RESEARCH AND DEVELOPMENT YEARBOOK 2018

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RESEARCH AND DEVELOPMENT YEARBOOK 2018. STERF. SCANDINAVIAN TURFGRASS AND ENVIRONMENT RESEARCH FOUNDATION

STERF YEARBOOK 2018

Fifteen years ago, Scandinavian golfers acted as both initiators and early adopters when they decided to contribute €0.5/year to research on sustainable golf, a decision that has been recognised all over the world. This farsighted decision to invest in ready-to-use research is today an important contribution by the golf sector to minimising factors affecting climate change, stopping the accelerating loss of biodiversity and meeting the increasing need for sustainably managed green areas in the urban landscape.

Ready-to-use research is an important tool to help prevent negative impacts on the planet and new knowledge is necessary to change the mind-set and attitudes of people worldwide. A global agenda is needed to guide this work. The best available agenda at present is the United Nation's 2030 Agenda for Sustainable Development with its 17 Sustainable Development Goals (SDGs), which was adopted in 2015 (sustainabledevelopment.un.org.)

During 2018, STERF contributed to the fulfilment of seven of the 17 SDGs in Agenda 2030. These were:

1. Sustainable use of natural resources and chemicals (SDGs 12, 14, 15).
2. Ecosystem services and enhanced biodiversity (SDGs 14,15).
3. Adapting to a changing climate and minimising factors affecting climate change (13).
4. Sustainable cities and communities (SDG 11).
5. Healthy lives and well-being for people of all ages (SDG 3).
6. Partnership for sustainable development and for new regulations (SDG 17).

These goals are closely related to the turfgrass industry´s everyday challenges and to STERF's programmes, projects and dissemination efforts. They should thus be used as the framework for efforts by all within the turfgrass industry.

To achieve maximum impact from the turfgrass sector´s sustainability work in the future, it is of the utmost importance to establish international interdisciplinary collaborations, where all stakeholders make efforts to cooperate and align their resources and efforts using Agenda 2030 as a global steering document. STERF is very proud to have important followers and partners in this strategic work. The European Golf Association has formed a sustainability expert committee, the R&A has launched a Golf Course 2030 initiative and the Federation of European Greenkeepers' Associations has taken a decision to increase research on sustainable golf. We hope that these initiatives will be followed by many more.

All efforts count when it comes to improving the environment, no matter how small they are. What is important is that we start acting now! We hope that the projects and activities presented in this annual report will inspire others to begin working proactively to effect change.

Bruno Hedlund
STERF Chairman

IMPORTANT EVENTS IN 2018

TWO NEW VIDEOS

From dense sward to biodiverse roughs

Golf courses have considerable potential to support biodiversity and prevent habitat loss in the peri-urban landscape. The aim of the STERF project 'From dense swards to biodiverse roughs' is to provide knowledge of management strategies that can enhance the diversity of flowering plants and pollinators in golf course roughs. In 2018, this project produced a video showcasing various methods to reduce soil fertility, and thus grass dominance, before sowing a native wild flower seed mixture. Most of the video was produced at Oslo GC and included interviews with the course manager and the researchers responsible for the project. It sparked considerable interest, not at least from the environmental authorities. The video can be found at http://www.sterf.org/sv/about-sterf/news-archive/dense-swards-video

The golf course as an outdoor classroom

Children's learning experience can be improved if part of the teaching takes place in a natural outdoor environment. Using golf courses and the land that surrounds them as outdoor classrooms could become particularly important at a time when most of the world's population lives in urban landscapes and when local areas suitable for outdoor activities are becoming scarce.

In collaboration with a local primary school, Motala Golf Club in Sweden participated in a STERF project about outdoor teaching. The teachers and the golf course staff investigated the best methods for outdoor teaching on golf courses and the most suitable areas of the golf course for use as an outdoor classroom. The game of golf was used to help train children to focus and concentrate.

A training course for participating teachers was held in autumn 2017 and the children visited their new classroom at the golf course in spring 2018. Through this project, Motala Golf Club has become a pilot model for outdoor teaching on golf courses, and experiences from the project are presented in a video of inspiration. The video with English subtitles can be found at: http://www.sterf.org/sv/about-sterf/news-archive/inbjudan-skolseminarium

IRRIGATION WORKSHOP

With very limited rainfall and temperatures 2-4 °C higher than the long-term average, May-July 2018 became one of the worst drought periods ever recorded in Northern Europe. This extreme situation highlighted a need for more knowledge about saving water and about efficient irrigation practices on golf courses. By coincidence, 2018 was also the final year of the STERF project 'Engineering better irrigation in turf', in which an irrigation workshop had been scheduled well before the 2018 growing season.

The workshop took place at Furesö GC, Copenhagen, on 20 June. Ph.D. student Carlos Gomez-Armayones and his supervisor, Jerry Knox of Cranfield University, presented results from his research into the adequacy, uniformity and sensitivity to wind of irrigation systems with various sprinkler pressures and placements. Trygve Aamlid of NIBIO also presented previous STERF projects on evaporative demands, irrigation scheduling and the need for soil surfactants on greens and fairways. After these lectures, the participants went outside for a practical training session on how to monitor irrigation uniformity on one of the greens at Furesø GC. The number of participants, most of them Danish greenkeepers, was limited to 30 to ensure practical hands-on experience for everyone. Evaluation forms collected at the end of the day showed that the participants found this workshop very useful and that similar training days should be set up also in the other Nordic countries. Thanks to course manager Thomas Pihl for excellent facilitation.

NATIONAL VERSIONS OF THE WINTER STRESS MANAGEMENT HANDBOOK

During 2018, the very important handbook 'The Golf Course Managers' Handbook on Turfgrass Winter Stress Management', with practical advice and recommendations, was translated into Swedish and Norwegian and launched at several seminars. The handbook summarises results and experiences from several research projects related to turfgrass winter stress, focusing on winter stresses caused by: 1) winter diseases, 2) ice and water damage and 3) desiccation/spring challenges.

NEW HANDBOOK ON GOLF CLUBS AS FRONTRUNNERS FOR SUSTAINABLE DEVELOPMENT

2018 saw the release of a new step-by-step workbook, tailor-made for golf clubs, for mapping values, functions and activities on and beyond golf facilities, and also for finding key partners and engaging them in multifunctional projects that contribute to sustainable development (Agenda 2030).

The handbook is based on a project showing that multifunctional golf clubs contribute significantly in a landscape perspective to the United Nation's Agenda 2013 Sustainable Development Goals, e.g. SDG 3 (Good health and well-being), SDG 6 (Clean water and sanitation), SDG 11 (Sustainable cities and communities), SDG 12 (Responsible consumption and production), SDG 15 (Life on land) and SDG 17 (Partnership for the goals).

TRANSLATION OF FACT-SHEETS TO ICELANDIC AND FINNISH

Global warming is likely to have an impact on certain types of winter damage in specific geographical regions, but winter survival continues to be the foremost challenge in turfgrass management in the Nordic countries. As an aid to greenkeepers trying to prevent or escape winter hazards, the joint Scandinavian/Canadian digital library consisting of 10 fact-sheets on winter stress management was published online by STERF in 2018 (www.sterf.org.) All fact-sheets were produced in English, Swedish, Norwegian and Danish back in 2016-2017. During 2018, many of these fact-sheets were also translated to Icelandic and Finnish.

NATIONAL SEMINARS IN ALL NORDIC COUNTRIES

Effective dialogue between researchers and practitioners is necessary to identify research priorities in new fields and to ensure that newfound knowledge is transferred into practice. Seminars and workshops are arranged regularly by the Nordic golf federations in collaboration with STERF to facilitate this dialogue. To guarantee continuous implementation of new knowledge, managers of STERF-funded project act as speakers at these seminars.

During 2018, a number of national seminars were arranged in the Nordic countries. These seminars focused on presentation and discussions on new knowledge delivered by different STERF projects. In total, more than 400 practitioners from the golf industry participated in the seminars.

SIXTH EUROPEAN TURFGRASS SOCIETY CONFERENCE

Since the foundation of the European Turfgrass Society (ETS) in 2007, the biennial ETS conferences have been an important meeting place for the turfgrass industry.

The ETS conferences are a forum for excellence for scientists, consultants, companies and practitioners to discuss technical issues related to the turfgrass industry. The sixth conference was held in Manchester, United Kingdom, in June 2018. The theme of the conference was different shades of green for the many and varied sports surfaces and amenity facilities the industry encompasses. Researchers and turfgrass professionals from 19 different countries participated in the conference. The two-day programme included 43 oral and poster presentations. STERF researchers contributed 10 presentations.

VISIT TO NORTHEAST AGRICULTURAL UNIVERSITY, HARBIN, AND TO CHINA AGRICULTURAL UNIVERSITY, BEIJING

In October 2018, Maria Strandberg, STERF, and Trygve Aamlid, NIBIO, were invited to Northeast Agricultural University, Harbin, and to China Agricultural University, Beijing. The purpose of this visit was 'Communication, visiting and learning'. This was an important initiative taken by Northeast Agricultural University. It gave us the opportunity to improve and extend an important international interdisciplinary collaboration, which is the only viable strategy to overcome current challenges and create a sustainable future. During the visit, Maria and Trygve gave guest lectures on Global challenges are the turfgrass specific challenges, including presentation of a number of STERF projects, and on Turfgrass nutrition, including STERF's model for 'Precision Fertilization' and results from the ongoing SUSPHOS project. We were also able to meet with faculty members and students. A field trip to the joint turfgrass trials at Beijing Jingshan Lake Golf course was included in the programme.

It was a great honor that Trygve Aamlid was appointed Honorary Professor at Northeast Agricultural University, Harbin.

Students and professor at NEAUIMG

MEETING WITH RESEARCHERS REPRESENTING USGA

On 23-26 April 2018, Professor Eric Watkins, University of Minnesota, visited Norway to study winter damage to golf courses and discuss future collaborations between USGA and STERF. With regard to damaged greens and research plots, Eric's visit certainly paid off, as many of the golf courses in SE Norway had experienced their most severe winter damage for more than 20 years, due to ice encasement.

A meeting between Eric, Maria Strandberg, STERF, and NIBIO researchers took place at NIBIO Apelsvoll, Norway, on 23 April. Other researchers from the US and Scandinavia participated via Skype. Several research initiatives were discussed, some of which have already resulted in joint research proposals to USGA (July 2018), STERF and the Research Council of Norway (Oct. 2018), and in a pre-proposal to USDA (Dec. 2018).

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 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.

BACKGROUND

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.

R&D is, and will continue to be, a necessary and strategically important investment for the golf sector in achieving economically and environmentally 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.

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.

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 programmes 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 na¬tural 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

14TH INTERNATIONAL TURFGRASS RESEARCH CONFERENCE 2021

The 14th International Turfgrass Research Conference 2021 (ITRC 2021) will be arranged by STERF and held in Copenhagen on 11-16 July 2021.

Turfgrass industry challenges relating to the United Nation's Agenda 2030 Sustainable Development Goals (SDGs) will constitute the conference programme framework. We have identified seven SDGs related to the turfgrass industry: SDG 3 (Good health and well-being), SDG 11 (Sustainable cities and communities), SDG 12 (Responsible consumption and production), SDG 13 (Climate action), SDG 14 (Life below water), SDG 15 (Life on land) and SDG 17 (Partnership for the goals).

The theme of the conference is development and sustainability. Climate change impacts are exceeding the worst expectations, strong restrictions on the use of chemicals, fertilisers and energy are expected and there is accelerating loss of urban green areas and biodiversity. All this calls for more research and innovation for the future. The conference programme will focus on increased sustainability by a multidisciplinary approach; science in action by ready-to-use research; and mobilising forces from academia to industry.

New for this conference is The One-Day Practitioner Seminar, a meeting arena for practitioners and turfgrass researchers, which will strengthen the ambition to take a lead in making research results and new knowledge easy accessible to end-users and to provide support to implement changes.

The conference is an arena established to exchange knowledge and experiences with the best experts in this field. It will bring together researchers, greenkeepers, superintendents, planning authorities, technical experts, consultants, high level turfgrass managers and top industry delegates. This will give us the best opportunities to improve and extend important international interdisciplinary collaboration, which is the only viable strategy to overcome the current challenges and create a sustainable future.

