of Fairways - A strategy for finer turf with less broad-leaved weeds and Poa annua. Anne-Mette Dahl Jensen, University of Copenhagen (2011-2016)

46. Identification and risk assessment for dollar spot on Scandinavian golf courses. Tanja Espevig, NIBIO (2014-2016)

47. Experience mapping and multifunctional golf course development - enhanced possibilities of increased and more varied use of golf courses. Ole Hjorth Caspersen, University of Copenhagen (2011-2016)


52. Evaluation of the soil surfactant Qualibra on sand-based putting greens. Trygve S. Aamlid, NIBIO (2015-2016)

53. Evaluation of Aquatrols experimental biostimulant formulations on fine turfgrass subjected to wear, drought (nutrient) and winter stress. Agnar Kvalbein, NIBIO (2015-2016)


56. Evaluation of a phosphite pigment, alone and in combination with fungicides, for control of turfgrass winter diseases on green and fairway. Trygve S. Aamlid, (2016-2017)
## STERF KEY INDICATORS 2006 - 2017

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* Project proposals received by 1 December 2013
** New projects approved for funding in February 2014. Funding of new projects started in 2014.
*** Project proposals received by 9 December 2016.
**** New projects for which funding was agreed in March 2017. Funding of new projects started 2017.

The key indicators are based on information in project annual reports. STERF issues an open call for proposals approximately every two years. In exceptional circumstances, a project application may be approved for funding by the STERF board in between the open call for proposals.
### FINANCIAL SUMMARY

#### INCOME STATEMENT

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LIST OF PUBLICATIONS

FULL PAPERS IN INTERNATIONAL PEER REVIEWED JOURNALS

Aamlid, T.S., B. Molteberg, F. Enger, Å. Susort, Å. & A.A. Steensohn 2005a. Evaluation of Agrostis and Festuca varie-

Aamlid, T.S., M. Larsbo & N. Jarvis 2007. Effects of a surfac-

Aamlid, T.S., M. Larsbo & N. Jarvis 2008. Effects of wet-


Aamlid, T.S., M. Larsbo & N. Jarvis 2009. Effects of surfac-
tant use and peat amendment on leaching of fungicides and nitrate from golf greens. Biologia 64: 419-423.

Aamlid, T.S., M. Larsbo & N. Jarvis 2009. Effects of the non-ionic surfactant Revolution and peat amendment on leach-


Aamlid, T.S. et al. 2012. Irrigation strategies and soil surfac-


Aamlid, T.S., T.E. Andersen, A. Kvalbein, T. Pettersen & A.M.D. Jensen 2013. Composted garden waste as organic amend-
ment to the USGA-green rootzone and topdressing sand on red fescue (Festuca rubra) greens. European Journal of Horticultural Science 79(3): 87-96.


Aamlid, T.S., T. Espevig & A. Tronsmo 2016. Microbial pro-

Aamlid, T.S., H. Riley, A. Kvalbein, T. Pettersen & J.W. Knox 2016. Irrigation strategies on sand-based, creep-
ing bentgrass (Agrostis stolonifera) putting greens. In:


Eriksson, F., T. Eriksson & M. Ignatieva 2015. Golf courses as part of urban green infrastructure: Social aspects of golf courses and extensively managed turfgrass areas from a Nordic perspective, Proceedings from 52nd IFLA Congress, June 6-7 2015, St. Petersburg Russia: 474-478


LIST OF PUBLICATIONS STERF 63
Aamlid, T.S., T. Espevig & B. Sandström 2013. Vilka svamp- 
bevampningsmedel skall vi använda hösten 2013 och hur 
många bevampningar är nödvändiga? http://www.sterf.org
Aamlid, T.S. & A.M.D. Jensen 2017. Nytt forskningsprosjekt: Risiko for uttekkning och överflateav-
remning av soppmidler från onduerade, sandbaserade greener. 
Gressforum 2016(3): 10-12.
Aamlid, T.S., T. Espevig, S. Calvache Gil & A. Kvalbein 2017. Engrapgræs som greengræs? 
Aamlid, T.S. & B. Sandström 2016. Planera frönkjköpet 
nytt STERF-program: Framkalla resistens mot Microdochium 
Aamlid, T.S. 2015. Fortsat stort behov for oplæring i IPM på 
golfbanerne. Nyttigt møde mellom STERF og de nordiske 
myndigheder om planterovningsmidler. Greenkeeperen 29( 
3): 34-35.
Aamlid, T.S., T. Espevig & T. Pettersen 2014. Bekjemping av overvintringssopp på 
greener. Kan mikro-
biologiske preparat eller alginaeter ersätta kjemiske plante-
Bekjemping av overvintringssopp på greener. Kan mikro-
Bekjemping av overvintringssopp på golfbaner. Nyttigt 
med mellom STERF og de nordiske 
myndigheder om planterovningsmidler. Greenkeeperen 29( 
3): 34-35.
Aamlid, T.S. & B. Sandström 2016. Planera fröinnkjöpet 
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golfbanerne. Nyttigt møde mellom STERF og de nordiske 
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