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 the electric city bikes around the old maritime city.

The most recent information about ITRC 2021 can be found on www.itrc2021.org.

SCANGREEN: TURFGRASS SPECIES, VARIETIES, SEED BLENDS AND MIXTURES FOR INTEGRATED PEST MANAGEMENT OF SCANDINAVIAN PUTTING GREENS

PROJECT PERIOD: JANUARY 2015 – APRIL 2019

FUNDING (kSEK)

	2015	2016	2017	2018	Total
STERF	481	638[1]	563	569	2 251
Other sources	225	80	80	180	565
TOTAL	706	718	643	749	2 816

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 northern environments

TALKS AT CONFERENCES MEETINGS, SEMINARS, FIELD DAYS, ETC IN 2018

21 Mar.: Nytt om sorter, artsblandinger og konkurranse mellom gressarter på greener. Norwegian Golf Federation Seminar, Oslo (T.S. Aamid T. Pettersen, P. Heltoft, W. Waalen & J. Tangsveen)
23 & 24 Apr.:Visit by Prof. Eric Watkins, University of Minnesota to SCANGREEN trials at Apelsvoll and Landvik. P. Heltoft, W. Waalen, T. Espevig & T.S. Aamlid.
14 June: Visit by students from the Danish greenkeeper school AMU Sandmosen to the SCANGREEN trial at Landvik. T. Espevig & T.S. Aamlid.
15 Oct.: Guest lecture at Northeast Agricultural University, Harbin, China: Evaluation of turfgrass species and varieties for northern areas. T.S. Aamlid
17 Oct.: Guest lecture at China Agricultural University, Beijing, China: Evaluation of turfgrass species and varieties for northern areas. T.S. Aamlid
22 Dec.: Visit by Morten Eirik Engelsjord, Floratine, and Bjørn Molteberg, Strand Unikorn, to trial at Apelsvoll. P. Heltoft.
10 Nov.: Det gresselige året 2018: Fra isskader til tørkestress. NGF's 'Golfforum 2018', Gardermoen Norway.
23 Nov.: Lecture at HGU (Högare Greenkeeperutbildning), Stockholm: Turfgrass species and varieties for Nordic golf courses. T. S. Aamlid
12 Dec.: Visit by 18 Icelandic greenkeepers to trial in Reykjavik (B. Hannesson).
12 Dec.: Det gresselige året 2018: Fra isskader til tørkestress. Norwegian Greenkeeper Association Seminar Drøbak, Norway
Throughout 2018: Trial at Sydsjælland GC visited by individual greenkeepers (about 20 visits), two greenkeeper groups and several times by DLF and other seed companies.

Eric Watkins, Maria Strandberg and NIBIO scientists studying winter survival in the SCAN-GREEN trial at Apelsvoll, April 2018.

PROJECT SUMMARY AND STATUS BY 1 JANUARY 2019

Breeding and evaluation of turfgrass varieties is a key factor to better turf quality. STERF has since 2003 tested species and varieties under realistic green conditions, including wear from pedestrian- type wear machines equipped with golf spikes.

SCANGREEN 2015-2018 was carried out at NIBIO Apelsvoll, Norway (62°N) and Korpa GC, Reykjavik, Iceland (64°N) and in the northern zone, and at NIBIO Landvik, Norway (58°N) and Sydsjælland GC, Denmark (56°N) in the southern zone. The trials included 25 candidate varieties and seven controls representing eight different species. *Festuca* sp., *Lolium perenne* (*Lp*) and *Poa pratensis* (*Pp*) were mowed at 5 mm, other species at 3 mm. Pesticides were never used in the trials. Unlike former test rounds, SCANGREEN 2015-2018 also include seed blends of *Festuca rubra*.

Ranking for turfgrass quality over the four year testing periode produced the following lists among new varieties (refernce variety underlined):

Agrostis stolonifera:
Northern zone: Luminary = Riptide > Flagstic = Ignite > Independence > Crystal Blue = Memorial > Valderrama >> Pure Distinction
Southern zone: Luminary = Flagstick > Riptide = Pure Distinction > Independence > Ignite > Crystal Blue = Valderrrama > Memorial

Agrostis capillaris:
Northern zone: Heritage > Jorvik > 'DLF-PS-AT 3026' = Teetop >> CT 3030
Southern zone: 'DLF-PS-AT 3026' > Heritage > Jorvik = Teetop > CT 3030.

Festutca rubra* ssp. *commutata:
Northern zone: Musica = Humboldt = Barchip > Wagner 1 > Aureline
Southern zone: Musica > Humboldt > Barchip > Wagner 1 > Aureline

Festutca rubra* ssp. *litoralis:
Northern zone: Cezanne > Mirador > Borluna = Aporina
Southern zone: Cezanne > Aporina = Mirador > Borluna

Poa trivialis:
Northern zone: Sabrena = Dark Horse > Winterway > Qasar
Southern zone: Sabrena = Qasar > Dark Horse = Winterway

Lolium perenne:
Northern zone & southern zone: Chardin = Clementine > Rinovo

Within *Festuca rubra*, a blend of 75 % *F.r. commutata* Musica and 25 % F.*r. litoralis* Cezanne produced significantly better quality than the pure refernce varieties and other weight ratios in the northern zone. In the southern zone seed blends should include at least 50 % *F.r. litoralis.*

Complete results from the fourth SCANGREEN test round will be published at www.scanturf.org and www.sterf.org in March/April 2019.

ENGINEERING BETTER IRRIGATION IN TURF: QUANTIFYING IMPACTS OF APPLICATION UNIFORMITY ON TURF QUALITY IN GOLF

PROJECT PERIOD: OCTOBER 2014 - JUNE 2018

FUNDING (kSEK)

	2014	2015	2016	2019	Total
STERF	437	237	0	75	749
Other sources	0	0	281	0	281
TOTAL	437	237	281	75	1 030

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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 2018

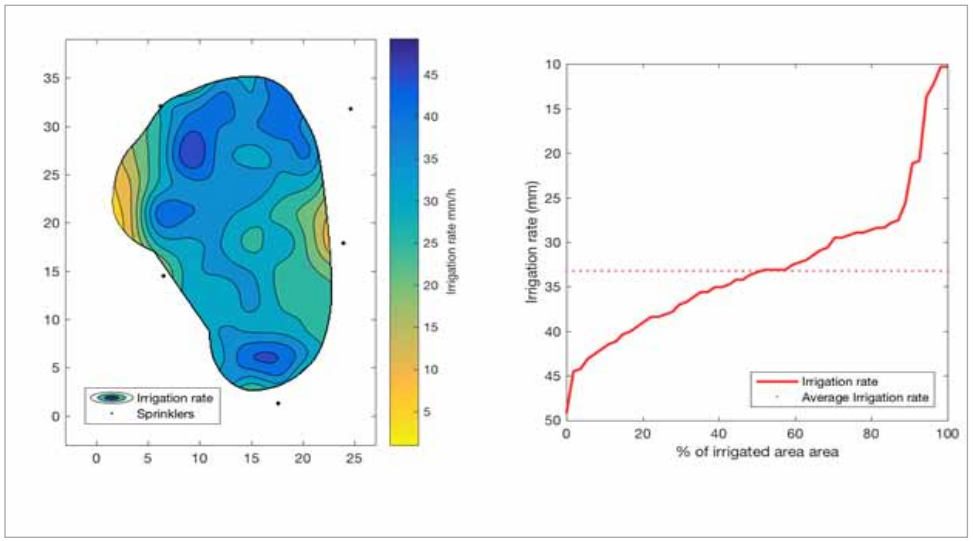
20 June: Furesø GK, Copenhagen. STERF Irrigation training day.
- Irrigation impacts on turfgrass agronomy and playability. T.S. Aamlid.
- Understanding the fundamentals of irrigation system performance and management. J. Knox.
- Simulating the impacts of irrigation performance on turfgrass growth and nutrient management. C. Gómez Armayones.
- Evaluating your irrigation system: Measuring uniformity and adequacy. J. Knox.

22 Nov.: Stockholm lecture HGU. Vatten som tillväxtfaktor. T.S Aamlid.
10 Nov.: Gardermoen, Oslo. NGF's 'Golfforum 2018'. Det gresselige året 2018: Fra isskader til tørkestress. T.S. Aamlid, A. Holmgeirsson & O. Tidemann.
12 Dec.: Drøbak GK, Norway. Norwegian Greenkeepers' Association Regionsamling for Sørøstlandet. Det gresselige året 2018: Fra isskader til tørkestress. T.S. Aamlid, A. Holmgeirsson & O. Tidemann.
Oct : Portugal Trioa. European Turfgrass Producers Seminar and Golf Expo. Engineering better irrigation - quantifying impacts of non-uniformity in golf. J.W. Knox.
July: European Turfgrass Society ETS Congress, Manchester UK. Simulated impacts of irrigation performance and management on turfgrass under northern European conditions. J.W. Knox, C. Gómez Armayones & T. Aamlid.

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2019

This project aimed to quantify links between irrigation heterogeneity (non-uniformity) and turf management and provide industry guidelines for greenkeepers and course managers on irrigation management and reducing environmental impacts. The 3-year PhD study

Conducting an irrigation uniformity field test Denmark in June 2017. Photo: C Gómez



Spatial distribution of irrigation rates (mm h^{-1}) (left panel) and percentage of green area that received at least the scheduled irrigation rate (mm h^{-1}) (right panel) for a sample green in Scandinavia.

combined fieldwork in the UK, Denmark and Norway to (i) calibrate and validate a ballistics model for simulating 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 work was informed by liaising with greenkeepers and key informants in 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.

Modelling turf growth and development STICS model successfully calibrated and validated and then used to model a range of irrigation system and irrigation scheduling scenario.

Modelling showed that system design plays a crucial role in achieving high irrigation uniformity, particularly sprinkler position and spacing. Greater spacing between sprinklers decreased irrigation rates and significantly decreased uniformity, particularly at wind speeds >2 m s^{-1}. The pressure and nozzle sizes tested did not significantly affect uniformity. Non-uniform irrigation had a considerable impact on the spatial variability in turf growth, soil moisture content, drainage and leaching. In the northern European climate, irrigation strategy had a more significant impact on turfgrass response than irrigation uniformity. A moderate deficit strategy (replacing 60% potential evapotranspiration) gave the highest growth rates (233 ± 10.6 g m^{-2}), reduced irrigation water use and minimised nitrate leaching in drainage. An inadequate irrigation schedule combined with poor irrigation uniformity (CU <60%) led to a threefold increase in water use and 114% and 50% increase in drainage and nitrate leaching, respectively. Inadequate irrigation practices had little impact on turfgrass growth, which could be misleading as excess irrigation might not affect plant growth and visual quality but would mask poor irrigation uniformities, leading to water overuse and an increased risk of groundwater contamination.

SUSPHOS: SUSTAINABLE PHOSPHORUS (P) FERTILISATION OF GOLF COURSES

PROJECT PERIOD: APRIL 2017 - DECEMBER 2020

FUNDING (kSEK)

	2017	2018	2019	2020	TOTAL
STERF	525	551	452	458[1]	1986
Other sources	149	177	177	173	676
TOTAL	674	728	629	631	2662

PRINCIPAL INVESTIGATOR / CONTACT PERSON

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Micah Woods, Asian Turfgrass Center, Bangkok, Thailand
Yajun Chen, Northeast Agricultural University, Harbin, China
Kim Sintorn, Swedish Golf Federation
Niels Dokkuma, Netherlands Golf Federation
Wolfgang Prämassing, University of Applied Sciences, Osnabrück, Germany
Dean Cleaver, Federation of European Greenkeepers' Associations

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:

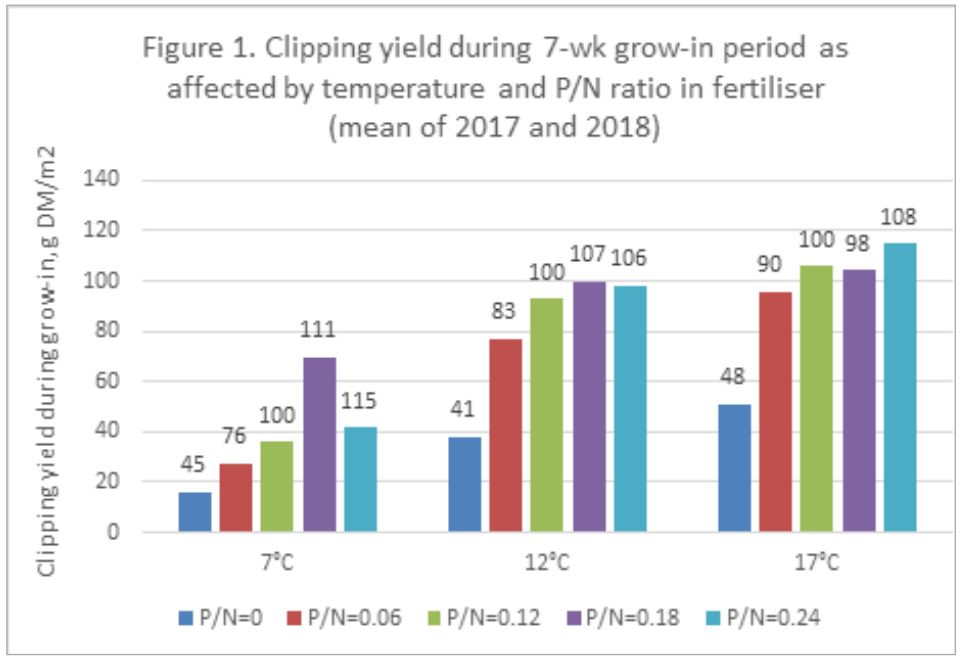
- To determine the need for extra P fertiliser for turfgrass establishment or re-establishment on sand-based golf greens with low soil P values and at various temperatures (WP 1)
- To determine the effect on time of green-up and turfgrass quality of foliar or granular applications of increasing amounts 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 2018

22 Feb. : Webinar for Federation of European Greenkeeper Associations (FEGGA), Sofia, Bulgaria. A comparison of two fertiliser models for golf courses: (1) (Scandinavian) Precision Fertilisation and (2) Minimum Levels of Sustainable Nutrition (MLSN) as exemplified by the STERF project SUSPHOS: T.S. Aamlid.
15 Feb.: Project/reference group meeting on Skype: SUSPHOS: Sustainable phosphorus (P) fertilisation on golf courses (2017-20). A.F. Øgaard & T.S. Aamlid.
15 Oct. : Guest lecture at Northeast Agricultural University, Harbin, China: Turfgrass nutrition: STERF's model for 'Precision Fertilisation' and the SUSPHOS project. T.S. Aamlid.
17 Oct. : Guest lecture at China Agricultural University, Beijing, China: Turfgrass nutrition: STERF's model for 'Precision Fertilisation' and the SUSPHOS project. T.S. Aamlid.
23 Nov. : Lecture at HGU (Högare Greenkeeperutbildning), Stockholm: Gödning, näringsupptag, 'Minimum level of sustainable nutrition' og STERFs projekt SUSPHOS.

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2019

Phosphorus (P) causes eutrophication and is the plant nutrient with the most limited global reserves. The turfgrass SLAN ('Sufficiency Level of Available Nutrients') recommendation to maintain soil P levels at >54 mg P/kg (Mehlich 3) has been challenged by MLSN ('Minimum Level of Sustainable Nutrition') suggesting a critical soil level of only 21 mg P/



Eric Watkins Anne Falk Øgaard and Trygve S. Aamlid discussing newly seeded trial in phytotrone, April 2018. Photo: Lily Watkins.

kg. MLSN usually means lower P inputs than the STERF recommendation for precision fertilisation (PF), in which P is given at a constant ratio to nitrogen (P/N = 0.12) irrespective of soil level. However, the PF recommendations were developed for established turf and have not been verified for turfgrass establishment from seed.

This projects compares P-inputs according to PF, MLSN and SLAN on sand-based greens. Work-package (WP)1 focuses on turfgrass grow-in, i.e. the developmental phase usually considered to require most P, especially at low soil temperature. In spring 2017 and 2018, turfgrass coverage, clipping yields, root development and P uptake at constant N but increasing P rates were studied over a 7-8 wk period after sowing creeping bentgrass in cylinders filled with silica sand (pH:5.3; Mehlich 3: 12 mg P/kg,) in phytotrones at 7, 12 and 17°C.

While control cylinders without P fell significantly behind, turfgrass coverage did not respond to a higher P/N ratio than the PF norm of 0.12 at any temperature. In contrast, there was a trend for clipping yields to increase up to P/N=0.24 (Figure 1). This was confirmed by leaf analyses showing above-ground dry matter production to be P-limited if the P/N ratio in input fertiliser was <0.18. Turfgrass top/root ratio always increased with higher P/N ratio.

WP2 is also conducted in phytotrons at 7, 12 and 17 °C in April and May and compares increasing inputs of foliar or granular P for faster green-up of established creeping bentgrass turf in spring. One more round of this trial will be conducted in 2019, but results to date show no benefit of either foliar or granular P on a sand with Mehlich 3 = 44 mg P/kg.

In WP3, field trials comparing zero P vs. P inputs according to SLAN, MLSN and PF models on golf courses in China, Netherlands, Sweden and Norway were accompanied by one new trial established in May 2018 at Dütetal GC, Germany. Observations from some of these trials show certain trends, e.g. better recovery in spring and more *Poa annua* with increasing P input. Observations will continue for two more years, and it is too early to conclude.

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)

	2016	2017	2018	Total
STERF	0	0	0	0
Other sources	95	96.4	47.5	238.9
TOTAL	95	96,4	47.5	238.9

PRINCIPAL INVESTIGATOR / CONTACT PERSON
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CO-APPLICANTS
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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.

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2019
A 2-factor experiment was conducted on a USGA-spec. annual bluegrass golf green at NIBIO research station Landvik from August 2016 to May 2018. Factor 1 consisted of two fertiliser programmes: traditional Wallco liquid mineral fertilizer at 2-wk intervals vs. long-lasting Marathon fertilizer at 4-wk intervals.

The programmes started on 15 Aug. 2016 and 7 Apr. 2017 and lasted to late October in 2016 and to mid-November in 2017. The total N dose 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 fungicides were applied each time microdochium patch exceeded 2%, in total 3 times in 2016-17 (4 Oct. 2016, 3 Jan. and 23 Feb. 2017) and 2 times in 2017-18 (12 Oct. and 6 Dec. 2017). Disease, 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 in winter 2016-17 and 2017-18 as weather conditions allowed.

In both years, Marathon significantly improved the colour of the annual bluegrass green, most likely due to a higher iron content in Marathon than in Wallco. In autumn 2017, Marathon also reduced microdochium patch and improved overall impression in spite of lower density on Marathon plots vs. Wallco plots. Marathon can be recommended for use on golf greens instead of Wallco, because of longer fertilisation interval (less labour), better colour and better overall impression.

While there was no significant effect of Melgreen Si or Melgreen Cu on microdochium patch, the experiment should be repeated as the annual bluegrass green died in the second winter due to abiotic winter damage.

Trond O. Pettersen applies Melgreen Cu to the annual bluegrass experimental golf green at Landvik on 26 October 2017. Photo: Tatsiana Espevig.

Better colour on Marathon plots than on Wallco plots on the annual bluegrass experimental golf green on 30 January 2018. Photo: Tatsiana Espevig.

EFFECT OF SOIL AMENDMENTS AND FERTILISER TYPES ON TURFGRASS VISUAL QUALITY, GROWTH RATE, PLAYING QUALITY AND THATCH CHARACTERISTICS ON A LOW-FERTILITY, USGA-SPEC. CREEPING BENTGRASS PUTTING GREEN, PHASE II

PROJECT PERIOD: MAY 2016 - MARCH 2019

FUNDING (kSEK)

	2017	2018	Total
STERF	0	0	0
Other sources	370	21	391
TOTAL	370	21	391

PRINCIPAL INVESTIGATOR / CONTACT PERSON

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CO-APPLICANTS

Trond O. Pettersen, NIBIO Turfgrass Research Group, Norway

PROJECT OBJECTIVE

- To study the effect of Melspring's soil amendments Matrix and Stor-it and Marathon fertiliser on turfgrass quality, growth rate, playing quality and organic matter accumulation over a longer period than was possible during phase I of this project.
- To specifically study the effect of Marathon TCR and a revised application scheme for Matrix and Stor-it adapted to Nordic climate conditions.

TALKS AT CONFERENCES, SEMINARS, MEETINGS ETC. IN 2018

3 July: European Turfgrass Conference, Manchester, UK. Effect of soil amendments and fertilizer types on turfgrass visual quality, growth rate, playing quality and thatch characteristics on a low-fertility, USGA-spec. creeping bentgrass putting green. T.S. Aamlid.

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2019

One-year extension of a project started in 2016 to evaluate Melspring/Olmix' sand/soil improvers Stor-it and Matrix, both containing natural zeolite and Matrix also containing seaweed. The amendments were mixed at 10% (v/v) ratio into the top 5 cm on a USGA-spec. green with an initial organic matter content of 0.8% (Sphagnum peat) before sowing creeping bentgrass on 9 June 2016. Stor-it and Matrix increased the pH and cation exchange capacity of the substrate and accelerated bentgrass establishment significantly compared with the unamended control. The fastest grow-in was achieved with Matrix, which, unlike Stor-it, contained 1.1% N and increased the water-holding capacity of the upper rootzone.

After grow-in was completed, Stor-it and Matrix continued to be added in the monthly topdress. Plots were split into four subplots with Melspring's organomineral fertiliser Marathon or the readily available liquid mineral fertiliser Wallco (control, 2-wk interval, but same total N rate) under two irrigation regimes. During this period, both Stor-it and Matrix resulted in firmer greens, while overall turf quality was improved by Matrix, but reduced by Stor-it, compared with the unamended control. Matrix also incurred two disadvantages: reduced root depth and more microdochium patch. The effects of Marathon vs. Wallco fertiliser were mostly insignificant except that Marathon gave lower N concentration in turfgrass clippings in both 2016 and 2017, suggesting that this fertiliser needed more time to trigger a microflora conductive to mineralisation.

In phase II of the project, starting 1 May 2018, the protocol was modified to optimise use of Stor-it, Matrix and Marathon under Nordic climate conditions. Marathon TCR (Turf Core Renovator) was introduced as an alternative to topdressing with Matrix during the first part of the season (until 1 August), after which Stor-it was used in all treatments to lower the soil water content and enhance rooting before winter. Furthermore, application of Marathon was discontinued in mid-September, one month before Wallco, to avoid microdochium patch in late autumn and winter. These changes clearly improved the performance of the Melspring/Olmix products in 2018. In particular, the combination of Marathon and Marathon TCR improved turfgrass recovery after a tough winter and alleviated the potentially negative effect of autumn-applied Stor-it on turfgrass quality in spring.

The Melspring trials survived the winter 2017-19 despite severe ice encasement (left photo taken 20 March). Spring recovery was faster on plots amended with Matrix than on unamended plots and plots amended with Stor-it (right photo taken 19 April). Photos: Trygve S. Aamlid.

TESTING THE EFFECT OF ALGAEGREEN® ON WINTER STRESS TOLERANCE

PROJECT PERIOD: JUNE 2016 - MAY 2018

FUNDING (kSEK)

	2016	2017	2018	Total
STERF	0	0		0
Other sources	100	100	135	335
TOTAL	100	100	135	335

PRINCIPAL INVESTIGATOR / CONTACT PERSON

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CO-APPLICANTS

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 2019

Seaweed or algae products have become a tool for turfgrass managers as biostimulants. One such product is AlgeaGreen® from the Irish company OGT. According to the label, this biostimulant has been extracted from pure *Ascophyllum nodosum* at low temperature.

Plots of creeping bent (*Agrostis stolonifera*) 'Independence', chewings fescue (*Festuca rubra* spp. *commutata*) 'Musica', perennial ryegrass (*Lolium perenne*) 'Chardin' and annual meadow grass (*Poa annua*) were established on a USGA green at NIBIO Landvik in June 2016. AlgeaGreen® was applied every second week at a rate of 15 L/ha from mid-August to late October 2016 and 2017. Turfgrass quality and diseases (microdochium patch, red thread, take-all, anthracnose and superficial fairy rings) were assessed and leaf chlorophyll index was measured regularly in autumn 2016, spring 2017 and autumn 2017. In autumn 2017 there was a tendency for AlgeaGreen to increase leaf chlorophyll index, exacerbating fairy rings in creeping bent but not in the other species. Otherwise, there was no effect of AlgeaGreen on quality characteristics determined in the field.

Freezing tolerance of the turfgrasses (LT50, lethal temperature for 50% of plants) was determined on 28 Nov. 2016 and 24 Nov. 2017. Results from the first freezing test in 2016 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 (-21.5 °C vs. -20.4 °C, respectively). In 2017, the mean LT50 value for untreated grass and grass treated with AlgeaGreen® was -18.5 °C and -18.8 °C, respectively, but the difference was not significant. The ranking in freezing tolerance among the grass species in 2016 and 2017 was as follows: creeping bent (-27.8 °C and 28.7 °C) > chewings fescue (-20.2 °C and -17.5 °C) > perennial ryegrass (-18.1 °C and -13.8 °C) = annual meadow grass (-17.5 °C and -14.6 °C).

Regrowth of annual bluegrass (orange labels), ryegrass (green labels), Chewings fescue (red labels) and creeping bent (purple labels) after freezing test, 11 December 2017. Photo: Tatsiana Espevig.

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 - DECEMBER 2018

FUNDING (kSEK)

	2014	2015	2016	2017	TOTAL
STERF	323	492	441	408	1 663
Other sources	110	183	183	110	586
TOTAL	433	675	623	518	2 249

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

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David Widmark, HS-konsult, Uppsala, Sweden
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 2018
23 Mar.: Vinteren 2017-18 i golfanlegget på Landvik. Norwegian Golf Federation Seminar, Oslo. T.S. Aamlid.
23 April: Fungicides and alternative products for control of Microdochium nivale. Talk at meeting on Transatlantic collaboration on turfgrass research (STERF, USGA, NIBIO, UMASS, MSU). NIBIO Apelsvoll, Norway. T.S. Aamlid.
14 June: Ongoing STERF projects. Lecture for 20 greenkeeper students from AMU Sandmosen visting Landvik. T.S. Aamlid.
3 July: Resistance to Microdochium nivale and abiotic damage as affected by Civitas One™ in a selection of creeping bentgrass cultivars. 6th European Turfgrass Conference, Manchester UK. T.S. Aamlid.
3 July: Evaluation of Civitas One™, alone or in combination with fungicides and potassium phosphite, for control of Microdochium nivale on Nordic golf greens. Oral presentation at 6th European Turfgrass Conference, Manchester, UK. T.S. Aamlid.
10 Nov.: Det gresselige året 2018. Lecture about winter stress management at NGF's 'Golfforum 2018', Gardermoen. T.S. Aamlid.
27, 28, 29 and 30 Nov. : Vinteroverlevelse av gress på golfbaner: hva dreper gress og hva kan gjøres? Modern banskötsel. Svenska Golfförbundet. (Jönköping, Örebro, Stockholm x 2), Sweden. T. Espevig.
12 Dec.: Det gresselige året 2018. Lecture about winter stress management for Norwegian Greenkeeper Association, Drøbak Norway. T.S. Aamlid.

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2019

Microdochium nivale is a serious pathogen on Nordic golf courses. Resistance to *M.nivale* can be present in all environmental conditions, or may require induction by defence activators. Canadian results suggest that Civitas One™, a mixture of isoparaffin and a copper-containing pigment, induces resistance to *M.nivale*.

In WP1 of this project, we screened 36 bentgrass cultivars, with and without Civitas One™, for resistance to *M.nivale* in glass vials. The trial was replicated three times in growth chambers. Differential response to Civitas One™ was not found in colonial or velvet bentgrass, but creeping bentgrass showed a significant interaction as Civitas One™ induced resistance in 'Penn A4', 'Penn G2', 'Penn G6', 'Focus', 'SR 1150', 'Bengal' and 'MacKenzie', but had phytotoxic effects and reduced overall turf quality in 'Independence', 'CY2', 'Alpha', 'Runner' and 'Cato'.

In WP2, the genetic component was investigated in field trials at Landvik and Apelsvoll, Norway. Bentgrass cultivars were compared on unsprayed control plots, plots receiving Civitas One™ (54 ha^{-1}) and plots receiving traditional fungicides. Civitas One™ was equally or more efficient than fungicides in controlling *M.nivale* at both sites. At Landvik there was also a carry-over effect as Civitas One™ applied in autumn 2015 and 2016 resulted in less abiotic damage in spring 2018 (Photo 1). On the negative side, the waxy layer after repeated applications of Civitas One™ in autumn impaired natural green-up at Apelsvoll in spring 2017.

In WP3, the effect of Civitas One™ (27 and 54 L ha^{-1}) was tested in five trials on golf courses in Denmark, Sweden and Finland, 2014-2017. In the Danish trials, with practically no snow, Civitas One™ controlled *M.nivale* to the same level as traditional fungicides and significantly better than potassium phosphite. One of the Finnish trials confirmed that high rates of Civitas One™ in autumn could thin out the turf in spring, but the problem was overcome within weeks. Besides controlling *M.nivale*, an interesting feature of Civitas One™ in these trials was its ability to act as a sunshield, reducing the need from grass to produce antocyan pigments after snow melt.

Thus Civitas One™ can become a viable alternative to traditional fungicides for control of *M.nivale* on Nordic golf courses. The legal rights to Civitas One™ in Europe belongs to Intelligo (http://www.intelligro.com) and work is underway on getting the product to market.

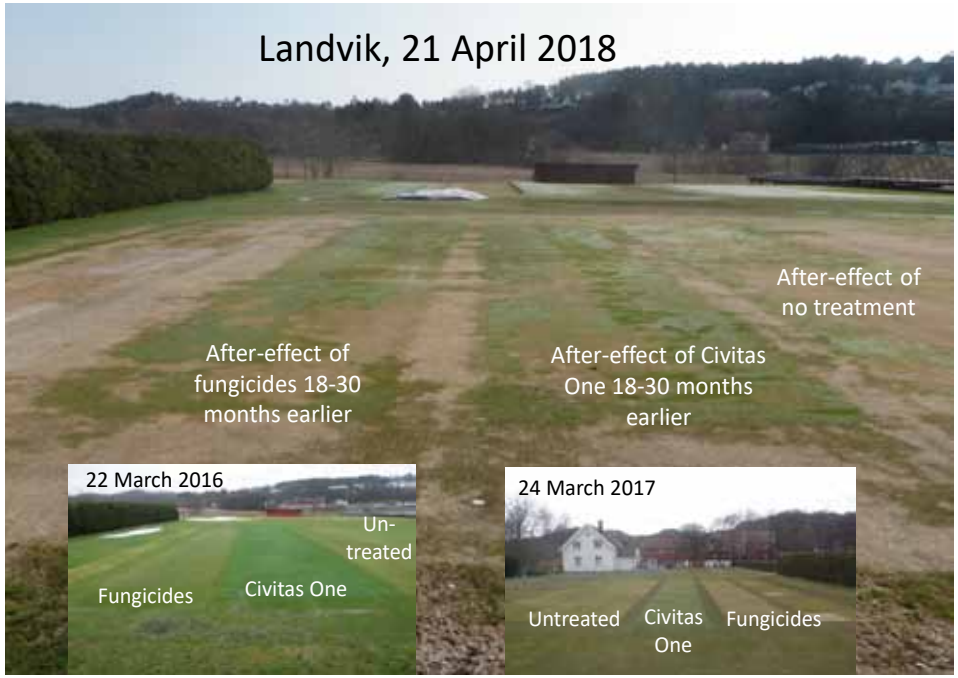

Photo 1. Effects of Civitas One on turf quality and winter survival at Landvik. Photo: T.S. Aamlid.

RISK ASSESSMENT, MANAGEMENT AND CONTROL OF DOLLAR SPOT CAUSED BY *CLARIREEDIA* SPP. ON SCANDINAVIAN GOLF COURSES

PROJECT PERIOD: APRIL 2017 - OCTOBER 2020

FUNDING (kSEK)

	2017	2018	2019	2020	TOTAL
STERF	365	490	382	135	1372
Other sources	334	364	54	25	777
TOTAL	699	854	436	160	2149

PRINCIPAL INVESTIGATOR / CONTACT PERSON

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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 2018

3 July: Entwistle K., T. Espevig, J. A. Crouch, K. Normann and M. Usoltseva. 2018. The effect of temperature on the in vitro growth rate of Sclerotinia homoeocarpa isolates of different origin. Eur. Turfgrass Soc. Conf., 6th, Manchester, UK.
2 July: Espevig T., K. Normann, S. Nilsson, N. Bosholdt and M. Usoltseva. 2018. Rolling reduces dollar spot on golf greens in Nordic countries. Eur. Turfgrass Soc. Conf., 6th, Manchester, UK.
14 June: Soppsykdommer på gress med vekt på myntflekk. Besøk fra Sandemose skole, Landvik. T. Espevig.
21 Mar.: Risiko for myntflekk på Nordiske golfbaner. NGF Anleggsseminar, Oslo. T. Espevig.
Sept.: Problem och utmaningar i 2018. SGA ERFA träff. Sept. 2018, Tjörn GK, Sweden. M. Usotseva.
27 Nov.: Ny forskning om Dollar spot. Modern banskötsel. Svenska Golfförbundet, Jönköping, Sweden. T. Espevig.
28 Nov.: Ny forskning om Dollar spot. Modern banskötsel. Svenska Golfförbundet, Örebro, Sweden. T. Espevig.
29 Nov.: Ny forskning om Dollar spot. Modern banskötsel. Svenska Golfförbundet, Stockholm, Sweden. T. Espevig.

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2019

Dollar spot (DS) was officially documented in Scandinavia in 2013 and today is present on more than 20 Nordic golf courses. Damage from DS 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 DS is very slow and the damage leads to indents on the green surface and significant lowering of playing quality. The aim of this project is to reduce the spread of DS 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):

Figure 1. *Field trial at Kävlinge GC on effects of nitrogen fertilisation (150 kg N ha^{-1} in April-October vs. 150 kg N ha^{-1} in April-October + 90 kg N ha^{-1} in summer) on severity of dollar spot, 21 August 2018. Photo: Marina Usoltseva.*

Figure 2. *Screening of turfgrass species and cultivars in vitro for resistance to dollar spot. Photo: Tatsiana Espevig.*

WP1. In summer 2017, on golf greens with red fescue (Vallda GC) and with red fescue, colonial bentgrass and annual bluegrass (Roskilde GC), rolling 2 times per wk reduced DS by 61% and 37% and rolling 4 times per wk reduced DS by 95% and 54%, respectively. Dollar spot did not develop on these experimental golf greens in 2018, most likely due to an extreme dry summer. Increasing N dose from 150 to 240 kg ha^{-1} yr^{-1} reduced DS by 24% on a red fescue/annual bluegrass green in Kävlinge GK in 2018 (Fig. 1).

WP2. In autumn 2017, all local isolates of *Clarireedia* spp. had 24 °C as the optimal temperature for growth (OGT), while isolates from the US had both 16 °C and 24 °C as OGT. Both 0 °C and 40 °C reduced growth by almost 100%. After 3 wk at 40 °C, all isolates were dead. After 3 wk at 0 °C, growth of Scandinavian and British isolates was reduced by 7-36% and 23-38%, respectively, with no reduction in an American and a Norwegian isolate. This indicates certain potential of the isolates for winter survival.

WP3. In spring 2018, 20 widely used turfgrass species and cultivars were tested for resistance to 10 different isolates from Norway, Denmark, Sweden, UK and US in NIBIO laboratory at Landvik (Fig. 2). The incubation temperatures were 14 °C night and 19-20 °C day. Preliminary results show the following ranking of resistance in turfgrass species (from most to least resistant): ryegrass > red fescue ≥ Kentucky bluegrass ≥ velvet bent ≥ creeping bent & colonial bent & annual bluegrass. There was great variation in resistance among the cultivars and in aggressiveness of the isolates. The most aggressive isolates were one from UK and two from the US, the weakest was from Norway and the second weakest from UK (isolates from Denmark and Sweden were intermediate). The experiment will be repeated in 2019.

RISKS OF SURFACE RUNOFF AND LEACHING OF FUNGICIDES FROM GOLF GREENS VARYING IN ROOTZONE COMPOSITION AND AMOUNT OF THATCH

PROJECT PERIOD: MAY 2016 - MAY 2019

FUNDING (kSEK)

	2016	2017	2018	2019	TOTAL
STERF	303	294	86	75	758
Other sources	518	422	259	94	1292
TOTAL	821	716	345	169	2052

PRINCIPAL INVESTIGATOR / CONTACT PERSON

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CO-APPLICANTS

Marit Almvik, NIBIO Department for Pesticides and Natural Products Chemistry.

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 2018

14 June: NIBIO Landvik. Foredrag for greenkeeperstudenter fra AMU Sandmosen Danmark Introduksjon til NIBIO Turfgrass Group og eksempler på forskingsprosjekter. T.S. Aamlid.

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2019

This project examines leaching and surface runoff of five fungicides and their metabolites after prophylactic application against snow mould in autumn. Field work was conducted in winter 2016-17 and 2017-18 at NIBIO Landvik, Norway. The plots had 5% slope and creeping bentgrass turf. The trial had four blocks and two factors, each with two levels:

Factor 1: Organic amendment to the sand-based (USGA) rootzone:	Factor 2: Turf age / thatch thickness
1.Sphagnum peat, loss on ignition 1.1 %, pH 5.5	A. Green sown in May 2016
2.Garden compost, loss on ignition 1.0 %, pH 6.5	B. Green established in May 2016 using sand-based sod, thatch layer 20 mm

In both years, Delaro SC 325 (prothioconazole + trifloxystrobin) and Signum (boscalid + pyraclostrobin) were sprayed in mid/late October and Medallion TL (fludioxonil) was sprayed in early/mid-November, followed by collection of leachate and runoff until the last snow or ice melt in late March/early April.

The experiment on 23 March 2018, after the snow above ice cover had been removed three times during the previous winter. Photo: Trygve S. Aamlid.

In winter 2016-17, the mostly unfrozen greens had very high infiltration rates: 91% of 601 mm precipitation that fell from first fungicide application to the last sampling was collected as drainage water and only 3% as runoff. Winter 2018-19 had 975 mm precipitation and freeze/thaw cycles on frozen greens resulted in ice cover. In that winter,53 and 32 % of precipitation was retained as leachate and runoff, respectively, while 9% was removed as snow.

In both winters, fungicide detections in drainage water were mostly rare; the Norwegian Environmental Safety Concentration (NESC) was exceeded slightly only for the prothioconazole metabolite desthio. In surface water, the NESC for all fungicides and/or their metabolites were often exceeded 10-100-fold, especially in 2017-18. The highest concentrations coincided with high rainfall intensity in the week after application but also when the green surface re-exposed due to melting episodes. Concentrations in runoff were usually higher on greens established from sod than from seed. This shows the importance of avoiding surface runoff after fungicide application. Infiltration rates must be upheld and wide buffer strips to open water maintained when spraying fungicides.

Collection of surface runoff on 20 October 2017, two days afer fungicide application. Photo: Trygve S. Aamlid.

PRACTICAL RE-ESTABLISHMENT OF GOLF GREENS FOLLOWING WINTER DAMAGE - A FIELD STUDY

PROJECT PERIOD: APRIL 2017 - JULY 2018

FUNDING (kSEK)

	2017	2018	2019	Total
STERF	30	15	5	50
Other sources	77	51	0	128
TOTAL	107	66	5	178

PRINCIPAL INVESTIGATOR / CONTACT PERSON

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PROJECT OBJECTIVES

- Explore the differences between slit, spikes and drop seeding technology and the impact of germination
- Compare two different grass species (*Poa trivialis* and creeping bentgrass) for any differences in germination
- Use of wetting agents. Is there any difference in green sward establishment during spring for the two species? Does 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 2018

19 June: Surahammars GC, Field day event. Successful re-establishment of golf greens following winter damage-a field study. C-J Lönnberg.
18 Aug.: Gothenburg, Jordelit Event, Successful re-establishment of golf greens following winter damage-a field study. C-J Lönnberg.
27 - 30 Nov.: Jonkoping, Örebro, Stockholm, Sundsvall. Seminar tour modern banskötsel, which sowing method is best? Final report on successful re-establishment of golf greens following winter damage-a field study. C-J Lönnberg.

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2019

The project was carried out on natural winter-damaged golf greens in central Sweden. In 2018 the research plots were on two different golf greens at Surahammars Golf Club.

The greens were divided into two blocks, where *Poa trivialis* was used in one block and *Agrostis stolonifera* in the other. Across the blocks, one half was designed to be treated with wetting agent (primer select 20 L/ha) and the other half was left untreated. Each block was divided into two plots, with two replicates each:

- Control (no seed)
- Vertical cutting + drop seeding (2 mm)
- Slit seeding (Vredo)
- Spike seeding (Sisis)

The results from 2018 were good. Re-establishment was good for both *Poa trivialis* and *Agrostis stolonifera*, except for the sowing method vertical cutting + drop seeding and the control plot, because of warm weather from the start of the experiment. The weather in May and June was so warm that germination of the two grasses went very quickly. The results showed that it is very important to have good soil contact if the seed is to germinate. Spring 2018 became extremely hot and no rain came during the study period. Another significant factor in this year was the high ground temperature, which caused the establishment to accelerate very quickly, especially for *Agrostis stolonifera*.

The results showed that both slit and spike seeding were clearly superior methods to drop seeding and the control treatment. Unfortunately, we were unable to test wetting agent in 2018.

Creeping bentgrass, May 9. Slit seeding (Vredo)

Creeping bentgrass, May 9. Spike seeding (Sisis)

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)

	2017	2018	Total
STERF	18	48	66
Other sources	0	43	43
TOTAL	18	91	109

PRINCIPAL INVESTIGATOR / CONTACT PERSON

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CO-APPLICANTS

Trygve S. Aamlid, Inghild Økland and **Wendy M. Waalen,** 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 2018

21 Mar.: De viktigste praktiske resultater fra Høstgjødslingsprosjekt. Håndbok Winter Stress Management. NGF Anleggsseminar, Oslo. T. Espevig.
23 Apr.: STERF Winter Stress Research: Meeting on Transatlantic collaboration on turfgrass research (STERF, USGA, NIBIO, UMASS, MSU), NIBIO Apelsvoll, Norway. T.S. Aamlid.
10 Nov.: Aamlid T.S., A. Holmgeirsson & O. Tidemann 2018. Det 'gresselige' året 2018. Fra isskader til tørkestress. Golfforum, Gardermoen.
12 Dec.: Aamlid T.S., A. Holmgeirsson & O. Tidemann 2018. Det 'gresselige' året 2018. Fra isskader til tørkestress. Norwegian Greenkeeper Association meeting, Drøbak GC Norway.
27 - 30 Nov. Vinteroverlevelse av gress på golfbaner: hva dreper gress og hva kan gjøres? Modern banskötsel. Svenska Golfförbundet. Jönköping, Örebro, Sundsvall, Stockholm, Sweden. T. Espevig.

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2019

In 2015, NIBIO and NGF, with the support of STERF, ran a survey regarding winter damage on golf greens. The survey, which consisted of 24 questions, was distributed online, and included the five Nordic countries: Denmark, Finland, Iceland, Norway and Sweden. More than 300 golf courses participated.

The results from the survey were analysed in two steps. The first article focused on course geography, size and age, grass species and extent of winter injuries (Kvalbein et al., 2016, 2017). It revealed that total costs of repair of winter-injured greens and fairways, together with lost revenue from players, in the Nordic countries amounted to at least €14 million. In a year with significant winter injuries, the average cost to repair the turf was between €3 000 and €12 000 on 88% of the courses. The revenue loss after a winter with

considerable injuries was less than €6 000 on 50% of the courses, while 25% of the courses reported a loss between €6 000 and €12 000 (Kvalbein et al., 2016, 2017). The second article focused on management before winter: autumn fertilisation, fungicide applications and winter maintenance (Økland et al., 2018).

The results showed that winter survival of golf greens can be improved and confirmed that the severity of snow mould infection can be reduced by continuing N-fertilisation at low and decreasing rates until growth stops and the greens freeze in late autumn. More research is needed on the effects of late K- and Fe-fertilisation before clear guidelines on this practice can be given. Use of only systemic or systemic and contact fungicides gave the same good control of snow mould infection. There was no overall effect of green topography on winter survival, but there were indications that lower areas may be more susceptible to ice and water damage and higher areas may be more susceptible to snow mould. Due to the low number of respondents who used protective covers in this survey, there was not enough information to conclude whether there is a benefit from using protective covers or not.

There are still unanswered questions about the mechanical treatments of golf greens during winter and the respective beneficial effects. A field experiment could be carried out to explore these, in which the survival of greens with different combinations and separate treatments is compared within one location, thereby eliminating the variable of winter stress pressure.

Snowmould damage on a annual bluegrass green. Photo: Agnar Kvalbein

FROM DENSE SWARDS TO BIODIVERSE ROUGHS

PROJECT PERIOD: JUNE 2017 - DECEMBER 2020

FUNDING (kSEK)

	2017	2018	2019	2020	TOTAL
STERF	175	200	200	200[1]	775
Other sources	1002	1091	1085	1196	4304
TOTAL	1177	1291	1285	1396	5149

1) Reserved, but not granted

PRINCIPAL INVESTIGATOR / CONTACT PERSON

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CO-APPLICANTS

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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 2018

15 May: Project information board mounted at Oslo GC.
3 Jul.: Release of the project video 'From dense swards to biodiverse roughs': http://www.sterf.org/sv/about-sterf/news-archive/dense-swards-video
28 Aug.: Meeting with BYBI (Urban honey producers in Oslo) to inform about project. H.M. Hanslin.
16 Oct.: Guest lecture at Northeast Agricultural University, Harbin, China: How can the turf industry contribute to biodiversity? T.S. Aamlid.
18 Oct.: Guest lecture at China Agricultural University, Beijing, China: How can the turf industry contribute to biodiversity? T.S. Aamlid.
30 Oct.: Project/Reference group meeting, Oslo Golf Course:
- From dense swards to biodiverse roughs: Status of Norwegian experiments. H.M. Hanslin /T.S. Aamlid
- Update from demo trial at Sigtuna GC, Sweden. J. Wissmann.
- Update from demo trial at Herning GC, Denmark. T.H. Jepsen.

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2019

To realise the potential of golf courses to support biodiversity and ecological functions, this project aims to establish knowledge on how to use cutting regimes, soil amendments, seed

Preparing for early cut Oslo GK , June 1 2018.

Seeding wild flower seeds, August 28 2018

addition and hemiparasitic plants to reduce grass dominance and improve biodiversity on roughs. A field experiment was established at Oslo GK and demonstrations at Sigtuna GK and Herning GK, in parallel with similar plots in agricultural and urban settings in 2017. In total, eight locations were included. Six treatment combinations were started in 2017 and local wildflower mixtures sown in autumn 2018.

Baseline data on vegetation, pollinators and soil characteristics were collected during 2017 and 2018. These revealed a reasonable range of bumblebee and solidary bee species at the experimental locations, but only few individuals. Honeybees were by far the most frequent pollinator species. Botanical assessment showed that the original vegetation was species-poor and dominated by common grasses. A test of the relationship between standing vegetation biomass and playability was run at Oslo GK. Information about the project and these results are available in a video at sterf.se. Outdoor information boards are in place at Herning and Oslo, and in progress at Sigtuna.

So far, the results show that both removal of cut material and addition of sawdust gave a wanted reduction in grass biomass at most locations. Establishment of *Rhinanthus* was highly variable and low. At some locations, the dry summer also gave high mortality of this species. One year after seeding, *Rhinanthus* had no major effect on grass biomass. In the second half of August 2018, plots were cut, hard-raked and seeded with a mixture of 18 wildflower species common in mesic to dry grasslands, at a total rate of 1 gm^{-2}. Observations during late autumn showed beginning establishment of some of these species.

At Sigtuna, summer 2018 was very dry, which restricted plant growth and flowering. No *Rhinanthus* survived and degradation of sawdust was hampered. Ten species were sown as planned. At Herning, there was some deviation from cutting protocol and no establishment of *Rhinanthus* was observed. Plots were sown with 21 species. Recording of vegetation and pollinators has been delayed due to lack of expert personnel. Experimental plots with a design similar to those at Oslo GK were established in 2018 at Munich GC, with one year delay compared with the Scandinavian plots.

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

Anders Esselin, Man & Nature AB, Borgmästarvägen 5, 193 35 Sigtuna, Sweden.
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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 2018

15 Mar. : Larvik Golf Club Norway. Future oriented workshop. Presentations of the project and preliminary results. Participants: Representatives from Larvik Golf Club and potential collaboration partners to the golf club.
19 Mar.: Linköping Golf Club Sweden. Future oriented workshop. Presentations of the project and preliminary results. Participants: Representatives from Linköping Golf Club and potential collaboration partners to the golf club.
12 Apr.: Asserbo Golf Club Denmark. Future oriented workshop. Presentations of the project and preliminary results. Participants: Representatives from Asserbo Golf Club and potential collaboration partners to the golf club.
18 Apr.: The Swedish Parliament, seminar about the role of golf facilities in the urban Society / landscape. Golf clubs as frontrunners for sustainable development in local landscapes. A. Esselin.
3 May: Sigtuna Golf Club. Workshop with reference group of the project. Presentation and discussions on preliminary results of report and on content of workbook.

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2019

This project studied three Nordic golf clubs (Asserbo GC, Denmark, Larvik GC, Norway, Linköping GC, Sweden). Initial research included visits to the golf clubs, mapping values, functions, activities. We also identified potential collaborating partners in the area, interviewed key persons and held future-oriented workshops with club representatives and key external actors.

Hotel for insects at Asserbo GC. Photo: Anders Esselin

Walk and talk at Larvik GK. Photo: Anders Esselin

All three clubs contribute significantly to social sustainability of local landscapes, particularly Linköpings GC, which has an urban setting. The golf courses are important green infrastructure contributing to ecological sustainability in the landscape, especially Asserbo GC, which has a very ambitious approach to conserving biodiversity. Larvik GC has some promising collaborations to enhance economic sustainability in the area. Overall, the economic dimension of sustainable development is not very pronounced at the clubs. The future-oriented workshops identified ways to raise the clubs' profile in sustainability issues and contribution to Agenda 2030:

- Asserbo GC: Birdlife could benefit from having wild plants in roughs, creating a strong food web, since diverse plant life supports diverse invertebrate presence. Possible collaboration with Dansk Ornitologisk Forening. SDG 15 (Life on land)
- Asserbo GC: Access by non-golfers to the golf course is already good, but a project started within Spor.dk could increase accessibility and help integrate the golf club in the social settings of the surrounding landscape. Possible collaboration with Spor i landskabet. SDG 3 (Good health and well-being) and SDG 11 (Sustainable cities and communities)
- Larvik GC: The golf club has put carp in two ponds. Carp is not native, so the club should re-consider this practice. Possible collaboration with Naturvernförbundet. SDG 14 (Life below water) and SDG 6 (Clean water and sanitation)
- Larvik GC: An event for sponsors of the golf club and sponsors of the culture house. Possible cooperation with Bölgen Culture House. SDG 11 (Sustainable cities and communities) and SDG 8 (Decent work and economic growth)
- Linköping GC: Renewable fuel for working machines. Possible collaboration with recreation dept. at Linköping municipality. SDG 7 (Affordable and clean energy) and SDG 13 (Climate action)
- Linköping GC: Develop the golf course and surrounding landscape to act as an outdoor classroom. Possible collaboration with Linköping university, Friluftsmuseet Gamla Linköping, Linköping municipality. SDG 4 (Quality education)

GO OUTDOORS AND USE THE GOLF COURSE IN AN EDUCATIONAL WAY – CREATIVITY, LEARNING AND HEALTH IN THE UNLIMITED CLASSROOM

PROJECT PERIOD: MAY 2017 - APRIL 2019

FUNDING (kSEK)

	2017	2018	2019	Total
STERF	83	115	20	218
Other sources	0	0	0	0
TOTAL	83	115	20	218

PRINCIPAL INVESTIGATOR / CONTACT PERSON

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PROJECT OBJECTIVES

- Pedagogic use of the golf area through all four sesaons.
- Develop a model for pedagogic land use of the golf area for outdoor teaching in compulsory school, grade 1-6 and a pedagogic ´rucksack´ including basic equipment.
- Connect the outdoor pedagogic activities to the norms and value in the Swedish (Lgr11) guidelines and curriculum with connection to subjects, themes and the Swedish right and public access to nature.
- Evaluate the ways of learning and experiences by teachers and pupils with interviews, open questions and questionnaires in a last evaluation and phenomenographic study over time, 2017-2018.

TALKS AT CONFERENCES, SEMINARS, MEETINGS ETC. IN 2018

11-14 May: Education and place-based learning, Peking University/Beijing Scandinavian Nature and Nordic Camp Association conference, Outdoor learning in green open urban settings, keynote presentation. A. Szczepanski Spetsa.
27-29 May: Tylösand dagarna, Outdoor Learning Race and Oudoor Classrooms: a project with Linne Food House and KI (Karolinska Institute) and the county of Halland. A. Szczepanski Spetsa
29-30 Aug.: Jönköping, National conferene Outdoor is Indoor – Ecosystem Services Golf courses as an outdoor classroom, Anna Cervin, Motala Municipality School, and Britta Brügge, Spetsa.
5-7 Oct.: Ireland/Waterville, Learning Landscape symposium in "Learning in, about and for landscapes – reflect rethink and reform", keynote presentation. A. Szczepanski Spetsa.
Nov.: Yokohama Japan, International School Ground confrence (ISGA), Outdoor teaching at a golf course, posterpresentation. Anna Cervin, first- and primary teacher at Motala Municipality School.
Nov.: Yokohama Japan, International School Ground confrence (ISGA), Outdoor teaching at a golf course. Outdoor teaching at a golf course, workshop dicussions. A. Szczepanski Spetsa.

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2019

Golf courses could contribute to better teaching by offering a variety of green surfaces for outdoor teaching. This gives opportunities to vary learning environments that complement the indoor classroom as the site of teaching activity.

Smedsby school in Motala, the pilot school, and its 15 teachers were part of an outdoor education intervention and training at Motala Golf Course during 2017-2018. A second qualitative study was carried out post-intervention, with questions about the teachers' experiences of teaching their pupils at the golf course. The results from the questionnaire, with open questions for the teachers to answer, showed that outdoor education makes pupils happier and more active. The outdoor teaching also had a positive effect on classroom teaching, with more motivated and focused children. The pupils wanted more outdoor teaching, on the golf course or similar areas. This is because the outdoor learning experience is a break from the predictable meeting with the same learning environment that often constitutes classroom teaching. The outdoor learning situation seems to support indoor learning in the classroom, but this second qualitative study indicates that it takes time for some teachers and pupils to understand that the outdoor environment is actually a learning environment. This phenomenographic study will continue and the results will be analysed during 2019. The study also includes documentation by the teachers on their reflections about the outdoor didactic questions: Where, when, what, how and why.

The pedagogic model and ´rucksack´ describe some teaching methods used on the golf course. They include some hand-out material and activities for outdoor teaching related to water, forest and other places close to the golf course. The findings described in the handbook are based on experiences from working with the teachers and their implementation in their everyday teaching of their pupils. The staff at the golf club have been very supportive and provided information about the golf course for teachers and pupils. The Swedish Golf Federation has produced an inspiration video. The project has been very praised, both nationally and internationally.

Outdoor teaching at Motala GC.

INVITE THE STARLING TO HELP THE GREENKEEPER

PROJECT PERIOD: MAY 2018 - OCTOBER 2019

FUNDING (kSEK)

	2018	2019	Total
STERF	90	10	100
Other sources	90	0	90
TOTAL	180	10	190

PRINCIPAL INVESTIGATOR / CONTACT PERSON

Henning Heldbjerg, DOF-Birdlife Denmark, Vesterbrogade 140, 1620 Kbh V, Denmark

PROJECT OBJECTIVES

- The main idea behind this project is invite starlings to settle on golf courses. This bird species preys upon larvae of insects such as craneflies in lawns and fields. It may thereby help the greenkeeper by performing biological control to remove larvae from the turf.
- This pilot project aims to identify parts of the golf course and the surrounding habitat used by foraging adult starlings during the breeding period.
- The aim is to attach high precision GPS-loggers to around five starlings, to learn which habitat they prefer and how far from their nesting site they forage.

TALKS AT CONFERENCES, SEMINARS, MEETINGS ETC. IN 2018

17 May: Plans for the project was presented in the field on a guided bird trip "Birds at golf courses" by the greenkeeper, the project leader and a group of volunteers from DOF Storstrøm to a large group of local nature enthusiast and golf players.

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2019

The project was initiated as collaborative work between Sydsjællands Golfklub, Dansk Golf Union, Dansk Ornitologisk Forening (DOF) and Birdlife Denmark in 2018. We soon realised that we needed more time for preparation to obtain better results during the project and therefore we have added an extra year. 2018 was mainly used to establish the collaboration and to acquire and adapt equipment. First, we identified prerequisites for successful fieldwork. We prepared 110 nest boxes and placed them all over the golf course. All were numbered and georeferenced via the Turfgrass app. Around 40 of the nestboxes were also prepared for catching breeding starlings. We started to record breeding birds and ringed juvenile starlings. The clutch of each successful pair is known to find and consume 2.5 kg larvae, which means that the more starlings we can attract, the more larvae will be removed from the golf course and surroundings.

Sydsjællands Golf Club hosted a succesful guided bird trip "Birds at golf courses" for 30 people one evening in May. This was led by ornithologists from the local branch of DOF-Birdlife Denmark and besides seeing birds, it gave the opportunity for interaction between members of the two organisations and for discussions about the new initiatives at the golf course.

The project is on-going and will include the study of breeding starlings in spring and summer 2019, when we will record all breeding birds in nestboxes and attach high-precision GPS-loggers to ~five adult starlings, to learn which habitat they prefer and how far from the nesting site they forage. Again this year, local people will be invited for a bird trip at the golf course. After the breeding season, the data will be analysed and all experiences evaluated and communicated. Hopefully the experiences will be useful on a broader scale.

Starlings. Photo: Gellinger, Pixabay.

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

1. The effects of soil organic matter, content, and quality on soil biological activity and turfgrass root development in sand dominated golf greens. Karin Blombäck, Swedish University of Agricultural Sciences (1999–2001)

2. Nitrogen utilisation efficiency in different golf green constructions of Creeping Bentgrass golf greens. Karin Blombäck, Swedish University of Agricultural Sciences (2001-2004).

3. Effects of demand-driven fertilisation on growth, appearance and nitrogen use efficiency of turfgrass. Tom Ericsson, Swedish University of Agricultural Sciences (2003-2004).

4. Leaching of fungicides from golf greens: Quantification and risk assessment. Nicholas Jarvis, Swedish University of Agricultural Sciences (2004-2005).

5. Benefits and environmental risks of fungicide use on Scandinavian golf greens. Trygve S. Aamlid, Norwegian Institute for Agricultural and Environmental Research (2004-2005).

6. Evaluation of *Agrostis* and *Festuca* varieties for use on Scandinavian golf greens. Trygve S. Aamlid, Norwegian Institute for Agricultural and Environmental Research (2004- 2007).

7. Environmental management programmes for golf facilities - a case study in the Stockholm golf district. Mårten Wallberg, Swedish Society of Nature Conservation, Stockholm (2005-2007)

8. Evaluation of Agrostis and Festuca varieties (Nordisk sortguide). Trygve S. Aamlid, Norwegian Institute for Agricultural and Environmental Research (2007).

9. Evaluation of biodiversity and nature conservation on golf courses in Scandinavia. Bente Mortensen, GreenProject (2006-2007).

10. Effects of organic amendments and surfactants on hydro-phobicity and fungicide leaching from ageing golf greens. Trygve S. Aamlid, Norwegian Institute for Agricultural and Environmental Research (2006-2007).

11. The role of golf course management in the support of wetland-associated organisms in greater metropolitan Stockholm. Johan Colding, Beijer Institute of Ecological Economics, Royal Swedish Academy of Science (2006-2008).

12. Ageing of a sand-based rootzone. Karin Blombäck, Swedish University of Agricultural Sciences (2006-2008).

13. Turfgrass demonstration trials in Dalarna. Erik Svärd, Swedish Golf Federation (2006-2008).

14. Improved strategy for control of *Microdochium nivale* on golf courses. Anne Marte Tronsmo, Department of Plant and Environmental Sciences, Norwegian University of Life Sciences (2006-2008).

15. The influence of golf on nature and environment – analyses and evaluation of the environmental performance in Scandinavia. Bente Mortensen, GreenProject (2006-2008).

16. Evaluation of the plant growth regulator trinexapac-ethyl (Primo MAXX®) on Nordic golf courses. Trygve S. Aamlid, Norwegian Institute for Agricultural and Environmental Research (2007-2009).

17. Development, evaluation and implementation of playing quality parameters in a continuous golf course evaluation concept – user survey. Anne Mette Dahl Jensen, Forest & Landscape, University of Copenhagen (2007-2009).

18. Prediction of turf growth as a function of light and temperature under Nordic conditions. Karin Blombäck, Swedish University of Agricultural Science (2007-2009)

19. Re-establishment of green turfgrass after winter damage, spring 2009. Agnar Kvalbein, Norwegian Greenkeepers' Association (2008-2009).

20. Impact of mowing height and late autumn fertilisation on winter survival of golf greens in the Nordic countries. Agnar Kvalbein, Norwegian Greenkeepers' Association (2008 -2010)

21. Multifunctional golf course with unique natural and cultural values. Carina Wettemark, Kristianstads Vattenrike Biosphere Reserve, Kristianstads kommun (2008 – 2010)

22. Evaluation of turfgrass varieties for use on Scandinavian golf greens, 2007-2010. Trygve S. Aamlid, Norwegian Institute for Agricultural and Environmental Research (2007-2010)

23. Demonstration trials with winter cover protection. Boel Sandström, Swedish Golf Federation (2007-2010)

24. Breeding of winterhardy turgrass varieties for central and northern Scandinavia. Petter Marum, Graminor AS, Bjørke Research Station (2007-2010)

25. VELVET GREEN: Winter hardiness and management of velvet bentgrass (*Agrostis canina*) on putting greens in northern environments. Tatsiana Espevig, Norwegian Institute for Agricultural and Environmental Research (2007-2011)

26. Fertiliser strategies for golf turf: Implications for physiology-driven fertilization. Tom Ericsson, Department of Urban and Rural Development. Swedish University of Agricultural Sciences. (2007- 2011)

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

28. The Nordic Turfgrass Guide 2012 and Variety Lists. Trygve S. Aamlid, Norwegian Institute for Agricultural and Environmental Research (2011-2013)

29. Optimal maintenance for hardening and early spring growth of green turfgrass. Karin Blombäck, 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)

35. Large-scale demonstration trials: Silvery thread moss on greens. Mikael Frisk, Swedish Golf Federation (2011-2014)

36. SCANGREEN: Turfgrass species and varieties for integrated pest management of Scandinavian putting greens. Trygve S. Aamlid, Norwegian Institute for Agricultural and Environmental Research (2011-2015)

37. Increasing rates of the current and a new formulation of Primo MAXX® for plant growth regulation on greens and fairways. Ingunn M. Vågen, Norwegian Institute for Agricultural and Environmental Research (2013-2015)

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. Tatsiana Espevig, Norwegian Institute for Agriculture and Environmental Research (2011-2015)

39. Validation of the GreenCast prediction model for microdochium patch on golf greens in the Nordic region. Tatsiana Espevig, Norwegian Institute for Agricultural and Environmental Research (2012-2015)

40. Testing of alternative plant production products for the control of *Microdochium nivale* and other diseases on golf greens.Trygve S. Aamlid, Norwegian Institute for Agricultural and Environmental Research (2011-2015)

41. Better turfgrass survival in a changing winter climate Tatsiana 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)

43. GreenCast validation of anthracnose (*Colletotrichum graminicola)* on golf greens in the Nordic region. Tatsiana Espevig, 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)

48. Multifunctionality in golf courses – effects of different management practices on the ecosystem services carbon sequestration and biodiversity. Thomas Kätterer and Jörgen Wissman, SLU (2014-2016)

49. Optimal application of nitrogen and sulfur in autumn for better winter survival. Agnar Kvalbein, NIBIO (2014-2017)

50. Successful reestablishment of golf greens following winter damages. Wendy Waalen, NIBIO (2014-2017)

51. Fairy rings and thatch collapse, Tatsiana Espevig, NIBIO (2016-2017)

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)

54. Sustainable fairway management. Trygve S. Aamlid, NIBIO (2014-2016)

55. Evaluation of fungicides for Nordic golf courses. Trygve S. Aamlid (2016-2017)

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)

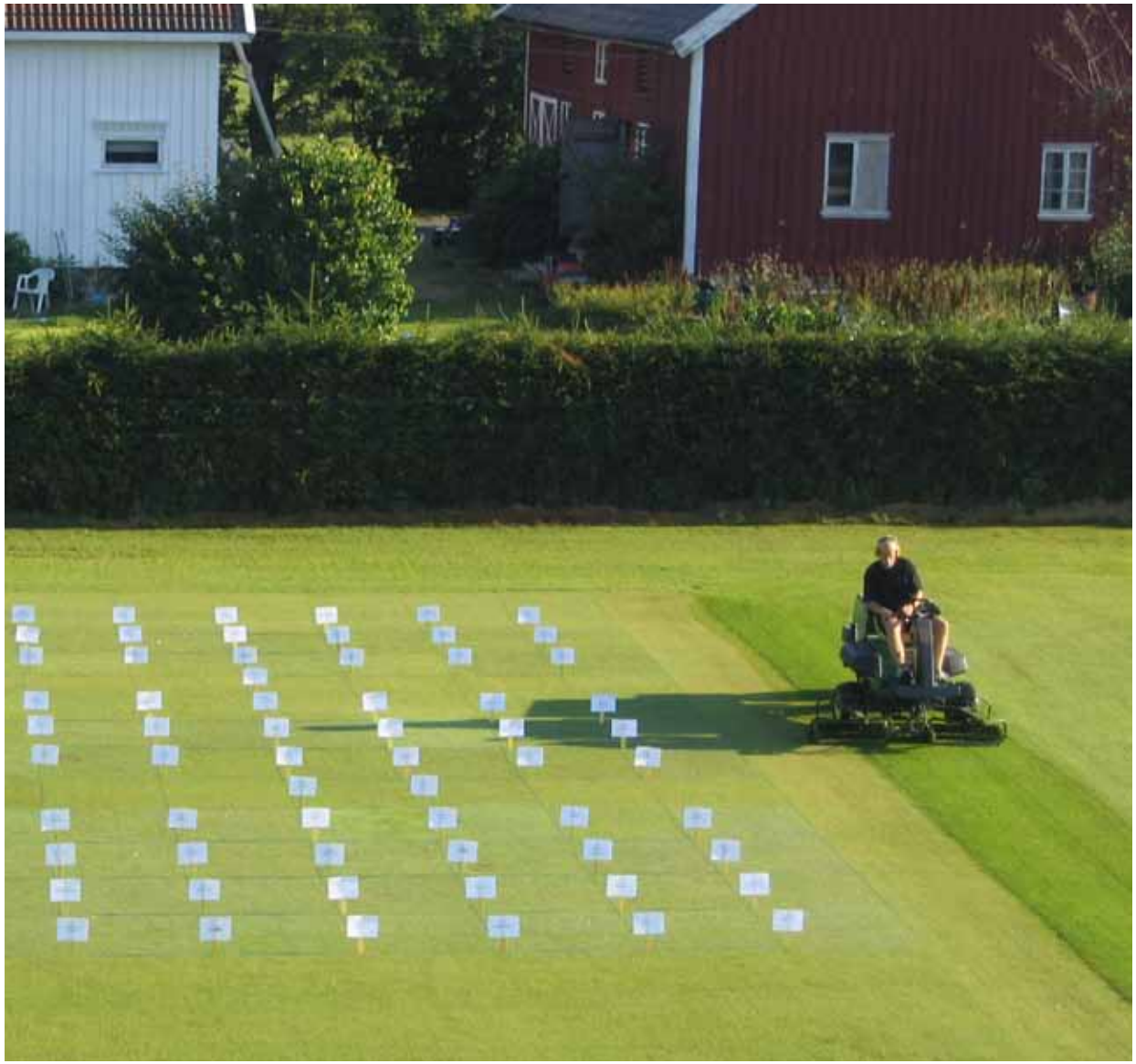
57. Optimal application of nitrogen and sulphur in autumn for better winter survival of perennial grasses – with emphasis on turf. Bert Sandell, NIBIO, (2014-2017)

58. Dandelion management at Värpinge golf course Håkan Rasmusson, Värpinge golf course (2014-2018)

59. Effect of irrigation, fertilizer type and soil amendment on turf quality and organic matter accumulation / thatch control on creeping bentgrass greens Bert Sandell, NIBIO (2016-2018)

60. Winter injuries on Golf Greens in the Nordic Countries: Survey of causes and economic consequences (part II) Tatsiana Espevig, NIBIO, (2017-2018)

61. Establishment of collaboration networks in the landscape for enhanced contribution to the 2030 Agenda on Sustainable Development Anders Esselin, Man & Nature AB (2017-2018)



STERF KEY INDICATORS 2006 - 2018

Year	Funding	Applications		Ongoing projects	Scientific publications		Popular publications	Presentations at seminars, conferences etc.	Handbooks, Fact sheets, Programmes	Subscribers to STERF newsletters	
		Received	Approved for funding								
2006	1 500 000 SEK	17	7	12	7		23	46			
2007	4 900 000 SEK	1	1	13	3		12	26	1		
2008	4 500 000 SEK	22	6	18	11		29	42	2		
2009	5 500 000 SEK	1	1	15	16		20	49	1		
2010	3 000 000 SEK	16	9	13	7		29	46	1		
2011	3 700 000 SEK			19	4		32	50	25		
					Peer-reviewed papers	**Publications and reports**				**English**	**Swedish**
2012	3 400 000 SEK			18	9	12	24	98	25		
2013	4 100 000 SEK			14	2	11	36	71	11		
2014	6 300 000 SEK	19*	8**	22	13	18	33	84	12		
2015	4 400 000 SEK			17	6	7	23	77	9		
2016	4 100 000 SEK	15***		19	14	6	25	86	126		
2017	4 700 000 SEK		7****	18	10	3	50	92	16	893	1233
2018	3 300 000 SEK	3	1*****	15	10	7	48	114	19	898	1238

* Project proposals received 1 December 2013 ** New projects granted funding in February 2014. Funding of new projects started 2014. ***Project proposals received 9 December 2016. **** New projects granted funding in March 2017. Funding of new projects started 2017. *****Two proposals still under review.

The key indicators are based on information in project annual reports. STERF has an open call for proposals approximately every two years. If there are specific reasons, a project application can be granted funding by the STERF board in between the open call for proposals.

FINANCIAL SUMMARY

INCOME STATEMENT

	01/01/2017 12/31/2017	01/01/2018 12/31/2018
Revenue		
Net revenue	3 969 440	3 640 441
	3 969 440	3 640 441
Expenses		
Other external expenses	-49 303	-104 751
	3 920 137	**3 535 690**
Income from financial items		
Interest	0	0
Surplus	**3 920 137**	**3 535 690**

BALANCE SHEET

	2017	2018
Other receivable	0	0
Cash and bank balances	5 830 956	4 694 457
Total assets	**5 830 956**	**4 694 457**
Liabilities and equity		
Equity		
Restricted reserves	262 719	262 719
Non restricted reserves	3 968 237	4 207 085
Total equity	**4 230 956**	**4 469 804**
Current liabilities		
Other current liabilities	1 600 000	224 653
Total current liabilities	**1 620 000**	**224 653**
Total liabilities and equity	**5 830 956**	**4 694 457**

LIST OF PUBLICATIONS 2018

FULL PAPERS IN INTERNATIONAL PEER REVIEWED JOURNALS

Aamlid, T.S., T. Espevig, A.A. Steensohn & E.U. Dahl. 2018. Resistance to Microdochium nivale and abiotic damage as affected by Civitas One™ in a selection of creeping bentgrass cultivars. In S. Brown et al. (eds.): Different Shades of Green. 6th Eur. Turfgrass Soc. Conf., 2-4 July 2018, Manchester, UK. Eur. Turfgrass Soc. Quinto Vicentino, Italy. ISBN:978-3-88579-568-1. p. 66-67.

Aamlid, T.S., O. Niemeläinen, K. Paaske, D. Widmark, P. Ruuttunen & A. Kedonperä. 2018. Evaluation of Civitas One™, alone or in combination with fungicides and potassium phosphite, for control of Microdochium nivale on Nordic golf greens. In S. Brown et al. (eds.): Different Shades of Green: 6th Eur. Turfgrass Soc. Conf., 2-4 July 2018, Manchester UK. Eur. Turfgrass Soc. Quinto Vicentino, Italy. ISBN:978-3-88579-568-1. pp. 66-67.

Aamlid, T.S., O. Niemeläinen, K. Paaske, D. Widmark, P. Ruuttunen & A. Kedonperä. 2018. Evaluation of a petroleum-derived spray oil for control of Microdochium patch and turfgrass spring performance on Nordic golf greens. Agronomy Journal 110 (6): 2189-2197.

Entwistle, K., T. Espevig, J. A. Crouch, K. Normann & M. Usoltseva. 2018. The effect of temperature on the in vitro growth rate of Sclerotinia homoeocarpa isolates of different origin. In S. Brown et al. (eds.): Different Shades of Green. 6th Eur. Turfgrass Soc. Conf., 2-4 July 2018, Manchester, UK. Eur. Turfgrass Soc. Quinto Vicentino, Italy. ISBN:978-3-88579-568-1. pp. 14-15.

Espevig, T., K. Normann, S. Nilsson, N. Bosholdt & M. Usoltseva. 2018. Rolling reduces dollar spot on golf greens in Nordic countries. In S. Brown et al. (ed.) Different Shades of Green. 6th Eur. Turfgrass Soc. Conf., 2-4 July 2018, Manchester, UK. Eur. Turfgrass Soc. Quinto Vicentino, Italy. ISBN:978-3-88579-568-1. pp. 18-19.

Espevig, T., T.S. Aamlid, T.O. Pettersen & A. Kvalbein. 2018. Effect of nitrogen in late autumn on microdochium patch on Nordic golf greens. In S. Brown et al. (ed.) Different Shades of Green. 6th Eur. Turfgrass Soc. Conf., 2-4 July 2018, Manchester, UK. Eur. Turfgrass Soc. Quinto Vicentino, Italy. ISBN:978-3-88579-568-1. pp. 16-17.

Gómez-Armayones, C., A. Kvalbein, T.S. Aamlid & J.W. Knox. 2018. Assessing evidence on the agronomic and environmental impacts of turfgrass irrigation management. Journal of Agronomy and Crop Science 1-14; DOI:10.1111/jac.12265.

Gomez-Armayones, C., J.W. Knox, A. Daccache & T.S. Aamlid. 2018. Simulated impacts of irrigation management on turfgrass under North-European climate conditions. In S. Brown et al. (eds.): Different Shades of Green. 6th Eur. Turfgrass Soc. Conf., 2-4 July 2018, Manchester UK. Eur. Turfgrass Soc. Quinto Vicentino, Italy. ISBN:978-3-88579-568-1. pp. 22-23.

Sandell, B., T. Pettersen & T.S. Aamlid 2018. Effect of soil amendment, fertilizer type and irrigation on turf quality and organic matter accumulation/thatch control on creeping bentgrass greens. In S. Brown et al. (eds.): Different Shades of Green: 6th Eur. Turfgrass Soc. Conf., 2-4 July 2018, Manchester UK. Eur. Turfgrass Soc. Quinto Vicentino, Italy. ISBN:978-3-88579-568-1. pp. 70-71.

Strandberg, M. & B. Hedlund. 2018. Multifunctional activities on Nordic golf facilities – a survey. In S. Brown et al. (eds.): Different Shades of Green. 6th Eur. Turfgrass Soc. Conf., 2-4 July 2018, Manchester UK. Eur. Turfgrass Soc. Quinto Vicentino, Italy. ISBN:978-3-88579-568-1. pp. 66-67.

OTHER PUBLICATIONS IN ENGLISH

Aamlid, T.S., T. Pettersen & B. Sandell 2018. Effect of soil amendments, fertilizer types and irrigation on turf quality and associated characters on a creeping bentgrass (Agrostis stolonifera) putting green: NIBIO Commissioned Report, Archive 17/00352. 47 pp.

Aamlid, T.S., T. Espevig & W. Waalen. 2018. Professor Eric Watkins came from Minnesota to see severe winter damages on Norwegian golf courses. ITS newsletter. May 2018: 4-5. http://turfsociety.com/newsletters/2018-05%20itsnd.pdf

Aamlid, T.S. 2018. What's the meaning of IPM on golf cour ses? 6 pp. http://www.sterf.org/sv/about-sterf/news-archive/meaning-of-article-ipm

Aamlid, T.S. 2018. What's the meaning of IPM on golf cour ses? http://www.sterf.org/sv/about-sterf/news-archive/meaning-of-article-ipm 6 pp.

Espevig, T., T.O. Pettersen & T.S. Aamlid. 2018. Effect of Marathon fertilizer and Melgreen Si and Melgreen Cu biostimulants on turf quality and microdochium patch on a Poa annua putting green. Report from the second experimental year. NIBIO confidential report 17/00351. 16 pp.

Espevig, T. & T.S. Aamlid. 2018. Winter diseases. Biotic winter damage. http://www.sterf.org/sv/about-sterf/news-archive/biotiska-vinterskador 9 pp.

Esselin, A. 2018. Golf clubs as landscape players - Final report. STERF http://www.sterf.org/sv/projects/project-list/golf-clubs-as-landscape-players. 19 pp.

Esselin, A. 2018. Golf clubs as frontrunners for sustainable development in local landscapes – Workbook for golf clubs. STERF. http://www.sterf.org/sv/projects/project-list/golf-clubs-as-landscape-players 13 pp.

Faskunger, J. A. Szczepanski & P. Åkerblom. 2018. Teaching with the Sky as a Ceiling – A research review about the significance of outdoor teaching for children's learning in compulsory school. Linköping University 2018. http://liu.diva-portal.org/smash/record.jsf?pid=diva2%3A1253050&dswid=-4501 70 pp.

Knox, J.W., C. Gómez Armayones, P.L. Burgess & T. Aamlid. 2019. Industry guidelines to support best management practices for golf course irrigation. Technical Report for STERF, www.sterf.org 28 pp.

Kvalbein, A, T. Espevig, W. Waalen & T.S. Aamlid. 2017. Skötsel av grönytegräs mot vinterskador Banchefens handbok. http://www.sterf.org/sv/library/handbooks/winter-stress-management 35 pp.
NIBIO and STERF. 2018. From dense swards to biodiverse roughs. Video. https://vimeo.com/275531294
Økland I., A. Kvalbein, W.M. Waalen, L. Bjørnstad, T.S. Aamlid & T. Espevig. 2018. Winter injuries on golf greens in the Nordic countries (part 2). Survey of causes and economic consequences. STERF's Popular Scientific Articles http://www.sterf.org/Media/Get/3087/survey-winter-injuries-part2
Sandell, B., S.A. Aamlid, W. Waalen & T. Espevig. 2018. STERF/NIBIO Seminar and Handbook on Turfgrass Winter Stress Management. ETS newsletter 01/2018: 4-5. https://issuu.com/europeanturfgrasssociety/docs/ets-nl-2018-01
Sandell, B., S.A. Aamlid, W. Waalen & T. Espevig. 2018. STERF/NIBIO Seminar and Handbook on Turfgrass Winter Stress Management. Newsletter of the ITS January 2018: 3-4. https://issuu.com/europeanturfgrasssociety/docs/ets-nl-2018-01
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Strandberg, M. 2018. Sustainable green space in urban landscapes. International Turfgrass Society Newsletter. January 2018: 7. http://turfsociety.com/newsletters/2018-01%20itsnd.pdf
Strandberg, M. & B. Hedlund. 2018. Multifunctional activities on Nordic golf facilities – a survey. http://www.sterf.org/sv/about-sterf/news-archive/multifunctionality-survey. 16 pp.
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Strandberg, M. & B. Hedlund. 2018. Golf facilities: An underu tilized resource. Golf Course Management 04 (18): 76-81.
Strandberg, M. & B. Hedlund. 2018. Multifunctional activities on Nordic golf facilities – a survey. http://www.sterf.org/sv/library/articles-and-other-papers 16 pp.
Strandberg, M. 2018. 14th International Turfgrass Research Conference in Copenhagen July 11-16 2021. International Turfgrass Society Newsletter January 2018: 8. http://turfsociety.com/newsletters/2018-01%20itsnd.pdf
Strandberg, M. 2018. STERF yearbook 2017. International Turfgrass Society Newsletter. May 2018: 8. https://turfsociety.com/newsletters/2018-05%20itsnd.pdf
Strandberg, M. 2018. STERF yearbook 2018. http://www.sterf.org/sv/library/annual-reports 71 pp.

EXTENSION PAPERS OR REPORTS IN NORDIC LANGUAGES

Aamlid, T.S. 2018. Hva innebærer IPM-forsking på golfgress? Gressforum 2018(3): 4-7.
Aamlid, T.S. 2018. Hvad indebærer IPM-forskning på golf græs ? Greenkeeperen 32(3): 28-31.
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Aamlid, T.S., T. Espevig, T. Pettersen, W. Waalen, P. Heltoft, J. Tangsveen & P. Melbye. 2018. Vinteren 2017-18: Større skader enn normalt på to av tre golfbaner på Sørlandet, Østlandet og i Trøndelag. Gressforum 2:4-8.
Aamlid, T.S., M. Almvik, M. Stenrød, B. Sandell & T. Pettersen, 2018. Undgå overfladeafstrømnng efter sprøjtning med planteværnsmidler. Greenkeeperen 32 (1): 30-35.
Aamlid, T.S., M. Almvik, M. Stenrød, B. Sandell & T. Pettersen, 2018. Unngå overflateavrenning etter sprøyting med plantevernmidler. Park & anlegg 17 (3): 32-36.
Aamlid, T.S., H.M. Hanslin, E. Svalhem, E. Kalloniemi, A. Kvalbein & B. Sandell, 2018. Tynn røff er lettere å spille fra og åpner for større biologisk mangfold. Gressforum 2018(1): 20-23.
Aamlid, T.S. & E. Svalheim, 2008. Drømmen om blomstereng. Veileder om anlegg og skjøtsel. NIBIO Landvik. 2s.
Aamlid, T.S., T. Espevig, T. Pettersen, W. Waalen, P. Heltoft, J. Tangsveen & P. Melbye. 2018. Vinteren 2017-18: Større skader enn normalt på to av tre golfbaner på Sørlandet, Østlandet og i Trøndelag. Gressforum 2:4-8.
Aamlid, T.S., T. Espevig, W. Waalen, P. Heltoft, T. Pettersen & J. Tangsveen 2018. Store vinterskader på norske golfbaner. Norsk Golf. http://www.norskgolf.no/artikler/nyheter/store-vinterskader-pa-norske-golfbaner
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Aamlid, T.S., H.M. Hanslin, E. Svalheim, E. Kalloniemi, A. Kvalbein & B. Sandell. 2018. Minor-use godkjenning for kjemisk bekjemping av rotdreper på norske golfbaner. Gressforum 2018 (2): 10-13.
Andersson, R., M. Strandberg & M. Pellborn. 2018. Så arbe tar din klubb hållbart. Golfnyttan podcast. https://golf.se/golfnyttanpodden
Björn, T. 2018. FN:s mål tar golfen till nästa nivå. Golfnyttan 1: 32-33. (https://golf.se/for-klubben/golfnyttan/golfnyttan/artiklar-fran-golfnyttan/?p=3#expandable-fns-mal-tar-golfen-till-nasta-niva)
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Espevig, T. & T.S. Aamlid. 2018. Vintersykdommer på gress Biotiske vinterskader. http://www.sterf.org/sv/about-sterf/news-archive/biotiska-vinterskador 9 pp.
Espevig, T. & T.S. Aamlid. 2018. Vintersjukdomar på gräs Biotiska vinterskador http://www.sterf.org/sv/about-sterf/news-archive/biotiska-vinterskador 9 pp.
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